ERIE
INTERNATIONAL CONFERENCE 2020

PROCEEDINGS

17TH INTERNATIONAL CONFERENCE
EFFICIENCY AND RESPONSIBILITY IN EDUCATION

4TH - 5TH JUNE 2020

Czech University of Life Sciences Prague
Faculty of Economics and Management

Czech University of Life Sciences Prague
Faculty of Economics and Management

Proceedings of the 17th International Conference

Efficiency and Responsibility in Education 2020

ERIE
INTERNATIONAL CONFERENCE 2020

4th - 5th June 2020
Prague, Czech Republic, EU

Editors:	Jiří Fejfar, Martin Flégl
Cover:	Michal Hruška
Technical editor:	Jiří Fejfar
Publisher:	Czech University of Life Sciences Prague Kamýcká 129, Prague 6, Czech Republic
Issue:	65 copies

Publication is not a subject of language check.
Papers are sorted by authors' names in alphabetical order.
All papers passed a double-blind review process.

ISBN 978-80-213-3022-1
ISSN 2336-744X

PROGRAMME COMMITTEE

Head

Jaroslav Havlíček
Czech University of Life Sciences Prague, Czech Republic

Members

- **Peter M. Bednar**
  University of Portsmouth, United Kingdom
- **Peter Fandel**
  Slovak University of Agriculture in Nitra, Slovakia
- **Martina Fejfarová**
  Czech University of Life Sciences Prague, Czech Republic
- **Jana Hančlová**
  Czech Society for Operations Research, Czech Republic
- **Milan Houška**
  Czech University of Life Sciences Prague, Czech Republic
- **Irem Comoglu**
  Dokuz Eylul University, Turkey
- **Eva Milková**
  University of Hradec Králové, Czech Republic
- **Jarmila Novotná**
  Charles University in Prague, Czech Republic
- **William O'Brien**
  Worcester State University, United States
- **Tomáš Šubrt**
  Czech University of Life Sciences Prague, Czech Republic
- **Milan Turčáni**
  Constantine the Philosopher University in Nitra, Slovakia

CONFERENCE CO-EDITORS

- **Irena Benešová**, Department of Economics, CZU Prague
- **Jiří Brožek**, Department of Information Engineering, CZU Prague
- **Helena Brožová**, Department of Systems Engineering, CZU Prague
- **Martina Fejfarová**, Department of Management, CZU Prague
- **Robert Hlavatý**, Department of Systems Engineering, CZU Prague
- **Tomáš Hlavsa**, Department of Statistics, CZU Prague
- **Milan Houška**, Department of Systems Engineering, CZU Prague
- **Martina Houšková Beránková**, Department of Systems Engineering, CZU Prague
- **Jakub Husák**, Department of Humanities, CZU Prague
- **Igor Krejčí**, Department of Systems Engineering, CZU Prague
- **Kristýna Krejčová**, Department of Psychology, Charles University
- **Petr Kučera**, Department of Systems Engineering, CZU Prague
- **Jarmila Novotná**, Department of Mathematics and Mathematical Education, Charles University
- **Jan Rydval**, Department of Systems Engineering, CZU Prague
- **Kristýna Vltavská**, Department of Economic Statistics, University of Economics, Prague

ORGANISATION COMMITTEE

Head

Martina Houšková Beránková
Czech University of Life Sciences Prague

Members

- **Jiří Fejfar**
- **Martin Flégl**
- **Tereza Horáková**
- **Tereza Jedlanová**
- **Igor Krejčí**
- **Petr Kučera**
- **Jan Rydval**

TECHNICAL EDITORS

- **Dominik Bláha**
- **Jiří Fejfar**
- **Michal Hruška**

Table of Contents

STUDENT ATTITUDE TOWARDS VIRTUAL CLASSROOMS (A PILOT STUDY AT THE URAL FEDERAL UNIVERSITY)
Natalya Antonova, Sofia Abramova, Natalia Popova 5

BENEFITS OF THE USE OF THE EXPERIMENTAL METHOD IN TEACHING HIGH SCHOOL MATHEMATICS
Karel Antoš 12

ORIGAMI-BASED INSTRUCTION IN THE HIGH SCHOOL MATHEMATICS CLASSROOM AND ITS IMPACT
Libor Beldík, Lucie Loukotová 22

INFLATION AS PART OF PRICE LITERACY AND AWARENESS OF THE CONCEPT OF INFLATION AMONG UNIVERSITY STUDENTS
Markéta Beranová, Jan Šíma, Miroslava Navrátilová 30

BIG-TESTS IN THE TEST CENTRE CZU OF THE SUBJECT APPLIED MATHEMATICS FOR INFORMATICS
Helena Brožová, Jan Rydval 38

WHERE TO INVEST IN ONLINE MARKETING EDUCATION IN MICRO AND SMALL ENTERPRISES
Francesca Cabiddu, Ludovica Moi, Pia Jaaskelainen, Ladislav Pilař, Jana Pitrová, Rosen Petkov 46

USING VIRTUAL AND AUGMENTED REALITY IN GRAPHIC SUBJECT
Ivana Čermáková, Ivo Martiník 54

TOLERANCE OF AMBIGUITY AND READING COMPREHENSION IN FOREIGN LANGUAGE EDUCATION
Anikó Ficzere, Eva Stranovská, Zdenka Gadušová 62

ARE STUDENTS ABLE TO IDENTIFY AN IMAGE OF A STRAIGHT LINE IN ROTATION?
Zdeněk Halas, Vlasta Moravcová, Jarmila Robová, Jana Hromadová 69

USING A SIMULATION GAME IN THE EDUCATION OF AN AGILE APPROACH
Ondřej Havazík, Petra Pavlíčková 76

DIMENSIONS OF LEARNING CULTURE AND EMPLOYEES' IDENTIFICATION IN AN ORGANIZATION
Miloslava Hiršová, Lenka Komárková, Martina Glaserová 83

CAREER ADVANCEMENT OF BUSINESS FACULTY IN THE UNITED STATES AND CZECHIA
Alena Höfrová, Pavla Rymešová, Dana Benediktová, Mark A. Small *91*

EXAMINING ENGLISH LANGUAGE SKILLS IN FIRST-YEAR UNIVERSITY STUDENTS
Miroslav Hrubý, Eva Staňková *101*

AN APPROACH FOR EVALUATING WORKERS IN ACADEMIC INSTITUTIONS BY LOGIC AGGREGATION
Miroslav Hudec, Jana Hančlová, Lucie Chytilová *108*

MENTAL LOAD: THE NEED FOR SOCIAL SUPPORT AND STRESS AVOIDANCE AT UNIVERSITY STUDENTS
Hana Chýlová, Kristýna Krejčová, Pavel Michálek, Luděk Kolman *116*

COMPARISON OF SOFTWARE TOOLS FOR SOLVING DEA MODELS
Josef Jablonský *123*

TYPES AND FUNCTIONS OF REPORTING VERBS IN LITERATURE REVIEWS OF STUDENTS' THESES
Martina Jarkovská, Lenka Kučírková *130*

CORPORATE SOCIAL RESPONSIBILITY AS THE SOURCE OF TEACHERS' JOB SATISFACTION
Petra Jarkovská *137*

THEORETICAL ACCOUNTING COURSES STUDENTS´ SUCCESS RATE AT FEM CULS PRAGUE APPRAISAL
Jakub Ječmínek, Ivana Kuchařová, Daniela Pfeiferová *144*

ENTRANCE EXAMINATIONS MOCK
Jindřich Klůfa *151*

INCREASING STUDENT READING COMPREHENSION USING EYE-TRACKING DATA ANALYSIS
Michal Kohútek, Milan Turčáni *158*

QUALITY OF SIBLINGS' RELATIONSHIP AND THEIR IMPACT ON ACADEMIC SELF-EFFICACY
Kristýna Krejčová, Hana Chýlová *166*

UNT PETRI NETS THEORY APPLIED TO RICH-MEDIA RECORDINGS OF APPLE MOBILE DEVICES
Ivo Martiník *173*

USING STATISTICAL SOFTWARE AT CZECH UNIVERSITIES
Aneta Mazouchová, Tereza Jedličková, Lucie Hlaváčová *181*

QUANTITATIVE STUDY OF FULL-TIME AND PART-TIME BACHELORS' STUDENTS DROPOUT
Libor Měsíček, Pavel Petrus *189*

PRIMARY SCHOOL TEACHERS' PERCEPTION OF THE CLASSROOM CLIMATE: CREATING AND INFLUENCING IT
Hana Mončeková, Miluše Vítečková, Miroslav Procházka, Martina Faltová *196*

DIVERSITY OF STUDENTS' INFORMATION BEHAVIOUR WITHIN A DIGITAL LEARNING ENVIRONMENT
Tatiana Noskova, Tatiana Pavlova, Olga Yakovleva *204*

HIDDEN TEACHER'S INCENTIVES IN TEACHING MATHEMATICS (A CASE STUDY)
Jarmila Novotná, Alena Hošpesová *212*

USE OF GAMIFICATION IN LECTURES USING THE KAHOOT! TOOL
Ladislav Pilař, Lucie Kvasničková Stanislavská, Kateřina Kuralová *219*

ASSESSMENT OF MANAGERIAL DECISION-MAKING SKILLS USING THE FACTOREASY®
Michal Prokop, Václav Švec, Michaela Nováková *225*

INFLUENCE OF ECONOMIC FACTORS ON SELECTION OF FIELD OF STUDY
Alice Reissová, Jana Šimsová, Michala Pátková *234*

UNDERSTANDING OF BASIC CONCEPTS IN NOVICE PROGRAMMING COURSES
Radim Remeš, Ladislav Beránek *242*

USE OF THE CLIL METHOD IN TEACHING MATHEMATICS AT LOWER SECONDARY SCHOOL LEVEL
Hana Reslová *249*

UNIVERSITY STUDENTS' EXPERIENCE WITH PROFESSIONAL SOCIAL NETWORKS
Daniela Šálková, Petra Šánová, Olga Regnerová *255*

OBSERVING HOW FUTURE PRIMARY SCHOOL TEACHERS REASON ABOUT GENERAL STATEMENTS
Libuše Samková *263*

ONLINE BEHAVIOUR AND PRIVACY DISCLOSURE
Tomáš Sigmund *272*

USING MOBILE DEVICES IN GRAMMAR SCHOOL LESSONS
Václav Šimandl, Václav Dobiáš, Miroslav Ditrych *279*

GENDER SCHEMAS AND RELATIONSHIPS IN SCHOOL PEER GROUPS
Irena Smetáčková, Petr Pavlík *287*

GEOGEBRA IN SECONDARY SCHOOL EDUCATION IN THE CZECH REPUBLIC: TEACHERS' PERCEPTIONS
Petra Surynková *293*

SECURITY OF CONNECTION TO SCHOOL WEBSITES: A COMPARISON OF VISEGRÁD GROUP MEMBER COUNTRIES
Jaroslav Svoboda, Jiří Georgiev *301*

TEACHING ERP CONCEPTS FOR NON-USERS AND USERS: A SURVEY AMONG COLLEGE STUDENTS
Miloš Ulman, Marek Dvořák, Eva Kánská, Věra Motyčková *309*

STUDENT TYPOLOGY IN TERMS OF CAREER LEARNING NEEDS
Jiří Votava, Kamil Urban, Jitka Jirsáková *316*

TEACHING STAFF RECRUITMENT IN PRE-UNIVERSITY EDUCATION: CASE OF ALBANIA
Orhan Zaganjori, Vladimír Krepl, Mansoor Maitah *324*

PRE-GRADUAL TEACHER TRAINING IN THE AREA OF DIDACTIC TECHNOLOGICAL COMPETENCIES
Jan Záhorec, Alena Hašková *332*

STUDENT ATTITUDE TOWARDS VIRTUAL CLASSROOMS (A PILOT STUDY AT THE URAL FEDERAL UNIVERSITY)

[1]Natalya Antonova, [1]Sofia Abramova, [2]✉Natalia Popova

[1]Ural Federal University, Russian Federation

[2]Institute of Philosophy and Law, Ural Branch of the Russian Academy of Sciences, Russian Federation, ngpopova@list.ru

Abstract

The present paper considers the virtual classroom as an innovative educational model in the context of education digitalization and the development of information and communication technologies. In this work, we set out to analyse attitudes of Ural Federal University students (Yekaterinburg) towards virtual classroom practices. The research methodology involved a standardized questionnaire survey among students (n = 150). The obtained results indicate that virtual learning is in demand at the stage of high-school education (preparation for a unified state exam or foreign language courses). Virtual classes allow learners to save time required for commuting to a campus and to acquire relevant knowledge under the conditions of a rapidly changing reality. According to our respondents, the advantages of virtual learning include increased convenience in terms of time and geographic location, as well as the possibility to revise learning materials when necessary. Study distractions connected with the use of Internet and the absence of social control were mentioned as a disadvantage of the model.

Keywords

Virtual classroom, education, students, education digitalization

Introduction

Penetrating all aspects of human life, digitalization is increasingly becoming a fundamental basis of contemporary processes and phenomena. Information and communication technologies in education are in steady demand at all education levels. Education is gradually becoming independent of students' location, thus providing flexibility in determining their learning trajectories (Lakhal et al., 2017). While changing the educational landscape, digital technologies improve the accessibility of educational services for the representatives of different social groups and communities (Cain, 2015). New technologies in education improve the affordability of education and boost cooperation and partnership (Stupnisky and Butz, 2016). The adjustment of teaching technologies to transforming learner needs and a growing request for innovative online educational services are the trends that increase the efficiency of education (Antonova et al, 2017). Being an innovative practice in modern educational technologies, the virtual classroom is aimed at meeting a wide range of educators' and students' needs. Virtual learning environments provide improved feedback for learners, thus supporting personalized and life-long learning (Bystrova et al, 2018). Online learning can be synchronous (in a real-time mode) and asynchronous, when the educator posts teaching materials (video lectures, etc.) online for the students to learn them at any convenient time.

Today, the real-time mode of virtual classroom (webinars, live streaming, etc.) is becoming increasingly popular, since it enhances learner motivation and provides an opportunity for ongoing interaction with educators. Therefore, working students, students residing abroad and those unable to attend traditional classes for health reasons can participate in virtual classroom

discussions (Wang et al., 2017). The virtual classroom also provides educational opportunities for disabled people (inclusive education), thus ensuring equity in access to education (Bell et al., 2014).

The virtual classroom has the following advantages over the traditional classroom. On the one hand, virtual learning removes the limitation of time and location; learners have the freedom to complete the coursework from any geographic location equipped with Internet access. Therefore, learners save hours that could otherwise be spent commuting forth and back to a campus. On the other hand, the virtual classroom relies on digital technologies that allow the entire learning process to be managed more efficiently (assignment updates, homework performance control, revision of recorded materials, immediate feedback on tests, etc.). Moreover, online collaborations take place not only within the virtual classroom itself, but also through a broad range of communication tools, such as online chats, forums and and social networks (Anekwe, 2017; Cakiroglu, 2014). Finally, students have permanent access to educational materials, which facilitates personalized learning.

Along with the aforementioned advantages, the virtual classroom has a number of drawbacks. From the educator's perspective, radical changes are required in terms of pedagogical technologies that support online learning (Bower et al., 2015; Ramsey et al., 2016). While adjusting learning materials to the new format, educators must adhere to state educational standards (Lightner and Lightner-Laws, 2016). In addition, educators need to sharpen their digital competencies to be able to apply new information and communication technologies. This cannot but increase mental workload (hyper-zoom / hyper-focus) due to the necessity to perform additional operations (Zydney et al., 2019).

The virtual classroom requires more self-discipline from students due to a lesser control on the part of the educator. As a result, the dropout level during online courses is usually much higher compared to traditional, face-to-face learning (Dietz-Uhler et al, 2007). Moreover, the absence of face-to-face interaction with the educator and other students sometimes leads to poor learning outcomes (Marshall, 2018).

It can be seen that modern literature on the efficiency of virtual learning presents conflicting opinions, which determines the need for additional research. Therefore, we undertook an empirical study to investigate university students' experience of virtual learning with the purpose of revealing their opinions about the advantages and disadvantages of the virtual classroom model. Such a study can elucidate the potential of virtual learning technologies in terms of their broad application in real educational practices.

Materials and Methods

The aim of the present study was to analyse students' attitudes towards virtual classrooms. In December 2019, we conducted a pilot standardized survey among 150 students of the Ural Federal University (Yekaterinburg, Russia). Although the sample cannot be considered representative of the whole population of Russian university students (inclusion of students from only one university and a high sampling error of 10%), the obtained data are useful for administrations of Russian universities in outlining the developmental trends of education digitalization.

A questionnaire comprising 15 questions (7 closed questions, 1 open question and 7 half-closed questions) was developed. The questions were aimed at: 1) identifying the most attractive subjects for learning via virtual classes; 2) determining motivations behind using virtual classes; 3) revealing the advantages and disadvantages of virtual classrooms.

In total, 150 students were questioned, 70% and 30% of whom were females and males, respectively. All respondents were undergraduate students: 23% of the respondents were first-year students, 29% – second-year students, 27% – third-year students and 21% of the respondents

were fourth-year students. 25% of respondents were obtaining education in sciences, while 75% were majoring in humanities and social studies. All the respondents had no unfulfilled curriculum requirements at the moment of survey. The respondents were requested to complete a paper questionnaire in their free time in the presence of an interviewer. The average time spent on completing the questionnaire was 20 minutes. The obtained data was processed by frequency, cross-stabilization and correlation analysis using the SPSS software.

Results

The Yekaterinburg students, who participated in the study, almost equally balanced between those who had *experienced online courses* based on the virtual classroom model (52%) and those who had never used this kind of learning (48%). The respondents' experience in virtual courses was independent of their sex and year of education. However, among all students with the experience of online education, the greatest number (75%) was represented by science students rather than by those majoring in humanities and social studies (33%).

The frequency of choosing virtual classroom learning was rather low: 61% of those having had such an experience took only 1–2 courses. At the same time, it can be said that *a core of regular users* (virtual classroom participants who have completed more than 5 courses) is steadily forming. These respondents account for 15% of all the students, mostly in humanities and social studies.

16% of the respondents experienced virtual classroom courses at university. 35% of students tend to choose courses in those subjects that have already been studied, in order to broaden their knowledge and sharpen their skills. 35% of students choose courses that are partly connected with their field of study. 33% of students focus on their future work and choose courses that might be required for employment. 31% use online learning to study subjects that are completely new for them. Therefore, all choice orientations are equally represented and can serve as a basis for real educational practices.

In order to form sustained interest and intention to virtual learning, it is important to consider the level of *satisfaction with the outcomes* of such education. Most students report their partial satisfaction, which cannot be considered as an active motivating factor. Such students are likely to need additional motivators that are not directly connected with the results of learning (transfer of credits, lower cost of education, etc.). 32% are fully satisfied with their results, which may become a motivation to use virtual courses in the future. It is important to note that higher-course students report lower levels of satisfaction with the learning outcomes of virtual education. Thus, out of the maximum 3 points, the satisfaction level among 1-2 course students was 2.46 points, gradually decreasing to 1.87 points among 4-course students.

The analysis of *motivations behind the choice of virtual learning* allowed us to distinguish the following groups.

The first group include motivations connected with the organizational form of such courses. 61% mentioned the absence of the need to attend traditional classes. 39% consider this kind of learning to be a modern and innovative form of education.

The second group of motivations is connected with the search for necessary or interesting information. The Internet serves as a main source of information for modern students. 54% of students were consciously seeking for online courses as a source of new (necessary) information, while 48% experienced accidental choice ("have encountered") of an interesting course on the Internet.

The third group of motivations includes those based on some external sources. It can be either recommendation from the academic environment (24% completed virtual classroom courses as part of university compulsory subjects, 17% received recommendations from their professors), or recommendations from friends, who shared their experience of successful online learning (17%).

Finally, another motivation is a relevantly low cost of virtual learning. Thus, 7% of online course participants conducted a prior comparative study of the cost of education to find more affordable learning options. 43% of our respondents with online learning experience took fee-based courses, 46% – only free courses, and 11% tried both types. It should be noted that, among those who paid for online courses, 52% were fully satisfied with their results. For comparison, only 20% of students were satisfied with free courses. This may indicate both the different quality of such courses, as well as different attitudes of students towards paid and free education.

The respondents identified two main *advantages of virtual classroom learning*: freedom to choose the location and time of the course (91%) and the possibility to download materials for further revision (72%). In addition, the following advantages were mentioned: development of independence and responsibility (44%), use of modern information and digital environment (37%), virtual education mobility (37%), up-to-date information of online courses (36%) and modern design and presentation of learning materials (24%).

The *disadvantages of the virtual classroom model* mostly correlate with typical difficulties arising while using online educational technologies. Firstly, the respondents mentioned the problem of distractions when using the Internet (52%) and a poor Internet connection (20%). Secondly, students face the problems of self-organisation and deadlines (44%), as well as the temptation to cheat by simulating presence in class (48%). Thirdly, students lack communication (48%) and feedback from the educator (28%), which makes them feel socially isolated (13%). As a result, 33% of the students consider the quality of education in a virtual classroom lower than that in a traditional class.

The students reporting no previous experience of virtual education mentioned similar reasons not to choose online courses. In particular, 54% of these respondents were concerned with the risk of poor attendance, which is lower under the traditional form of learning. These students claim that face-to-face education provides more information and knowledge (37%), enabling discussions and disputes with educators and groupmates (33%).

As a result, 77% of the respondents treat the *combination of traditional and virtual classroom models* as the most effective form of modern education. The number of students supporting traditional education is higher among those having no previous experience of virtual learning (32%) compared to those having such an experience (12%). Satisfaction with the results of education increases students' loyalty to blended learning: this option in the questionnaire was chosen by all the respondents with previous successful experience of online learning.

Discussion

The results obtained during our research show that high-school students tend to choose virtual courses either aimed at preparation for a unified state exam or those developing foreign language competencies. At this level, the selection of subjects is normally carried out by parents, who pay for such courses. For example, parents frequently select foreign language courses, believing that such competencies are crucial for their child's sociocultural capital and future success in the global labour market.

The courses chosen by university students can also be divided into two groups. On the one hand, these are online courses recommended by the university. In this case, the activity of students in using online educational technologies reflects the strategies pursued by the university, department or a certain educator. On the other hand, these are courses taken by students on their personal initiative, which can either be connected with the field of study or be in completely different areas (entrepreneurship, start-ups, etc.). Therefore, it would be wrong to treat virtual classes as those extending the curriculum of university programmes.

There are a limited number of publications investigating learner motivation to use virtual classrooms (Bekele, 2010). Researchers mainly focus on issues associated with the creation of a motivational learning environment (Keller, 2008), in which the educator plays a decisive role in increasing students' interest in educational activities (Xie et al., 2011). It was shown that active feedback and interaction with the educator and other learners contributes to increased student motivation (Schullo et al., 2007). In our study, respondents noted the deficit of interaction with the educator and other students as one of the main disadvantages of virtual learning. Therefore, it seems that the implementation of synchronous (real-time) virtual classes can increase the student satisfaction and learning outcomes. This assumption is in good agreement with the results reported by (McBrien et al., 2009), who found that the efficiency of synchronous virtual classes is higher due to the possibility of direct interaction between the educator and the students. Communication plays an essential role in the success of distant learning (Danesh et al., 2015).

However, the model of synchronous virtual learning has some limitations. Thus, according to our results, the freedom to learn at a place and time that best suit students' schedule is the leading advantage of virtual education. This finding is consistent with the results obtained in (Xenos, 2018) claiming that the main attraction of online courses is their flexibility. In addition, real-time virtual classes require stable Internet access, which may be challenging for some students. This problem was also discussed in previous publications (McBrien et al., 2009; Cakiroglu, 2014).

In general, we believe that virtual classrooms have significant prospects in the further development of educational technologies. A survey conducted by P. Alves, L. Miranda, and C. Morais among 6,300 undergraduate students found a positive correlation between students' access to virtual learning environments and their overall performance (Alves et al., 2017). The benefits of virtual education are yet to be realized in the Russian system of higher education.

Conclusion

The conducted research has allowed us to formulate the following conclusions.

1. Virtual classes are popular among students who have had previous positive experience of online learning during preparation for a unified state exam or enhancing foreign language competencies. At university, students tend to choose subjects directly connected with their field of study.
2. The leading motivation for students to engage in virtual classes is to save time on commuting, as well as to obtain innovative information not provided by traditional learning.
3. Our respondents identified both advantages and disadvantages of the virtual classroom model. The former include the freedom to choose the place of learning and the possibility to download materials for further revision. The latter include the problem of study distractions, which decrease the overall quality of education.

We believe that the virtual classroom model will be developing on the basis of new technological advances in the field of artificial intelligence and virtual reality. Universities should support management structures that are responsible for promotion of online education among their own students and external learners. In the long run, this will promote universities' positions in a global educational market.

Further research should be aimed at comparing the efficiency of various virtual education models, identifying criteria for assessing the quality of online courses, developing a system of motivators to support interest to virtual educational programmes, including those by "non-academic" educators (practitioners, business and public administration representatives, etc.).

Acknowledgement

This research was supported by the Ural Federal University. The authors express sincere gratitude to anonymous reviewers for their valuable comments and contribution.

References

Alves, P., Miranda, L. and Morais, C. (2017) 'The influence of virtual learning environments in students' performance', *Universal Journal of Educational Research*, vol. 5, no. 3, pp. 517-527. http://dx.doi.org/10.13189/ujer.2017.050325

Anekwe, J.U. (2017) 'Impacts of Virtual Classroom Learning On Students'of Nigerian Federal And State Universities', *European Journal of Research and Reflection in Educational Sciences,* vol. 5, no. 3, pp. 21-36.

Antonova, N., Shnai, I. and Kozlova, M. (2017) 'Flipped classroom in the higher education system: A pilot study in Finland and Russia', *New Educational Review*, vol. 48, no 2, pp. 17-27. http://dx.doi.org/10.15804/tner.2017.48.2.01

Bekele, T.A. (2010) 'Motivation and satisfaction in internet-supported learning environments: A review', *Educational Technology & Society, vol. 13, no.* 2, pp. 116-127.

Bell, J., Sawaya, S. and Cain W. (2014) 'Synchromodal classes: Designing for shared learning experiences between face-to-face and online students', *International Journal of Designs for Learning*, vol. 5, no. 1, pp. 68-82. http://dx.doi.org/10.14434/ijdl.v5il.12657

Bower, M., Dalgarno, B., Kennedy, G.E., Lee, M.J.W. and Kenney J. (2015) 'Design and implementation factors in blended synchronous learning environments: Outcomes from a cross-case analysis', *Computers & Education,* vol. 86, pp. 1-17. http://dx.doi.org/10.1016/j.compedu.2015.03.006

Bystrova, T., Larionova, V., Sinitsyn, E. and Tolmachev, A. (2018) 'Learning Analytics in Massive Open Online Courses as a Tool for Predicting Learner Performance' *Educational Studies Moscow*, vol. 4, pp. 139-166. http://dx.doi.org/10.17323/1814-9545-2018-4-139-166

Cain, W. (2015) *Technology navigators: An innovative role in pedagogy, design and instructional support*. In: Redmond, P., Lock, J., Danaher, P.A. (eds) *Educational Innovations and Contemporary Technologies*. Palgrave Macmillan, London, pp. 21-35.

Cakiroglu, U. (2014) 'Evaluating students' perspectives about virtual classrooms with regard to Seven principles of good practice', *South African Journal of Education*, vol. 34, no. 2, pp. 1-19.

Danesh, A., Bailey, A. and Whisenand, T. (2015) 'Technology and Instructor-Interface Interaction in Distance Education', *International Journal of Business and Social Science,* vol. 6, no. 2, pp. 39-47.

Dietz-Uhler, B., Fisher, A. and Han, A. (2007) 'Designing online courses to promote student retention', *Journal of Educational Technology Systems,* vol. 36, no. 1, pp. 105-112. http://dx.doi.org/10.2190/ET.36.1.g

Keller, J.M. (2008) 'First principles of motivation to learn and e3-learning', *Distance Education,* vol. 29, no. 2, pp. 175-185. http://dx.doi.org/10.1080/01587910802154970

Lakhal S., Bateman D. and Bedard J. (2017) 'Blended synchronous delivery mode in graduate programs: A literature review and its implementation in the master teacher program', *Collected Essays on Learning and Teaching,* vol. 10, pp. 47-60. http://dx.doi.org/10.22329/celt.v10i0.4747

Lightner, C.A. and Lightner-Laws, C.A. (2016) 'A blended model: Simultaneously teaching a quantitative course traditionally, online, and remotely', *Interactive Learning Environments*, vol. 24, no 1, pp. 224-238. http://dx.doi.org/10.1080/10494820.2013.841262

Marshall, S.J. (2018). *Shaping the university of the future: Using technology to catalyse change in university learning and teaching.* Singapore: Springer.

McBrien, L., Jones, P. and Cheng, R. (2009) 'Virtual Spaces: Employing a Synchronous Online Classroom to Facilitate Student Engagement in Online Learning', *The International Review of Research in Open and Distributed Learning,* vol. 10, no. 3, pp. 1-11. http://dx.doi.org/10.19173/irrodl.v10i3.605

Ramsey, D., Evans, J. and Levy, M. (2016) 'Preserving the seminar experience', *Journal of Political Science Education*, vol. 12, no. 3, pp. 256-267. http://dx.doi.org/10.1080/15512169.2015.1077713
Schullo, S., Hilbelink, A., Venable, M. and Barron, A.E. (2007) 'Selecting a virtual classroom system: Elluminate live vs. Macromedia breeze (adobe acrobat connect professional)', *Merlot: Journal of Online Teaching and Learning,* vol. 3, no. 4, pp. 331-345.
Stupnisky, R.B. and Butz, N.T. (2016) 'A mixed methods study of graduate students' self-determined motivation in synchronous hybrid learning environments', *The Internet and Higher Education*, vol. 28, no. 2016, pp. 85-95. http://dx.doi.org/10.1016/J.IHEDUC.2015.10.003
Wang, Q., Quek, C.L. and Hu, X. (2017) 'Designing and improving a blended synchronous learning environment: An educational design research', *International Review of Research in Open and Distance Learning*, vol. 18, no. 3, pp. 99-118. http://dx.doi.org/10.19173/irrodl.v18i3.3034
Xenos, M. (2018) *The Future of Virtual Classroom: Using Existing Features to Move Beyond Traditional Classroom Limitations*. In: Auer M. and Tsiatsos, T. (eds) *Interactive Mobile Communication Technologies and Learning*, IMCL 2017. Advances in Intelligent Systems and Computing, vol. 725. Springer, Cham. pp. 944-951.
Xie, K., Durrington, V. and Yen, L.L. (2011) 'Relationship between students' motivation and their participation in asynchronous online discussions', *Merlot: Journal of Online Teaching and Learning, vol. 7, no.* 1, pp. 17-29.
Zydney, J.M., McKimm, P., Lindberg, R. and Schmidt, M. (2019) 'Here or there instruction: Lessons learned in implementing innovative approaches to blended synchronous learning', *TechTrends*, vol. 63, pp. 123-132. http://dx.doi.org/10.1007/s11528-018-0344-z

BENEFITS OF THE USE OF THE EXPERIMENTAL METHOD IN TEACHING HIGH SCHOOL MATHEMATICS

Karel Antoš

Institute of Technology and Business in České Budějovice, Czech Republic, antos.vste@seznam.cz

Abstract

The article aims to support studies dealing with the benefits of using the heuristic methods in teaching mathematics at secondary schools. The paper presents a study conducted with secondary school students, the aim of which was to compare two approaches in mathematics teaching, teaching by using scientific-research method to classical teaching. The research questions were whether the experimental method of teaching can improve the relationship of the students to mathematics and their ability to solve problems compared with the students who were taught classically. The experiment was conducted in the secondary school with 16 years old students. The results were evaluated by standardized statistical methods. The results of the experiment were discussed in comparison with the results of similarly focused researches. The discussion of the possibilities of using the experimental method in mathematical lessons is carried here, too.

Keywords

Experiment, heuristics, hypothesis, research, result, statistics

Introduction

Modern methods of teaching mathematics have an important aim which is how to improve mathematics teaching so that pupils achieve better results, improve their attitudes towards mathematics and adopt some skills which would be useful in other areas of life. One of the ways to do this, is to find teaching methods which would make pupils to be more involved in lessons and which would make them to participate more in the teaching process. These teaching methods, using the participation of pupils in teaching, are collectively referred to as heuristic teaching methods, as described, for example, by Polya (1981). Teaching methods that make the pupil more active and involved in teaching are referred to as constructivist teaching methods.

Teaching methods based on constructivist principles differ among themselves according to the degree of pupils‘ involvement in teaching, as Zieleniecová (2012) writes. Zieleniecová (2012) considers the scientific-research method to be the method with the greatest degree of pupil independence. Scientific research methods include the experimental method, which is the method that belongs into the scientific-research methods and is described in this article.

As a compromise between the scientific-research method, where the pupil solves the problem task entirely by himself and by the transmissive method, when only the teacher is involved in the teaching, is the experimental method. According to Schoenfeld (1985), the experimental method uses constructivist approaches to problem-solving teaching. Polya (1945) was the first who described the stages of problem solving.

Kopka (2013) specifies the experimental method as a scientific research method in which experimentation is used for solving problems. The scheme of the problem solving process according to Kopka (2013) looks like this: given problem - experimentation - hypothesis - hypothesis verification - hypothesis proof - correct answer. Because experimentation begins with the entire problem-solving process, this approach to problem-solving is called an experimental approach. We must always perform enough experiments to make a hypothesis. Kopka (2013)

describes the experimental method of teaching as a method based on a research approach, in which we seek a mathematically purposeful and systematic approach to finding a solution to the problem. Kopka (2013) further reminds that experimentation can be systematic (often in algebra or arithmetic) or unsystematic (eg in geometry).
Schoenfeld (1985) describes the experimental method as the „most scientific“ method of teaching. He defines it as a problem solving method which is based on experimenting with the problem. He sees the difference from other scientific methods that in solving a problem by using experimenting, we check the situation where we are purposefully changing any variable to find a solution to the problem.
As Molnár et al. (2007) describes, the transmissive approach to teaching consists in the fact that teaching is the transfer of final knowledge from the teacher to the students. Teaching here is a passive reception of information. In transmissively guided teaching, the teacher tries to pass on already finished knowledge to the pupils, because it is the easiest and fastest way to acquire knowledge.

Current research results

Polya (1945) states that solving problems in school mathematics can improve the school results of pupils and explaines that the solution of the problem can be divided into four basic phases: 1. understanding the problem, 2. proposing a solution plan, 3. executing a planned solution, and 4. verifying the result.
Yuan (2013) claims that teaching through an experimental method increases the ability of students to solve problems more than classical teaching.
Stein et al. (2003) describes the research which showed that students who learned by experimental method of teaching were later more successful in solving new problems and in future they were more flexible in selecting appropriate strategies than students who were taught clasically.
The authors of pedagogical research Čadež and Kolar (2015) focused on how the individual learns to solve problems. Research results have shown that teaching students by using an experimental method helped them to develop research schemes and they then used them to solve new problems. The results also showed that teaching through an experimental method improves students‘ ability to solve problems.
In the teaching experiment conducted by Steel and Johanning (2004) students were introduced to various problem-solving strategies. The results of the research have shown that mathematical education through the experimental method develops algebraic thinking of students and the ability to solve problems.
The research aimed to assess the influence of teaching led by the experimental method of teaching on the relationship of pupils to mathematics was performed by Doulík et al. (2016). The results of the research confirmed that the pupils of the experimental group changed their relationship to mathematics more positively than the pupils of the comparative group.
Improving the relationship of pupils to mathematics is described by Schukajlow et al. (2011), based on the results of the project in which the problem-solving method was taught.
Eisenmann et al. (2015) conducted research which had to show how students can learn mathematics through selected heuristic strategies. The research took place at four Czech schools with a total of 62 pupils, for 16 months. The two of the strategies examined were experimental. The research showed that it was possible to teach them to pupils and then they were more successful in solving the new tasks.
In the research conducted by Doulík et al. (2016), one of the aims was to verify the hypothesis that teaching using an experimental method will improve students‘ relationship to mathematics. The research took place over a long period of time, between 2012 and 2014. At the beginning

of the research, there were selected 20 pupils aged 16, who were taught using the experimental method, and the pupils who formed the comparative group were taught classically. The findings of the research confirmed that the students of the experimental group changed their relationship to mathematics more positively than the students of the comparison group.
An interesting research was carried out by Ersoy (2016) with 3rd year students of the pedagogical faculty at Samsun Ondokuz Mayıs University Turkey. Pupils were taught for 13 weeks using the experimental method. The research sought to answer a number of research questions. First, they tried to verify whether the experimental method would improve students‘ relationship to mathematics. At the end of the research, two thirds of the pupils had an improvement in their relationship to mathematics, mathematical skills and thinking.
The research also sought to answer the question of whether experimental teaching will improve students‘ ability to solve problems. The results of the research showed an improvement in half of the monitored pupils in choosing the right problem solving strategy and in a third of the pupils finding the right solution to the problem.

Research objective

The aim of the research was to verify how the experimental teaching method can influence the pupil‘s relationship to mathematics and pupil´s ability to solve problems. The conducted research study was based on systematic application of experimental method of teaching in mathematics classes at secondary school. Based on the theoretical analysis of the problemacy and the results of other studies focused on this area were stated research questions.

1. Does the teaching of experimental methods significantly improve pupils‘ relationship to mathematics compared to classical teaching of mathematics?
2. Does the teaching of experimental methods significantly improve pupils‘ ability to solve problems compared to classical teaching of mathematics?

Based on proclaimed research questions, the following working hypotheses were formulated.
H_1: After teaching led by the experimental method, it is assumed that pupils in the experimental class will improve their relationship to mathematics more than pupils in the comparative class.
H_2: After teaching led by the experimental method, it is assumed that pupils in the experimental class will improve their problem solving skills more than pupils in the comparative class.

Materials and Methods

To answer the research questions and verify the formulated hypothesis, a pedagogical experiment was chosen as a suitable method. As a method for data collection, a questionnaire and a test were selected.
For the pedagogical experiment, two groups of students were selected, one experimental for experimental teaching, and the other comparative, in which the classical teaching was used. In the experimental class there were 18 pupils, of which 1 girl, aged 17 years. In the comparison class there were 28 pupils, all boys. The experiment took place at the secondary school in Tábor during the school year 2017/18.
The questionnaire was a standardized questionnaire created for questionnaire surveys at different types of schools. There were three sections of the questions in the questionnaire, 1. The relationship to subject of mathematics. 2. The relationship to teaching mathematics. 3. The relationship to teaching to all school subjects. Questionnaire evaluation was done for each area separately. The problem solving test was prepared according the level and study of students.
MS Excel and Statistical Program R were used for data processing. To compare the results of the same class before and after the experiment, we used a pair test. To compare the average results of the experimental and comparative classes to each other, we used the unpaired two-sample Student Test (*t*-test).

Results and Discussion

The main indicator of the change in student performance in the pre-post period was the change in means using numerical characteristics. We compared the results of one and the same class before and after the experiment, and we compared the results of both classes. Then we verified whether the change was significant or not. We compared the *p*-value with the significance level $\alpha = 0.05$. According to the significance of the change, the working hypothesis was accepted or refused. The null hypothesis H_0 says that the final results will not change significantly, against the alternative hypothesis H_A, which says that the final results will increase significantly compared the initial results.

Results of the questionnaire data

The evaluation of the questionnaire results was carried out separately for each area and in both classes, in the experimental class and in the comparative class. We followed the methodology of statistical testing described for example by Chráska (2016).

First, we had to verify the normality of the data by Shapir - Wilk test in the statistical program R. We tested beginning and final data of both classes. We performed the verification using a *p*-value. If this value is higher than the significance level 0.05, the null hypothesis H_0 holds and the data are of the normall distribution. Then we can use a parametric test to verify the working hypothesis. If the *p*-value is lower than the significance level 0.05, the null hypothesis is refused in favor of the alternative hypothesis H_A and a non-parametric test must be used to verify the working hypothesis.

Test results: The normality of the data was proven in all areas in the experimental class, in the comparative class the data did not have normal distribution in the beginning in the area of the attitude to mathematics and at the final data in the area of teaching to all subjects. The nonparametric Wilcoxon test had to be used here for comparison. In other cases, two-sample *t*-test was used to analyze the results.

Then we compared the results of one and the same class before and after the experiment, and we compared the results of both classes. The main indicator of the change in student performance in the pre-post period was the change in means using numerical characteristics. Statistically, it was then necessary to verify whether the change was significant or not. Based on the demonstration of the significance of the change, the working hypothesis was adopted or rejected.

According to standardized statistical methods, as described for example by Chráska (2016), we first pronounced null and alternative hypothesis for evaluating the significance of the difference between initial and final results.

The null hypothesis H_0 says that the final results do not change significantly, against the alternative hypothesis H_A, which says that the final results will increase significantly compared to the initial results. We used this procedure in all areas and in both classes.

According to Chráska (2016), we compared the *p*-value with the significance level α (error α). We then formulated the following conclusions:

1. If the *p*-value is greater than the 0.05 level of significance, then there is the statistically insignificant difference between the compared sets and the null hypothesis H_0 cannot be refused, ie. $H_0 : x_K - x_P = 0$, where x_K are the final mean values and x_P are the initial mean values.
2. If the *p*-value is less than 0.05 level of significance, we refuse the null hypothesis H_0 and adopt the alternatice hypothesis H_A. Then there is statistically significant difference between the files being compared, ie. $H_0 : x_K - x_P \neq 0$, where x_K are the final mean values and x_P are the initial mean values.

Summary of results of pupils' attitudes to mathematics in experimental class

Mean of results: pre-test $x_P = 1.36$, post-test $x_K = 1.47$, p-value = 0.4404 (> 0.05). Since the p-value was greater than the 0.05 significance level, the null hypothesis was not refused. Since the p-value was greater than the 0.05 significance level, there was no significant improvement in the results. Improvement of the final results of the experimental class compared to the starting results was not statistically significant in this area.

Summary of results of pupils' attitudes to mathematics in comparative class

Mean of results: pre-test $x_P = 2.44$, post-test $x_K = 2.29$, p-value = 0.3052 (> 0.05). Since the p-value was greater than the 0.05 significance level, the null hypothesis was not refused. The decrease in final results was not significant. The worse results of students attitudes to mathematics was reduced, but not significantly.

Summary of results of pupils' attitudes to teaching mathematics in experimental class

Mean of results: pre-test $x_P = 9.79$, post-test $x_K = 8.37$, p-value = 0.2197 (> 0.05). Since the p-value was greater than the 0.05 significance level, the null hypothesis was not refused. Final test results decreased but not significantly in experimental class. This means that students' attitudes towards the mathematics as a subject got worse, but not significantly.

Summary of results of pupils' attitudes to teaching mathematics in comparative class

Mean of results: pre-test $x_P = 8.11$, post-test $x_K = 5.92$, p-value = 0.1225 (> 0.05). Since the p-value was greater than the 0.05 significance level, the null hypothesis was not refused. Final test results decreased but not significantly in comparative class. This means that students' attitudes towards the mathematics as a subject got worse, but not significantly.

Summary of results of pupils' attitudes to teaching all subjects in experimental class

Mean of results: pre-test $x_P = 43$, post-test $x_K = 47.1$, p-value = 0.09835 (> 0.05). Since the p-value was greater than the 0.05 significance level, the null hypothesis was not refused. The increase in mean of experimental class results was not statistically significant. The experimental class attitudes have improved but not significantly. But at p-value we see that if we chose a 10% level of significance, the increase would already be significant.

Summary of results of pupils' attitudes to teaching all subjects in the comparative class

Mean of results: pre-test $x_P = 48.2$, post-test $x_K = 53.7$, p-value = 0.047 (< 0.05). Since the p-value is less than 0.05, the null hypothesis is refused in favor of an alternative hypothesis. Wilcoxon right-hand paired-samples test has shown the significance of increase in mean in comparative class. In the comparative class, the students' relationship to all subjects was significantly improved. Since p-value was only slightly below the significance level of 0.05, the significance of the increase should be taken with caution.

The results of all areas of the questionnaire clearly show that the experimental class did not achieve any significant improvement in final results compared to starting results. The alternative hypothesis H_A has not been verified in any area.

Validation of H_1 hypothesis

Based on all the previous findings, it was concluded that the attitudes to mathematics of the experimental class pupils did not improve significantly after experimental teaching, compared to

those of the comparative class. Therefore, the validity of the H_1 research hypothesis has not been proven.

Discussion on results of the questionnaire

It has not been proven that experimental class pupils achieved better attitudes towards mathematics than the comparative class pupils after the end of the experiment. As a whole, the experimental class did not have significantly better results than at the beginning, as we expected before the experiment began. We can say that experimental teaching did not bring any change in the pupils' attitudes towards mathematics.

Conclusions of Doulík et al. (2016) did not confirm the results of my research. The reasons may be different.

The difference is in the length of the research of Doulík et al. (2016) and mine, because my research lasted less than one school year, and Doulík´s research lasted for 2 years. The difference is in the quality of the pupils. He followed the grammar school students, where it can be assumed that they are better-level students then the students that I followed because they were mostly preparing for practical work. In my opinion, the reasons of different results my research were both in lower-level students and of the fact that my research lasted too short.

Research of Schukajlow et al. (2011) has shown that students had more positive attitudes towards mathematics after the end of the project. I cannot confirm the results of this research with my work, but it may also have played a role that the period of his research was longer than my research, or that his experimental group had a larger number of pupils than mine.

Pupils in the experimental class had improved attitudes in the areas studied, but the significance of these improvements was not verified.

Improvements in results were not significant and cannot be assessed as a result of teaching conducted by an experimental method. Pupils of the comparative class also improved their results, but this class was not evaluated.

There were no significant changes in pupils' attitudes towards mathematics. The duration of experimental teaching was too short to change the attitudes, especially when attitudes are more stable than, for example, basic school pupils. In addition, a number of pupils in the experimental class have received a negative attitude towards mathematics and its teaching at lower levels of education. It is always easier to create a new relationship than to change the existing negative attitude.

Comparison of the final and beginning experimental class results did not bring the expected result that the pupils would change their attitudes to mathematics significantly after the end of the experiment.

There were no significant changes in the attitudes of students to mathematics. This is not surprising for the attitudes we have been talking about here. The duration of the experimental teaching was too short for changing the attitudes, especially in a situation when attitudes are already more stable than, for example, in primary school pupils. In addition, many pupils in the experimental class gained a negative attitude towards mathematics and its teaching at lower levels of education. It is always easier to create a relationship than to change an already established negative attitude.

We can base this statement on the psychological literature, as described, for example, by Nakonečný (2009), who says that it is always easier to create a relationship than to change an already established negative attitude. Nakonečný (2009, p. 268) distinguishes two types of changes in attitudes, as homogeneous changes (congruent), which relate to the strengthening of a positive or negative attitude, or as inconsistent changes (incongruent), where a certain degree of positive attitude changes to a certain degree of negative attitude. It is more likely to weaken or strengthen a certain attitude, either towards a positive or negative attitude.

Statistical results of the problem solving test

The results of the paired tests were the basis for the final verification of the significance of the change in mean of the initial and final results. We first pronounced a null and alternative hypothesis for evaluating the significance of the difference between initial and final results.

First, we had to verify the normality of the data by the Shapir - Wilk test in statistical program R. We performed the verification of the beginning and final data of both classes using a *p*-value. If this value is higher than the significance level of 0.05, the null hypothesis H_0 holds and the data are of the normall distribution. Then we can use a parametric test to verify the working hypothesis. If the *p*-value is lower than the significance level of 0.05, the null hypothesis is refused in favor of the alternative hypothesis H_A and a non-parametric test must be used to verify the working hypothesis. Test results showed that the data are of the normall distribution in all areas in the both class, so we could use the two-sample *t*-tests to analyze the results.

When comparing the means of the results of the experimental and comparison classes, we already work with independent selections. We therefore used an unpaired two-sample Student's *t*-test. We used this test twice, before and after the experiment. Before using it, we verified that the variances are the same in both groups. For this we used Fisher's - Snedecor test (F-test).

The results of the F-test showed that the data in both groups had approximately the same variance. In the Student's test, we again formulated the null and the alternative hypothesis to evaluate the significance of the difference between the means of the results in the experimental and comparative classes.

1. The null hypothesis says that the means of results in both classes will be the same, ie. $H_A : x_E - x_S = 0$, where x_E are the final mean values of the experimental class and x_P are the initial mean values of the comparative class.
2. The alternative hypothesis says that the means of results in the experimental class will be significantly higher than in the comparative class, ie. $H_0 : x_E - x_S = 0$, where x_E are the final mean values of the experimental class and x_P are the initial mean values of the comparative class.

Summary of results of the problem solving test in experimental class

Mean of results: pre-test $x_P = 19.1$, post-test $x_K = 22.4$, *p*-value = 0.0181 (< 0.05). Since the *p*-value is less than 0.05, the null hypothesis is refused and an alternative hypothesis is accepted. The mean of results of problem solving test has increased significantly (from 19,2 to 22,5). The paired test showed the significance of this increase at 5% significance level.

Also interesting is the standard deviation indicator. The data variability was 6,5 in the beginning and 2,5 in the final test. It shows that the majority of the pupils had better and similar results in the final test than at the beginning. In fact, the pupils learned better how to solve problems at the end of the experiment compared to the beginnig.

Summary of results of the problem solving test in comparative class

Mean of results: pre-test $x_P = 17.3$, post-test $x_K = 20.5$, *p*-value = 0.9968 (> 0.05). Since the p-value is greater than 0.05, the null hypothesis is not rejected. The paired test did not show the significance of improving final results compared to beginning results at a 5% significance level.

Validation of H_2 hypothesis

Based on all previous results, it was concluded that the problem solving abilities of pupils in the experimental class significantly increased compared to the results of the comparative class. The research hypothesis H_2 proved to be valid.

Discussion on results of the problem solving test

The problem-solving test results showed that, in the experimental class, the results of the problem solving abilities at the end of the experiment significantly improved. In the final test, the pupils were able to find far more successful solutions to the tasks which they could not solve at the beginning. The results of the post-test significantly improved compared to the pre-test. With the paired test it was verified that the results increased significantly at the end of the experiment. This was one of the aims of the research. The experiment confirmed the validity of the hypothesis HO2. The conclusions of Čadež and Kolar (2015) that teaching through the experimental method will improve pupils‘ problem-solving skills are in line with the results of this research. The results of this work also support the results of Čadež and Kolar (2015) that experimental teaching will improve pupils‘ ability to solve problems.

These conclusions of Čadež and Kolar (2015) are consistent with my results, but it is important to point out that their research involved significantly older pupils preparing for the teaching profession, and therefore far more motivated to learn new things.

Similar research has been described by Stein et al. (2003), in which they taught similarly old students using an experimental method for three years. They studied experimentally at one school and classically at another. The results showed that students who worked with the experimental method in the experiment were later more successful in solving new problems and more flexible in choosing appropriate strategies for solving problems. These results are relatively in line with my results, only my research was shorter, and tasted less than one school year.

The conclusions of my research are in line with the conclusions of Eisenmann et al. (2015). This research took place in the same school environment, with similarly mentally advanced pupils, in a similar school teaching system, with similar school curricula, classifications, etc. The differense of the research of Eisenmann et al. (2015) is, that it lasted longer period of time and with more pupils. My research took place for a shorter time and with fewer students. Conclusion is that I can agree with their results and my research confirms them.

Experimental class students were able to explore the new problem, to work with it, even though they might not find the final solution. Students of the comparative class did not start to solve the new problem, very often. The difference between the experimental and comparative classes at the end of the experiment showed that the experimental class pupils were able to use the problem-solving experience to solve a new problem, were able to use new approaches to discover it and were able to discover any new knowledge to learn. The experimental class students actively participated in the teaching process.

The experimental method was purposefully taught in the experimental classroom, the students solved problems and tasks using this method, the teacher helped them appropriately, corrected them. Pupils saw that if they could find a solution in a certain way and achieve the goal that the next time they could use this method and procedure again, they could find a general solution and discover some mathematical rule. In the end, in the output test, they were able to find solutions to problems that they could not solve at first much more successfully. This significantly improved the results of the output test compared to the input test. This was shown by the numerical characteristics performed by the statistical program R. The results increased significantly at the end of the experiment. That was one of the goals of the research. The experiment confirmed the validity of hypothesis H_2.

Pupils in the experimental class were able to investigate a new problem and experiment with it, even though they did not find a final solution in the end. Pupils in the comparison class did not even know how to know the problem. Here, the difference between the two groups of students was that at the end of the experiment, the students of the experimental class were able to use the

experience of solving problems given to them during experimental teaching, were able to come up with new procedures and partially discover new ones using previous knowledge and experience. knowledge to be learned. They actively participated in the teaching process.
This method is definitely motivating, involving students in lessons and teaching them creativity. As the teacher of the experimental classes noted: "I would definitely recommend teaching this method, because it involves students more in the class than if they just passively watched the lecturer. It forces students to think more, because if they do not come up with the problem, they are not able to continue with the follow-up material. As with any method, this method must not be exaggerated, as this method could overwhelm students over time. It is therefore necessary to alternate different approaches in individual lessons. Of course, it also depends on the topic discussed."

Conclusions

The results of the experiment have shown that the experimental method is beneficial for the teaching of mathematics because the results of the experimental class pupils have improved.
Certainly in some areas of mathematics, such as functions or algebra, this method can be successfully used, but in many areas of mathematics, such as sets or complex numbers, classical teaching is preferable.
Definitely, this method is motivational, involving pupils in lessons and teaching them creativity. As the experimental class teacher noted that he would definitely recommend teaching this method, as it involves pupils more in the lesson than if they were only passively watching the lecturer. It makes pupils think more. It is therefore necessary to alternate different approaches in each lesson. It also depends on the topic.
For further research in this area, I would recommend that they follow up on this research and be targeted at pupils in vocational secondary schools. Research focused on the use of scientific research methods in the teaching mathematics has not yet been carried out in secondary schools, I have not encountered similar research.
The use of the experimental method in teaching is primarily a matter of the teacher, his willingness to lead teaching differently, the method to identify and prepare appropriate problems for teaching by this method. Therefore, it is necessary to systematically prepare future teachers to work with this method during their studies at the faculties of education.

References

Čadež, T.H. and Kolar, V.M. (2015) 'Comparison of types of generalizations and problem-solving schemas used to solve a mathematical problem', *Educational Studies in Mathematics*, vol. 89, no. 2, pp. 283–306. http://dx.doi.org/10.1007/s10649-015-9598-y
Doulík, P., Eisenmann, P., Přibyl, J. and Škoda, J. (2016) 'Unconventional Ways of Solving Problems in Mathematics Classes', *The New Educational Review*, vol. 43, no. 1, pp. 53 – 67.
Eisenmann, P., Novotná, J., Přibyl, J. and Břehovský, J. (2015) 'The development of a culture of problem solving with secondary pupils through heuristic strategies', *Mathematics Education Research Journal*, vol. 27, pp. 535–562.
Ersoy, E. (2016) 'Problem solving and its teaching in mathematics', *The Online Journal of New Horizons in Education*, vol. 6, no. 2, pp. 79-86.
Chráska, M. (2016) *Metody pedagogického výzkumu: Základy kvantitativního výzkumu*. Praha: Grada.
Kopka, J. (2013) *Umění řešit matematické problémy*. Ústí n. Labem: UJEP.
Molnár, J., Schubertová, S. and Vaněk, V. (2007) *Konstruktivismus ve vyučování matematice*. Olomouc: PřF UP.

Nakonečný, M. (2009*). Sociální psychologie*. Praha: Academia. 287p.
Polya, G. (1945) *How to solve it. Princeton*, NJ: Princeton University Press.
Polya, G. (1981) *Mathematical Discovery on Understanding Learning and Teaching Problem Solving*, NewYork: John Wiley and sons.
Schoenfeld, A. (1985) *Mathematical Problem Solving*, Orlando (FL): Academic Press.
Schukajlow, S., Leiss, D., Pekrun, R., Blum, W., Müller, M. and Messner, R. (2012) 'Teaching methods for modelling problems and pupils' task-specific enjoyment, value, interest and self-efficacy expectation', *Educational Studies in Mathematics*, vol. 79, pp. 215–237. http://dx.doi.org/10.1007/s10649-011-9341-2
Stein, K.M., Silver, E.A. and Boaler, J. (2003) 'Teaching mathematics through problem solving', *National Council of Teachers of Mathematics*, Editors: Harold Schoen. pp. 245-256.
Yuan, S. (2013) 'Incorporating Pólya's Problem Solving Method in Remedial Math', *Journal of Humanistic Mathematics*, vol. 3, no. 1, pp. 96-107. http://dx.doi.org/10.5642/jhummath.201301.08
Zieleniecová, P. (2012) 'Objevování ve škole - heuristická metoda výuky', *Doplňkový text k předmětu Pedagogika ve studiu učitelství na MFF UK*, [Online], Available: http://kdf.mff.cuni.cz/vyuka/pedagogika/dopl_texty/Heuristicka%20metoda%20vyuky.pdf [29 Jan 2020].

ORIGAMI-BASED INSTRUCTION IN THE HIGH SCHOOL MATHEMATICS CLASSROOM AND ITS IMPACT

[1]✉Libor Beldík, [2]Lucie Loukotová

[1]High School of Electrical Engineering Žatec, Czech Republic, beauduc@seznam.cz

[2]Department of Mathematics, Faculty of Science, Jan Evangelista Purkyně University in Ústí nad Labem, Czech Republic, lucie.loukotova@ujep.cz

Abstract

This research study examined the effect of Origami-based geometry instruction on creativity, spatial visualization and geometric thinking of high-school students in the Czech Republic. The sample (two groups of 15 students) was chosen from a second-grade population of a public high school. A quasi-experimental pre-test/post-test design was used in this study. The control group received regular instructions during geometry units in their classroom whereas the experimental group received Origami-based instructions for 5 months. The test assessing students' creativity, spatial visualization and geometric thinking were administered to both groups. The results suggested that Origami might be integrated into high school geometry lessons to make geometry learning more effective.

Keywords

Creativity, geometric thinking, high school geometry instruction, Origami, paper folding, spatial visualization

Introduction

Mathematics stands as an essential part of a child's education. Beyond the obvious everyday applications, mathematics is seen as a needed element in developing student readiness for the workforce demands of the 21st century. Geometry has considerable benefits and applications in real life. The fundamental skills such as reasoning, proving, problem solving, creative and innovative thinking can be developed by geometry learning (Aslan-Tutak and Arici, 2013). Origami or paper folding is not an uncommon practice in the mathematics classroom. From a cognitive perspective, Origami has connections to mathematics. The mathematics of Origami is a recent focus of study in mathematics (e.g. Hull, 2006) that has implications for teaching school mathematics. Origami is also recommended to enhance geometric reasoning and spatial visualization (e.g. Boakes, 2009a; 2009b; Aslan-Tutak and Arici, 2013). The use of manipulatives in geometry instruction may support students' understanding in geometry (Clements and Battista, 1992). Manipulatives may play an instrumental role in enhancing geometric reasoning skills of students by creating a suitable context that allows transition from empirical thinking to more abstract thinking. In this context, Origami, may be a useful tool to teach geometry. As another framework, the van Hiele (1986) model considers geometric thinking in a different way.

According to this theory, the development of the mathematical thought process, especially geometry, can be divided into five levels (Mason, 1998: 4-5):

- level 0: visualization (students can identify geometric forms and understand the differences between them),
- level 1: analysis (students start analysing and naming properties of geometric figures),
- level 2: abstraction (students perceive relationships between properties and figures),

- level 3: deduction (students can give deductive geometric proofs),
- level 4: rigor (students can work in axiomatic system).

Van Hiele thought geometric experience as an important part of the van Hiele model (van Hiele, 1986).

Guilford (1967) first proposed the concept of "divergent thinking". He thus associated divergent thinking with creativity, appointing it several characteristics (Guilford, 1967):

fluency (the total number of interpretable, meaningful, and relevant ideas generated in response to the stimulus), flexibility (the number of different categories of relevant responses),

originality (the statistical rarity of the responses), elaboration (the amount of detail in the responses), sensitivity and redefining (the change of sense).

Unfortunately, there is a very limited number of researches about Origami and creativity (e.g. Golan and Oberman, 2015; Pope and Tung, 2009). Thus, the purpose of the present research is to investigate the effect of Origami-based instruction on high school students' creativity, spatial visualization and geometric thinking skills.

Material and Methods

Research design

The quasi-experiment took place between September 2018 and January 2019. All participants in this study were students from a public high school in Žatec, Czech Republic. The sample was chosen from a second-grade population (two classrooms, 17 years). One of the selected classrooms was determined randomly as an experimental group and the other one as a control group. Both groups consisted of 15 students. Both groups were homogeneous (2 parallel classes of the same field of study, boys of the same age except for 1 girl). They also had similar study results (Table 1). None of the pupils had previous experience with Origami. Both classes participate in the Mathematical Kangaroo competition every year without any special results. None of the pupils participated in any other mathematical competition or event. None of the groups integrated physically or mentally disabled pupils or pupils from low socioeconomic status. All the pupils were native speakers of Czech.

Group	Mathematics *M (SD)*	Total *M (SD)*
Experimental	2.33 (1.05)	2.01 (0.50)
Control	2.40 (0.74)	2.09 (0.60)

M (SD) - mean (standard deviation)

Table 1: Average score of pupils for the previous school year (2017 – 2018) (source: own calculation)

The cognitive level of the experimental and control groups was judged on the basis of the results achieved in the pre-test of the individual components of creativity, spatial visualization, and geometric thinking (Table 2). The statistical analysis was performed by the software TIBCO Statistica 13. To control normal distribution of the samples the Kolmogorov-Smirnov test was used. In this case all the data have normal distribution. A two-sample unpaired t-test was used to compare both groups in terms of cognitive level. This and subsequent tests were performed at the significance level of $\alpha = .05$.

Test	Exper. group M (SD)	Control group M (SD)	Result
Creativity			
Fluency	8.42 (30.72)	8.42 (26.41)	t (14) = 2.06, p = 1.00
Flexibility	2.57 (0.73)	1.78 (0.44)	t (14) = 2.06, p =.01*
Originality	10.43 (52.41)	9.64 (30.09)	t (14) = 2.06, p =.75
Elaboration	11.50 (86.42)	9.57 (37.49)	t (14) = 2.06, p =.48
Spatial visualization	14.92 (15.61)	11.50 (13.50)	t (14) = 2.06, p =.03*
Geometric thinking	1.71 (0.53)	1.50 (0.42)	t (14) = 2.06, p =.41

** differences are significant, p <.05*

Table 2: Comparison of the pre-tests results, 2019, (source: own calculation)

The results show comparable input values of level for fluency, originality, elaboration, and geometric thinking for both groups; the experimental group was better in indicators of flexibility and spatial visualization. We can say that the groups did not differ in most of the monitored indicators.

A quasi-experimental pre-test/post-test design was used in this study. Prior to the start of the geometry unit, student participants (both groups) were given pre-tests for creativity, spatial visualization, and geometric thinking. Following this pre-test, the geometry unit began. Every week, for five months, both groups received their traditional instruction from their regular classroom teacher. Over the course of the unit the experimental group received Origami-mathematics lessons (one day a week for 45 minutes at a time), taught by one of the authors, in addition to the traditional instruction. Following the completion of the geometry unit, student participants completed the creativity, spatial visualization, and geometric thinking tests. At the same time, a written record of these lessons was kept, where significant moments (accomplishment or non-accomplishment of the task, unusual solution, etc.) were described and commented.

Instruments were selected to assess creativity, spatial visualization, and geometric thinking. To assess the participants' creativity, the Torrance Thinking Creative Test (TTCT-subtest The Circle Game) was used. TTCT is suitable for all age categories. It contains 36 circles on two pages. The task is to supplement or join circles to create as many interesting pictures as possible. No other clue is provided; it all depends only on the imagination of the tested person. TTCT was scored on four scales: fluency, flexibility, originality and elaboration. Although the assessment of this test is subjective, more original or sophisticated images can usually be distinguished (Honzíková, 2011).

To assess the spatial visualization ability, commercial test purchased by authors including spatial visualization (ability to mentally represent visual appearances of an object and spatial imagery), mental folding (ability to fold a 2D pattern or material into 3D objects), and mental rotation (ability to rotate 2-3 dimensional objects in space) was used. It is always a mental operation with objects in space or plane. One point is awarded for each correctly answered task; maximum is twenty-one points. Each task has only one correct solution.

To assess the geometric thinking, the test designed on the base of the Usiskin's test of geometric thinking to assess the van Hiele's levels was used (Golan, 2010). This test consists of 25 questions focused on school geometry with increasing difficulty, each with five questions on each level of geometric thinking according to van Hiele. There are five answers to each question, of which only one is correct. Student needs to answer correctly at least three of these 5 questions in order to upgrade his level. For information about tests see Table 3.

Test	Fluency	Flexibility	Originality	Elaboration	Spatial visualization	Geometric thinking
Max. score	unlimited	unlimited	unlimited	unlimited	21 points	25 points (5th level)

Table 3: Maximum test scores (source: own calculation)

Brief Anatomy of the lessons (short list of themes), inspired by Hull (2006):

1. Basic construction: square, rectangle, triangle
2. Equilateral triangle and trisection of an angle
3. Simple prisms, cube, triangular and square prism
4. Triangular and square pyramid
5. Regular hexagon and octagon
6. Pentagon, pentagonal prism and antiprism
7. Division of segments into parts by iteration, Euclidean unconstructible polygons
8. Prisms and antiprisms, whose top and bottom faces are Euclidean unconstructible polygons
9. Sonobe unit, more complicated solids
10. Simple fractals, Sierpinski tetrahedron

Three lessons were dedicated to each theme.
First lesson: students in the groups are challenged to make an existing Origami object by following the teacher's instructions. Working with an Origami model provides opportunities to use mathematical vocabulary correctly in a context that is meaningful and purposeful.
Second lesson: students in the groups are challenged to discover geometric properties of models. Examining the geometric properties of the creased paper can help to develop understanding about symmetry and fractions and naturally lead to a proof through the development of mathematical reasoning.
Third lesson: students in the groups are challenged to design shapes to have given properties. In contrast with students following the teacher's instructions, these activities allow students to think for themselves and to solve problems. Students can work at their own level. This activity can lead to the development of their creativity.
An abbreviated example of used origami-based activity:
First lesson: Folding Perfect Thirds
Take a square piece of paper. It is easy to fold the side of a square into halves, or fourths, or eights etc. But folding odd divisions like thirds, exactly is more difficult. The below procedure is one was to fold thirds. See Figure 1. The numbers indicate the folding order.

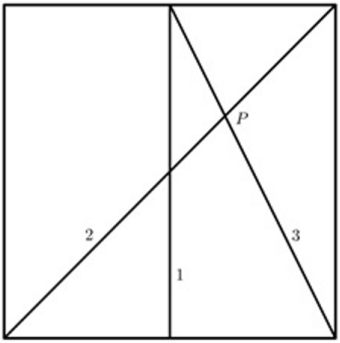


Figure 1: Folding Perfect Thirds (source: own)

Problems to solve:

a) What can we say about the coordinates of the point P?
b) Prove that the diagonal of the square is divided by the point P in the ratio $1:2$.
c) And the side of the square?

Second lesson: Construct the point P and second diagonal of the square (see Figure 2).

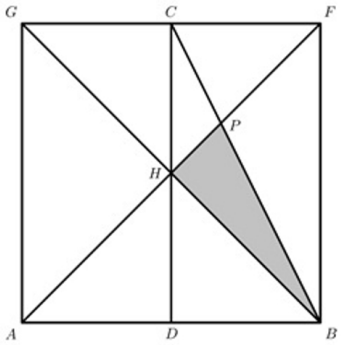


Figure 2: Geometric properties of triangles (source: own)

Problems to solve:

a) What can we say about the lengths of the sides of the triangle PHB ?
b) What can we say about the lengths of the sides of the triangles PFC and HPC ?

Third lesson: How could you generalize this method, say, to make perfect 5^{ths} or n^{ths} (for n odd)?

Research questions

The current study was guided by the following research questions:
1. Is there any significant difference in creativity, as assessed by the TTCT between pre-tests and post-tests by second-grade students who participate in Origami-based instruction?
2. Is there any significant difference in spatial visualization ability as assessed by the JobTestPrep (Spatial Reasoning Test), between pre-tests and post-tests by second-grade students who participate in Origami-based instruction?
3. Is there any significant difference in geometric thinking, as assessed by the Test of geometric thinking, between pre-tests and post-tests by second-grade students who participate in Origami-based instruction?

The following hypotheses can be formulated in accordance with the findings of the research activities:
H_1: Based on the results of the research conducted by M. Golan and J. Oberman (2015) and S. Pope and K.L. Tung (2009), we assume that pupils who are additionally taught geometry using Origami will show an improvement in the level of their creativity at the end of the reporting period compared to the level observed at the beginning of the monitored period.
H_2: Based on the results of the research conducted by N. Boakes (2009a, 2009b) and F. Aslan-Tutak & S. Arici (2013), we assume that pupils who have are taught geometry using Origami will show an improvement in the level of their spatial visualization at the end of the reporting period compared to the level observed at the beginning of the monitored period.
H3: Based on the results of the research conducted by F. Aslan-Tutak & S. Arici (2013), we assume that pupils who are additionally taught geometry using Origami will show an improvement in the level of their geometric thinking at the end of the period compared to the level observed at the beginning of the monitored period.

Results

Both groups (experimental and control) were tested before the beginning of the quasi-experiment and at the end of the quasi-experiment using tests of creativity (fluency, flexibility, originality,

elaboration), spatial visualization and geometric thinking. The evaluation of the quasi-experiment took place in two phases. First, the differences between the pre-test and post-test results within the experimental and control groups were tested. For this purpose, a two-sample paired mean value t-test was used. The results are shown in Table 4 and 5.

Test	Pre-test *M* (*SD*)	Post-test *M* (*SD*)	Result
Creativity			
Fluency	8.27 (28.92)	13.33 (47.38)	t (14) = 2.14, p =.005*
Flexibility	2.6 (0.69)	2.93 (1.21)	t (14) = 2.14, p =.27
Originality	10.13 (49.98)	16.53 (86.55)	t (14) = 2.14, p =.003*
Elaboration	11.27 (81.07)	15.93 (62.64)	t (14) = 2.14, p =.02*
Spatial visualization	15.27 (16.21)	16.07 (15.78)	t (14) = 2.14, p =.12
Geometric thinking	1.73 (0.49)	2.4 (0.92)	t (14) = 2.14, p =.003*

** improvement is significant, p <.05*

Table 4: Comparison of the pre- and post-tests results for experimental group, 2019 (source: own calculation)

Test	Pre-test *M* (*SD*)	Post-test *M* (*SD*)	Result
Creativity			
Fluency	8.20 (25.13)	9.80 (27.74)	t (14) = 2.14, p =.14
Flexibility	1.87 (0.95)	2.40 (0.97)	t (14) = 2.14, p =.01*
Originality	9.33 (29.38)	11.60 (44.69)	t (14) = 2.14, p =.17
Elaboration	9.67 (36.20)	12.46 (39.12)	t (14) = 2.14, p =.05*
Spatial visualization	11.25 (12.99)	11.92 (16.56)	t (14) = 2.14, p =.76
Geometric thinking	1.46 (0.41)	2.13 (0.41)	t (14) = 2.14, p =.003*

** improvement is significant, p <.05*

Table 5: Comparison of the pre- and post-tests results for control group, 2019 (source: own calculation)

The tables show that there were statistically significant improvements in four out of six tests (fluency, originality, elaboration, geometric thinking) in the experimental group and in half of the tests (flexibility, elaboration, geometric thinking) in the control group.

In the second phase, an unpaired two-sample t-test was performed, i.e. a comparison of the relative change of score between pre-tests and post-tests results, in both groups; the results are shown in Table 6.

Test	Exper. group *M* (*SD*)	Control group *M* (*SD*)	Result
Creativity			
Fluency	1.00 (1.95)	0.37 (0.60)	t (14) = 2.05, p =.14
Flexibility	0.23 (0.44)	0.36 (0.23)	t (14) = 2.05, p =.57
Originality	0.94 (1.30)	0.67 (1.27)	t (14) = 2.05, p =.31
Elaboration	0.91 (1.40)	0.65 (0.89)	t (14) = 2.05, p =.53
Spatial visualization	0.08 (0.04)	0.07 (0.08)	t (14) = 2.05, p =.99
Geometric thinking	0.42 (0.34)	0.63 (0.52)	t (14) = 2.05, p =.38

** improvement is significant, p <.05*

Table 6: Relative change of score between post-test and pre-test comparison, 2019 (source: own calculation)

Concerning the H_1 hypothesis: This hypothesis was partially confirmed for creativity indicators – fluency, originality, and elaboration, when the experimental group showed a significant improvement compared to the level observed at the beginning of the monitored period. In

flexibility, there was no significant improvement in the experimental group compared to the level observed at the beginning of the reporting period.
Concerning the H_2 hypothesis: This hypothesis was not confirmed. There was no significant improvement in the experimental group in terms of spatial imagination compared to that observed at the beginning of the monitored period.
Concerning the H_3 hypothesis: We can say that this hypothesis was confirmed. There was a significant improvement in the level of geometric thinking of the experimental group compared to that observed at the beginning of the monitored period.

Discussion

The aim of this study was to examine the claim that Origami is an effective teaching tool capable of strengthening students' creativity, geometric thinking, and spatial visualization.
In the case of creativity – fluency, originality, and elaboration – the results emphasized a significant change in the experimental group.
The results of this study concerning creativity were consistent with the studies that found a significant influence of Origami on creativity: Golan and Oberman (2015), Pope and Tung (2009).
The results concerning spatial visualization did not indicate significant improvement. But it is necessary to repeat that in the pre-test of spatial visualization, the results for both groups were outstanding. So, there was no space for improvement. The post-tests confirmed these results.
The studies of Boakes (2009a), Boakes (2009b), Aslan-Tutak and Arici (2013) indicate that Origami can be beneficial to students' spatial visualization.
The results concerning geometric thinking emphasized a significant change in the experimental group. The studies of Boakes (2009a), Boakes (2009b), Aslan-Tutak and Arici (2013), Golan (2010), and Frigerio and Spreafico (2015) indicate that Origami can be beneficial to students' geometric thinking.
Improvement of the experimental group may be related to additional Origami lessons in which the pupils have to intensively deal with the assigned task. Even when they work in pairs or in groups, they still have to look for a solution and imagine the result of the intended paper operation. The result of the work is an assembled model; pupils have to participate actively, and it is difficult to copy the procedure. This can affect creativity and geometric thinking. Except for spatial visualization, the group managed to slightly increase the number of points achieved in the post-test. On the one hand they had limited scope for improvement; on the other hand, a good level of spatial visualization helped them to solve specific problems and tasks.
The control group also showed some improvements, with math taught in the normal way, which brings improvement in motivated pupils. Creativity has improved in less important indicators: flexibility and elaboration. There was no improvement in achieved in spatial visualization; commonly taught geometry does not seem to have effective tools for this progress.
The resulting experience is that Origami-mathematics lessons can serve a teacher well as they seek to understand a students' disposition. Origami gives students the chance to see mathematics in another context. Through Origami, students can visualize certain geometric concepts (Golan, 2010). The importance of the statistical evaluation of this quasi-experiment and its results cannot be overestimated. Both sets are small (15 people in each group), while more plausible results would require larger sets. The results can be understood as indicative. They can also be interpreted as the assessment of how the experimental group could have developed if it had not been influenced by the Origami lessons and supplement them with lessons learned by observing the pupils in these lessons (qualitative assessment).

Conclusion

In all, the intent of this study was to determine the impact that Origami lessons integrated into a mathematics classroom would have on certain students' abilities. Based on the consideration of

the creativity, spatial visualization, and geometric thinking tests results, it can be said that Origami can be beneficial to students. So, the results of this study suggest that geometry teachers may use Origami in their lessons to develop students' creativity, spatial visualization, and geometric thinking.

Acknowledgement

This research was supported by The Students´ grant competition of Jan Evangelista Purkyne University (UJEP-SGS-2020-53-001-1).

References

Aslan-Tutak, F. and Arici, S. (2013) 'The Effect of Origami-based instruction on spatial visualizatiom, geometry achievement, and geometric reasoning', *International Journal of Science and Mathematics Education*, vol. 13, no. 1, pp. 179–200.

Boakes, N.J. (2009 a) 'Origami Instruction in the Middle School Mathematics Classroom: Its Impact on Spatial Visualization and Geometry Knowledge of Students', *RMLE Online: Research in Middle Level Education*, vol. 32, no. 7, pp. 1–12. http://dx.doi.org/10.1080/19404476.2009.11462060

Boakes, N.J. (2009b) 'The Impact of Origami-Mathematics Lessons on Achievement and Spatial Ability of Middle-School Students' in Lang R.J. (ed.) *Origami 4. Fourth International Meeting of Origami Science, Mathematics, and Education,* pp. 471-481. Wellesley, MA. AK Peters, Ltd. http://dx.doi.org/10.1201/b10653-46

Clements, D.H. and Battista, M.T. (1992) 'Geometry and spatial reasoning', In Grouws D.A. (ed.) *Handbook of research on mathematics teaching and learning: A project of the national council of teachers of mathematics*, pp. 420–464, Reston, VA. NCTM.

Frigerio, E. and Spreafico, M.L. (2015) 'Area and Optimization Problems' In Lang R.J. (ed.) *Origami 6. Sixth International Meeting of Origami Science, Mathematics, and Education,* pp. 679-687, Natick, MA. AK Peters, Ltd. http://dx.doi.org/10.1090/mbk/095.2/28

Golan, M. (2010) 'Origametria and the van Hiele Theory of Teaching Geometry', In Lang R.J. (ed.) *Origami 5. Fifth International Meeting of Origami Science, Mathematics, and Education,* pp. 141-150, Natick, MA. AK Peters, Ltd. http://dx.doi.org/10.1201/b10971-15

Golan, M. and Oberman, J. (2015) 'The Kindergarten Origametria Program', In Lang R.J.(ed.) *Origami 6. Sixth International Meeting of Origami Science, Mathematics, and Education,* pp. 669-678, Natick, MA. AK Peters, Ltd.

Guilford, J.P. (1967) *The Nature of Human Intelligence*, New York: McGraw-Hill Education.

Honzíková, J. (2011) 'Transverzální výzkum tvořivých schopností na základní škole, subjektivní předpoklady a objektivní podmínky rozvoje dětské tvořivosti', (Transversal research on creative skills in primary school, subjective prerequisites and objective conditions for the development of children's creativity), *Arnica*, vol. 1, no. 1, pp. 15–24.

Hull, T. (2006) *Project Origami: Activities for Exploring Mathematics,* Wellesley, MA. AK Peters, Ltd.

Mason, M. (1998) 'The van Hiele Levels of Geometric Understanding', In *Geometry*: *Explorations* and *Applications* (*Professional Handbook for Teachers*), McDougal Littell Inc.

Pope, S. and Tung, K.L. (2009) 'Using Origami to Promote Problem Solving, Creativity and Communication in Mathematics Education', In Lang R.J. (ed.) *Origami 4. Fourth International Meeting of Origami Science, Mathematics, and Education*, pp. 517-524, Wellesley, MA. AK Peters, Ltd. http://dx.doi.org/10.1201/b10653-50

van Hiele, P.M. (1986) *Structure and Insight. A theory of Mathematics Education*, Academic press Inc.

INFLATION AS PART OF PRICE LITERACY AND AWARENESS OF THE CONCEPT OF INFLATION AMONG UNIVERSITY STUDENTS

[1]✉Markéta Beranová, [2]Jan Šíma, [3]Miroslava Navrátilová

[1]Department of Trade and Accounting, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, mberanova@pef.czu.cz

[2]Faculty of Physical Education and Sport, Charles University, Czech Republic

[3]Department of Trade and Accounting, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

Price literacy plays an essential role in financial literacy. It includes knowledge necessary to understand price mechanisms and inflation. The objective of this paper is to examine, based on data collected from primary research, the awareness and understanding of inflation as a concept and also, the level of the inflation rate students from three selected universities in the Czech Republic are subject to. The primary research was conducted at three Czech universities with the participation of 1,437 respondents (n = 1 437). First, their understanding of the notion of inflation and its principles were investigated. This question was correctly answered by 57.48% (826) of respondents. The relation between the knowledge of the notion of inflation and the level of study and specialization of the faculty was obvious. Furthermore, respondents were asked if they knew the inflation rate. This question was answered correctly by 41.34% (594) of respondents.

Keywords

Finance, inflation, price literacy, student, university

Introduction

At present, many countries attach considerable importance to the financial literacy of the younger generation. This results in the gradual collection of relevant data which reflect the level of financial literacy of each group of inhabitants in order to find opportunities for improvement (Kubak et al., 2018). Financial literacy at universities, and its assessment performed directly within this segment of individuals, seems to still remain a marginal topic (Gerrans and Heaney, 2019; Philippas and Avdoulas, 2019). University students can be considered to be young adults who, during their studies or after graduation, embark on the productive part of their lives (de Bassa Scheresberg, 2013).

One of the reasons why people make inappropriate financial decisions is their financial illiteracy. These people lack the knowledge of simple economic relations, the ability to make basic calculations, and other skills which would enable them to make partial financial decisions in an optimal manner (Hastings and Mitchell, 2020). This idea has been further developed by Robb (2011) who provides evidence that financial education can improve the behaviour of the conscious use of financial resources, especially for young adults who are at the right age to develop skills that they will carry for life. Lusardi (2015) insists that financial literacy has become a skill that is essential for life and prosperity in advanced economies. According to Feng et al. (2019), the significance of the impact of the level of financial literacy on households is obvious as it affects the management of household finances, financial planning, and decision making.

Financial literacy as a notion refers to various domains of knowledge. Monetary literacy includes competences necessary to administer cash and non-cash monetary transactions and, moreover,

the administration of tools associated with them (e.g. current account, payment tools, etc.). Budget literacy represents the skills necessary to manage the personal/household budget (e.g. the ability to manage the budget, set financial goals, decide on the allocation of financial resources, and assess risks) (MF ČR, 2010). Price literacy includes skills necessary to understand price mechanisms and inflation. Knowledge of taxes can also be included as a separate part of financial literacy (Ječmínek et al., 2018).

Understanding of the concept of inflation is essential for price literacy. Mechanisms and impacts of inflation manifest themselves in everyday financial life – in the use of the current account, savings, etc. Rumler and Valderrama (2019) have even introduced a separate "inflation literacy" indicator within financial literacy.

The objective of this paper is to examine, based on data collected from primary research, the awareness and understanding of inflation as a concept and, also, the level of the inflation rate students from three selected universities in the Czech Republic are subject to.

The introduction of this paper includes a theoretical background of the examined issue. Section of materials and methods describes how primary data were analyzed and research was made. Section of results and discussion present results obtained, in discussion are compared final results of own research with similar studies of other authors on similar topics.

Materials and Methods

The theoretical framework of this article has been elaborated through the method of document research using scientific articles. Primary data were collected using a questionnaire survey. The questionnaire survey was conducted in 2018 and the data on printed questionnaires were manually transferred into an electronic format for further processing. The questionnaire included 32 questions. The respondents were full-time students at three selected universities in the Czech Republic focused, among other things, on agriculture, forestry, and veterinary science. These were the University of South Bohemia in České Budějovice (hereinafter referred to as USB), the Mendel University in Brno (hereinafter referred to as MEU), and the Czech University of Life Sciences in Prague (hereinafter referred to as CZU). At each university, the researchers approached both respondents studying at the faculties focused on economics (at USB this was the Faculty of Economics, at MEU it was the Faculty of Business and Economics, and at CZU it was the Faculty of Economics and Management) and respondents studying at faculties not specializing in economics (at USB this was the Faculty of Agriculture, at MEU it was the Faculty of Agri Sciences, and at CZU it was the Faculty of Environmental Sciences). In total, 1,437 respondents took part in the primary research. The sample was determined based on quota sampling and represented 14% of the total number of students at the selected faculties.

Basic sociodemographic factors of the reference group of respondents were as follows (at the same time, each of these characteristics stands for one investigated variable):

Gender	Female	57.48
	Male	42.52
Level of study	Bachelor s degree (BD)	66.32
	Master's degree (MD)	33.68
Field of study	Economic studies (ECO)	63.40
	Non-economic studies (NON-ECO)	33.60
University	USB	18.02
	CZU	59.29
	MEU	22.69

Table 1: Sociodemographic factors of respondents in % (source: own research, 2018)

Statistical tools for analysis

The contingency table is usedit for transparent visualization of mutual relations of two statistical variables. The type of the contingency table is given by the number of rows r and the number of columns s, it means $r \times s$ (Hindls, 2007). Obviously, χ^2 is a measure of the overall dissimilarity of n_{ij} and m_{ij}. The greater the difference between the observed and the expected values, the higher the test statistic χ^2.

$$m_{ij} = \frac{n_i \cdot n_j}{n} \tag{1}$$

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{s} (n_{ij} - m_{ij})^2 / m_{ij} \tag{2}$$

i and j are indices of rows and columns, n_{ij} are observed frequencies, ni and nj are marginal totals, n is grand total of observations, m_{ij} are expected frequencies. We compare χ^2 to the critical value χ^2 with a chi-square distribution of (r-1) (s-1) degrees of freedom at the chosen level of significance (α = 5%). We reject the hypothesis if χ^2 is larger than the table value. This test is valid asymptotically and, thus, can only be applied if there are enough observations. All expected values ought to be higher than one (Hendl, 2009); at the same time, the table should not contain more than 20% of theoretical incidence rates (frequencies) of less than 5. Where zero values occur in any of the fields, we proceed to analyse a derived table, created by merging a small number of categories (Hendl, 2009). Cramer's V was used to determine the degree of association between the variables. Additionally, the method of adjusted residuals was applied. The calculation of adjusted residuals indicated precisely the location of the dependency. The results of adjusted residuals are included in the tables for zero hypotheses. The principle of adjusted residuals is based on comparing the values in the cells of the contingency table with the critical value of 2 (or 1.96). The comparison was performed and, considering that wherever the value in a cell equals or exceeds 2 (-2) a statistically significant difference exists, the dependency was confirmed. This method was enhanced by the sign scheme. Information on where the assumption of independence of both the compared characteristics was violated could be obtained through this method.

The data analysis was focused on the following tested hypotheses.

- $H0_1$: Adequate description of the notion of inflation is independent of gender.
- $H0_2$: Adequate description of the notion of inflation is independent of the university.
- $H0_3$: Adequate description of the notion of inflation is independent of the specialization of the faculty.
- $H0_4$: Adequate description of the notion of inflation is independent of the level of study.
- $H0_5$: Knowledge of the inflation rate in the CR in 2017 is independent of gender.
- $H0_6$: Knowledge of the inflation rate in the CR in 2017 is independent of the university.
- $H0_7$: Knowledge of the inflation rate in the CR in 2017 is independent of the specialization of the faculty.
- $H0_8$: Knowledge of the inflation rate in CR in 2017 is independent of the level of study.

Hypotheses were compiled from 2 questions:

1. What does the term "inflation" mean (adequate description)? (open question)
2. Estimate the annual inflation rate in the Czech Republic last year? (choice of options)

Results

This chapter presents the results of the primary research focused on students' financial literacy – the field of macroeconomics, including comments.

The question about the meaning of the term "inflation" was answered correctly by 57.48% (826) of respondents while the remaining 42.52% (611) of respondents answered the question incorrectly. Four zero hypotheses were tested in terms of this question.

Number of hyp.	Wording of hypotheses	$\chi 2$	Critical value	H0 can be rejected	Cramer s V
$H0_1$	Adequate description of the notion of inflation is independent of gender.	2.03	3.84	-	-
$H0_2$	Adequate description of the notion of inflation is independent of the university.	4.25	5.99	-	-
$H0_3$	Adequate description of the notion of inflation is independent of the specialization of the faculty.	43.22	3.84	X	0.17
$H0_4$	Adequate description of the notion of inflation is independent of the level of study.	5.51	3.84	X	0.06

Table 2: Statistical values for H01 – H04 in relation to the investigated variables (source: own research, 2018)

The table above (Table 2) implies that the dependence between the knowledge of the concept of inflation and the specialization of the faculty and also, the respondents' level of study has been proved. For the structures of responses please see below.

Specialization of the faculty / response	Correct		Incorrect		Total	
	Absolute frequencies	Relative frequencies within faculties	Absolute frequencies	Relative frequencies within faculties	Absolute expression	Relative frequencies within faculties
ECO	583	64.00%	328	36.00%	911	100%
NON-ECO	243	46.20%	283	53.80%	526	100%
Total	826	57.48%	611	42.52%	1 437	100%
	Value of adjusted residuals/sign notation				**Statistics**	
ECO	6.57	+++	-6.57	---	χ^2 > Critical value	
NON-ECO	-6.57	---	6.57	+++	43.22 > 3.84	

Table 3: Summarized responses to $H0_3$, relation to specialization (source: own research, 2018)

The calculated value of statistics χ^2 43.22 is substantially higher than the critical value on the level of significance $\alpha = 5\%$. Thus, the zero hypothesis can be rejected. The dependency between the understanding of the notion of inflation and the specialization of the faculty has been proved. The dependency determined by Cramer's V reached the value of 0.17, which means that it is rather weak. The differences between the theoretical and actually measured occurrences imply a statistically significant difference at the 0.001 level and show conclusively that the respondents from faculties specializing in economics have a significantly better knowledge of this concept than the respondents from "non-economics" faculties.

Level of study/ response	Correct		Incorrect		Total	
	Absolute frequencies	Relative frequencies within levels of study	Absolute frequencies	Relative frequencies within levels of study	Absolute expression	Relative frequencies within levels of study
BD	527	55.30%	426	44.70%	953	100%
MD	299	61.78%	185	38.22%	484	100%
Total	826	57.48%	611	42.52%	1 437	100%
	Value of adjusted residuals/sign notation				**Statistics**	
BD	-2.35	-	2.35	+	χ^2 > Critical value	
MD	2.35	+	-2.35	-	5.51 > 3.84	

Table 4: Summarized responses to $H0_4$, relation to the level of study
(source: own research, 2018)

The calculated value of statistics χ^2 5.51 is slightly higher than the critical value on the level of significance α = 5%. Thus, the zero hypothesis can be rejected. The dependency between the understanding of the notion of inflation and the level of study has been proved. The dependency determined by Cramer's *V* reached the value of 0.09, which means that it is nearly negligible, which, among other things, results from the differences between the theoretical and actually measured occurrences. A statistically significant difference can only be observed at the 0.05 level, which is proved by the value of the calculated adjusted residuals and supported by the sign notation. It can be concluded that the respondents studying in bachelor's degree programmes gave incorrect answers slightly more often than the respondents from master's degree programmes. Considering the degree of dependency, however, this result should be interpreted with caution.
In addition to the question asking about the notion of inflation, respondents were asked to give the inflation rate in 2017 (the survey was performed in 2018 and that was the reason why respondents were asked about the inflation rate in 2017).

Number of hyp.	Wording of zero hypothesis	χ^2	Critical value	H0 can be rejected	Cramer's V
$H0_5$	Knowledge of the inflation rate in CR in 2017 is independent of gender.	2.29	5.99	-	-
$H0_6$	Knowledge of the inflation rate in CR in 2017 is independent of the university.	60.57	9.49	X	0.15
$H0_7$	Knowledge of the inflation rate in CR in 2017 is independent of the specialization of the faculty.	20.38	5.99	X	0.12
$H0_8$	Knowledge of the inflation rate in CR in 2017 is independent of the level of study.	5.18	5.99	-	-

Table 5: Statistical values for $H0_5$ – $H0_8$ in relation to the investigated variables
(source: own research, 2018)

Respondents chose their answers from indicated ranges. Of the total number of respondents, 41.34% (594) of respondents selected the right answer from the suggested options, while 41.27% (593) of respondents selected an incorrect answer. Respondents were also given an opportunity to answer "Do not know" and this answer was selected by 17.40% (250) of respondents.

University / response	Correct		Incorrect		Do not know		Total	
	Absolute frequencies	Relative frequencies within university	Absolute frequencies	Relative frequencies within university	Absolute frequencies	Relative frequencies within university	Absolute expression	Relative frequencies within university
USB	120	46.33%	84	32.43%	55	21.24%	259	100%
MEU	137	42.02%	99	30.37%	90	27.61%	326	100%
CZU	337	39.55%	410	48.12%	105	12.33%	852	100%
Total	594	41.34%	593	41.27%	250	17.40%	1 437	100%
	Value of adjusted residuals /sign notation						**Statistics**	
USB	1.80	0	-3.19	--	1.80	0	χ^2 > Critical value	
MEU	0.29	0	-4.55	---	5.53	+++	60.57 > 9.49	
CZU	-1.66	0	6.37	+++	-6.12	---		

Table 6: Summarized responses to $H0_6$, relation to the university studied (source: own research, 2018)

The value of statistics $\chi 2$ is substantially higher than the critical value on the level of significance α = 5%. Thus, the zero hypothesis can be rejected. The knowledge of the inflation rate in the Czech Republic depends on the university attended by the respondents, even though the dependency measured by the Cramer's coefficient is weak (0.15). Analysis performed with the help of adjusted residuals has shown that a statistically significant difference from theoretical occurrences (the level of significance at 0.001) can be observed mainly among students of USB, 48.11% (410) of who stated an incorrect annual inflation rate. The sign notation indicates that students of CZU chose one of the suggested variants, even though they were not sure about the correct answer, rather than selecting "Do not know". A statistically significant residual at the 0.001 level has been identified for the "Do not know" response among the respondents from MEU, who opted for this variant significantly more often (27.66%, 90) than respondents from the other universities.

Specialization of faculty / response	Correct		Incorrect		Do not know		Total	
	Absolute frequencies	Relative frequencies within faculties	Absolute frequencies	Relative frequencies within faculties	Absolute frequencies	Relative frequencies within faculties	Absolute expression	Relative frequencies within faculties
ECO	411	45.12%	367	40.29%	133	14.59%	911	100%
NON-ECO	183	34.79%	226	42.97%	117	22.24%	526	100%
Total	594	41.34%	593	41.27%	250	17.40%	1 437	100%
	Value of adjusted residuals /sign notation						**Statistics**	
ECO	3.83	+++	-0.99	0	-3.68	---	χ^2 > Critical value	
NON-ECO	-3.83	---	0.99	0	3.68	+++	20.38 > 5.99	

Table 6: Summarized responses to $H0_7$, relation to specialization of study (source: own research, 2018)

The value of statistics $\chi 2$ is higher than the critical value on the level of significance α = 5%. The zero hypothesis can be rejected. The knowledge of the inflation rate in the Czech Republic depends on the specialization of the faculties studied by the respondents. The dependency measured by Cramer's V is weak (0.12). Statistically significant differences between the theoretical and actual occurrences were identified and tested with the help of adjusted residuals and supported by the sign notation. The residual between the empirical and theoretical occurrences on the level of significance at 0.001 means that respondents who study at faculties specializing in economics gave a significantly higher number of correct answers (45.12%, 411). A statistically significant

difference between the empirical and theoretical occurrences (at the 0.001 level) was observed among respondents who study "non-economics" faculties (22.24%, 117).

Discussion

In several recent decades, experts and teachers have expressed their concerns about whether young people who graduate from universities possess knowledge adequate enough for meeting the challenges of creating and living a healthy financial life and making the right decisions (Bramhandkar, St Clair and Shields, 2019) If financial decisions have consequences for the nearer future, economic prosperity of individuals can also depend on their knowledge of inflation and the ability to forecast the inflation rate (Bruine de Bruin et al., 2010).

The question asking about the meaning of the word inflation was correctly answered by 57.48% (826) of respondents; the remaining 42.52% (611) of respondents answered incorrectly. In their research, Clarsk, Gosh and Hanes (2018) also focused on inflation and concluded that approximately 50% of respondents showed their knowledge of the notion of inflation. In this respect, the dependence between the specialization of the faculty and the level of study was observed. Respondents studying at faculties specializing in economics show significantly better knowledge of this notion than respondents from faculties specializing in non-economic studies. This conclusion is in harmony with Kubak et al., (2018), who say in their research that the studies of economics enhances financial literacy and knowledge. This is contrary to the opinion held by Fernandes, Lynch, and Netemeyer (2014) who claim that the knowledge acquired through learning is only temporary. It can also be said that respondents studying in a bachelor's degree programme gave a slightly higher number of incorrect answers than respondents in a master's degree programme.

In addition to the question asking about the notion of inflation, respondents were asked to give the inflation rate in 2017. Of the total number of respondents, 41.34% (594) of respondents selected the right answer from the suggested options, while 41.27% (593) of respondents selected an incorrect answer. Respondents were also given an opportunity to answer "Do not know" and this answer was selected by 17.40% (250) of respondents. In this case also, the dependency on the specialization and the type of university has been observed. Bharat and Surendra (2015) say that the knowledge of the inflation rate is around 60% among university students.

Conclusion

Education is an integral part of the contemporary world. It also includes financial literacy education. The research investigated the financial literacy of university students in the Czech Republic. The results were obtained through a questionnaire survey which was conducted at three selected universities in 2018. The focus was laid on the macroeconomic phenomenon of inflation and the inflation rate. The notion of inflation was correctly explained by 57.48% (826) of respondents, the remaining 42.52% (611) of respondents responded incorrectly. Of the total number of respondents, 41.34% (594) of respondents were able to give the correct inflation rate.

The research was performed at three selected universities in the Czech Republic only, which may be considered as a limitation. Further research can focus on high schools to assess the development of financial literacy towards universities.

Acknowledgement

This work was also supported by the Internal Grant Agency of Faculty of Economics and Management, Czech University of Life Sciences Prague - grant number 2020B0002 – "The impact of climate change on the economic performance of the viticulture and wine-making sector in the Czech Republic".

References

Bharat, S.T. and Surendra, R.N. (2015) 'Financial Literacy in Nepal: A Survey Analysis from College Students', *NRB Economic Review*, vol. 27, no. 1, pp. 49-74.

Bruine De Bruin, W., Vanderklaauw, W., Downs, J., Fischhoff, B., Topa, G. and Armantier, O. (2010) 'Expectations of Inflation: The Role of Demographic Variables, Expectation Formation, and Financial Literacy', *Journal of Consumer Affairs*, vol. 44, no. 2, pp. 381-402. https://doi.org/10.1111/j.1745-6606.2010.01174.x

Clark, A., Ghosh, A. and Hanes, S. (2018) 'Inflation expectations in Singapore: A behavioural approach', *Macroeconomic Review*, vol. 17, no. 1, pp. 89-98.

De Bassa Scheresberg, C. (2013) 'Financial Literacy and Financial Behavior among Young Adults: Evidence and Implications', *Numeracy*, vol. 6, no. 2, pp. 1-21. http://dx.doi.org/10.5038/1936-4660.6.2

Feng, X., Lu, B., Song, X. and Ma, S. (2019) 'Financial literacy and household finances: A Bayesian two-part latent variable modeling approach', *Journal of Empirical Finance*, vol. 51, pp. 119-137. https://doi.org/10.1016/j.jempfin.2019.02.002

Fernandes, D., Lynch, J.G. and Netemeyer, R.G. (2014) 'Financial Literacy, Financial Education, and Downstream Financial Behaviors', *Management Science*, vol. 60, no. 8, pp. 1861-1883. https://doi.org/10.1287/mnsc.2013.1849

Gerrans, P. and Heaney, R. (2019) 'The impact of undergraduate personal finance education on individual financial literacy, attitudes and intentions', vol. 59, no. 1, pp. 177-217. https://doi.org/10.1111/acfi.12247

Hastings, J. and Mitchell, O. (2020) 'How financial literacy and impatience shape retirement wealth and investment behaviors', *Journal of Pension Economics and Finance,* vol. 19, no. 1, pp. 1-20. https://doi.org/10.1017/S1474747218000227

Hendl, J. (2009) *Overview of statistical methods: data analysis and meta-analysis,* Prague: Portál.

Hindls, R., Hronová, S., Seger, J. and Fischer, J. (2007) *Statistika pro ekonomy*, Praha: Professional publishing.

Ječmínek, J., Kukalová, G., Moravec, L. and Bína Filipová, D. (2018) 'Tax Courses Exams Results at FEM CULS Prague Evaluation' *Proceedings of the 15th International Conference Efficiency and Responsibility in Education (ERIE 2018)*, Prague, pp. 132-139.

Kubak, M., Tkacova, A., Androniceanu, A., Tvaronavičienė, M. and Huculova, E. (2018) 'Financial literacy of students in chosen universities – research platform for regulatory processes of educational system in Slovakia', *E M Ekonomie a Management*, vol. 21, no. 1, pp. 175-190. https://doi.org/10.15240/tul/001/2018-1-012

Lusardi, A. (2015) 'Financial Literacy Skills for the 21st Century: Evidence from PISA', *Journal of Consumer Affairs*, vol. 49, no. 3, pp. 639-659. https://doi.org/10.1111/joca.12099

MF ČR, 2010. *Ministerstvo finanční ČR: Proč se finanční vzdělávat?,* [Online], Available: https://www.psfv.cz/assets/cs/media/PSFV_Narodni-strategie-financniho-vzdelavani.pdf [30 Dec 2019].

Philippas, N.D. and Avdoulas, C. (2019) 'Financial literacy and financial well-being among generation-Z university students: Evidence from Greece' *The European Journal of Finance*, vol. 22, no. 1. https://doi.org/10.1080/1351847X.2019.1701512

Robb, C.A. (2011) 'Financial Knowledge and Credit Card Behavior of College Students', *Journal of Family and Economic Issues*, vol. 32, no. 4, pp. 690-698. https://doi.org/10.1007/s10834-011-9259-y

Rumler, F. and Valderrama, M.T. (2019) 'Inflation literacy and inflation expectations: Evidence from Austrian household survey data', *Economic Modelling*, in press. https://doi.org/10.1016/j.econmod.2019.06.016

BIG-TESTS IN THE TEST CENTRE CZU OF THE SUBJECT APPLIED MATHEMATICS FOR INFORMATICS

[1]✉Helena Brožová, [2]Jan Rydval

[1]Department of Systems Engineering, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, brozova@pef.czu.cz

[2]Department of Systems Engineering, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

The exam results of Applied Mathematics for Informatics have been worsening from the year 2012, so we are constantly thinking about how to better prepare students for the exam. Specifically, how to better present the exam test and context of its questions, because connecting the different parts of the knowledge is very difficult for students. Therefore, we create the new Big-test for the year 2019/2020. Its successful passing is condition for receiving a credit. The Big-test consists of a complex example with practical and theoretical questions. Unlike of it, the Self-test consists of partial small questions without any context. However, the questions are very similar. To prevent students from cheating, the Big-test is designed for the University Test Centre. The goal of this paper is to find out whether the Big-test had an impact on the students' results or not, and to analyse the difficulty and discrimination of the Big-test.

Keywords

ANOVA, Bartlett's Test, Difficulty Index, Discrimination Index, educational tests, Kruskal-Wallis's Test

Introduction

Periodic testing of students is an important part of pedagogical activities, it serves to verify students' knowledge and their knowledge deficiencies. Information about these deficiencies is important to both the educator and the students themselves. Students can focus on their shortcomings and improve their knowledge. Periodic testing of students thus serves as motivation to learn for the final exam. Because student numbers are increasing and information and communication technologies are developing, e-testing is an appropriate way of testing. An appropriate form of e-testing are self-tests with multiple-choice questions. However, in order for such tests to be relevant, questions must not only be well constructed, but individual questions must be put in the appropriate context (Nicol, 2007, Silva et al, 2017). Nicol further argues that the context in which self-test questions occur can greatly affect student responses. Electronic self-tests allow students to test themselves in their homes. This obviously has advantages and disadvantages. The main advantages are: providing direct and immediate feedback for the student, improving student performance, reducing the time and effort of the teachers, decreasing the cost for the institution (Alruwais, Wills and Wald, 2018). The main disadvantage is that it is very easy for students to cheat.

The contribution of students' testing should be measured. It is necessary to find out whether the tests are well designed, how difficult they are, how they can distinguish between well prepared and less prepared students. It is also important to analyze the results of the students and whether they improve their knowledge or not.

This paper is focused on testing Applied Mathematics for Informatics (AMIT) students at the Czech University of Live Sciences Prague (CZU) and follows previous research and improvement of self-

tests (Brozova, Rydval and Horakova, 2014; Rydval and Brozova, 2017). The students of this subject are getting worse and worse results in the final examinations (Brozova, Rydval and Horakova, 2014), despite the fact that the conditions of the currently used self-tests and the conditions for enrolment for the exams have been tightened (Rydval and Brozova, 2017). Due to insufficient results of students by the final examination, a new complex test (Big-test) was created for students, situated in the Test Centre of the CZU. The main goal of this paper is to find out whether the newly introduced Big-test had an impact on the students' results or not and to analyse the difficulty and discrimination of the Big-test as well.

Materials and Methods

Methods of test analysis

The high-quality exam tests help to evaluate student's knowledge and consequently to motivate the students to learn. In this research we use the following methods for the analysis of the test quality (Jacobs, 1991, Miller, 2012, Wells and Wollack, 2003):

- Basic statistical analysis of results;
- Difficulty Index of the tests;
- Discrimination Index of the tests.

Basic statistical analysis of results

The mean, median, minimal and maximal values of results and variance of results is used. The Null hypothesis: *There is no significant difference in the test results* ($H_0 : \mu_1 = \mu_2 = \ldots = \mu_n$), where $\mu_1, \mu_2, \ldots, \mu_n$, are the means of the results of the analysed tests groups, is tested. Used significance level is $\alpha = 0.05$. Rejecting the Null hypothesis and accepting the Alternative hypothesis implies that the test results are different. If Bartlett's test showed the variances are equal across groups the single factor ANOVA for analysis of variance is used. Otherwise, the Kruskal-Wallis's test is used (Anderson et al., 2014).

Difficulty Index

The difficulty index of the test questions is very useful characteristic. It is a measure of the proportion the correct answers; it is calculated as:

$$0 \leq P = \frac{B_{\text{sum}}}{B_{max}} \leq 1 \tag{1}$$

where B_{sum} is a total number of obtained score of all students and B_{max} is maximal possible amount of score of all students. The higher value indicates a greater proportion of correct answers, so, the question is easier. The index of difficulty of a suitable question has to be in the interval $[0.2;0.8]$ (Škoda et al, 2006).

Discrimination Index

The discrimination index shows the ability of the test items to distinguish between the good and bad students.

$$-1 \leq ULI = \frac{B_U - B_L}{B} \leq 1 \tag{2}$$

where B_U is the average of points from better group of students, B_L is the average of points from poorest group of students and B is the evaluation of the question. A negative discrimination

index shows that the test question is not correct, because the worst students answer it better than the best students.
The discrimination and the difficulty index of test items have to be analysed together. The suitable combinations of their values are in the Table 1.

Difficulty (P)	[0.2;0.3]	[0.3;0.7]	[0.7;0.8]
Discrimination (ULI)	≥ 0.15	≥ 0.25	≥ 0.15

Table 1: Recommended values of difficulty and discrimination indices (Škoda et al, 2006)

Data of exams and tests

The analysed data describe the exam results from the period 2012/13 till 2019/20. Data are collected from the Study information system CZU. We evaluated a total of 1864 marks from the exam terms during the winter exam period, in individual years 186, 245, 249, 292, 268, 237, 181, and 206. We also compared 211of Self-test results, 141(106 the best) results of the Big-test – Linear programming and 131 (112 the best) results of the Big-test – Transportation model from the year 2019/20. These data are collected from the e-learning system Moodle CZU. Although we know the names of the students, we did not need and used them to analyse the results. Also, we were not interested in the numbers of women and men, because our analysis only looked at the impact of Big-tests on the test results regardless of gender.

Results

Since 2012, the results of the AMIT exam have been very unsatisfactory, so we are constantly thinking about how to better prepare students for the exam, in particular how to better present the exam test and the need to link the different parts of the knowledge from the seminars. The general reason for failure in this subject is certainly its mathematical orientation. The decreasing level of study and knowledge of mathematics is generally discussed. Another reason is the time allocation of teaching (2 hours of lectures and 1 hour of seminar weekly) is not very suitable. Students call for two-hour seminars in order to practice each method more. This will be introduced in the next semester of this subject.
That's why we create the new test for year 2019/2020, which successful passing is also condition for receiving a credit. We call it Big-test, because it consists of complex example with practical and theoretical questions related to this example. Unlike of it the self-test consists of partial small questions without any context. However, the question itself are very similar. To prevent students from cheating, the Big-test are designed for the University Test Centre.
The Big-tests consist of practical questions (construction and solution of models) and of theoretical questions (related to the model included in the test or general). Big-test consists of various types of questions (Table 2).
Our main research question in this paper is: "Do the Big-tests improve the students' preparation for final examinations?" To analyse the quality and the impact of the new Big-test, we have set out following basic research questions and hypotheses:

1. RQ_1: What is the impact of the Big-test on exam results?
2. H_{01}: There is no significant difference between the results of Big-test and Self-test.
3. H_{02}: There is no significant difference between the results of both types of Big-tests.
4. RQ_2: What is the difficulty of individual test questions of the Big-tests?
5. RQ_3: Are individual test questions able to distinguish between more prepared and less prepared students?

Big-test Linear Programming	Question type	Points
1. Construction and solution of system of linear equations	Gap Fill / Cloze	20
2. Model constraints and criterion	Multiple choice	5
3. Type of criterion and constraints	Multiple choice	5
4. Theoretical question related to the model	Multiple choice	10
5. Existence and number of model solutions	Multiple choice	10
6. Values of variables	Gap Fill / Cloze	10
7. Value of criterion function	Gap Fill / Cloze	5
8. Post-optimization analysis	Gap Fill / Cloze	5
9. General theoretical question 1	Multiple choice	10
10. General theoretical question 2	Multiple choice	10
11. General theoretical question 3	Multiple choice	10
	Sum	100
Big-test Transportation Model	**Question type**	**Points**
1. Construction and solution of system of linear equations	Gap Fill / Cloze	20
2. Number of model constraints and variables, of solutions	Multiple choice	5
3. Theoretical question related to the model	Multiple choice	5
4. Values of variables I	Gap Fill / Cloze	10
5. Values of variables II	Gap Fill / Cloze	10
6. Value of criterion function	Gap Fill / Cloze	5
7. Post-optimization analysis	Gap Fill / Cloze	5
8. Traveling salesman problem	Gap Fill / Cloze	10
9. General theoretical question 1	Multiple choice	10
10. General theoretical question 2	Multiple choice	10
11. General theoretical question 3	Multiple choice	10
	Sum	100

Table 2: Structure of the Big-tests

Final examination test results

The initial readiness of students to successfully pass the exam should be evident especially in the regular exam period (in the winter semester), especially during the first attempts of the exam (Figure 1). The results of the students' examinations in the regular exam period, especially the results of their first attempts are not satisfying. The average exam mark 2012 and 2020 of the first attempts was 3.69, the average exam mark of the second and third attempts are slightly better (3.35 and 3.15). The better exam marks in the second and third attempts are mainly due to the fact that students already know what to expect from the exam test and they might be better prepared. The average exam mark of all students who pass the exam is 2.57 (without mark 4).

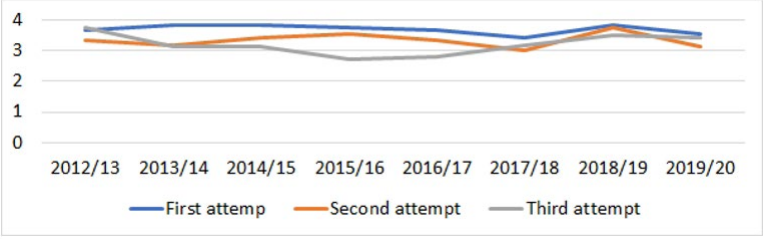


Figure 1: The mean of the marks in the first, second and third attempt of the exam

The average exam mark shows a steady worsening trend, with a slight improvement in the first attempts in the academic years 2017/2018 and 2019/2020. Bartlett's test showed the same data variability and the ANOVA test shows that the averages of the exam marks in individual years are significantly different (p-value = 0.00001 ≤ 0.05). The improvement in the academic year 2017/2018 is also evident in the overview of marks of all attempts in the winter exam period and for both winter and summer exam periods in total (Figure 2). This could be probably due to a change in the lecturer in the year 2017/2018, students were tested using other exam tests by different team of examiners than other years. A slight melioration in the average of marks is also evident in the academic year 2019/2020 (especially compared to 2018/2019). This fact could be caused probably by a implementing the Big-test and corresponding change in the conditions for obtaining credit and to be enrolled for the exam. We assume the change in students' preparation for exam in this context as many students confirmed during random inquiries at the end of the exam. However, for the relevant verification of this reason, it is necessary to obtain data from the summer examination period of the academic year 2019/2020 and the following years.

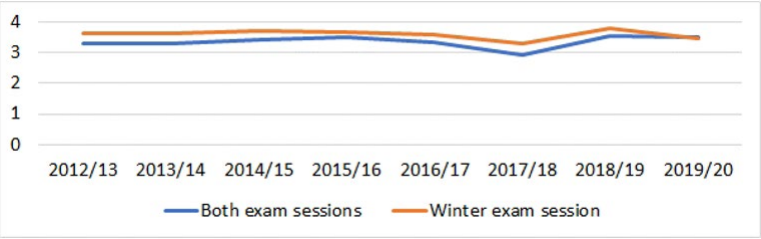


Figure 2:The mean of the final marks

By the above-mentioned changes of students' exam results, the Big-test seems to force the students to prepare more deeply and carefully not only for the Big-test but also for the final examination test as well.

Analysis of Big-tests

Comparisons of Self-test and Big-tests

We assume that the well-designed tests with higher difficulty can lead to an increase in students' efforts to prepare for the final examination. Therefore, we wanted to find out if the new Big-tests are more difficult than the currently used Self-tests.

The comparison is made only for the final evaluation of Self-tests and Big-tests. The mean number of points of the Big-test is 49.38 and the mean number of points of the Self-test is 74.74. Bartlett's test did not show the same data variability, so we used the Kruskal Wallis test. The null hypothesis H01: "There is no significant difference between the results of Big-test and Self-test" is rejected, because p-value = 0.00001 ≤ 0.05.

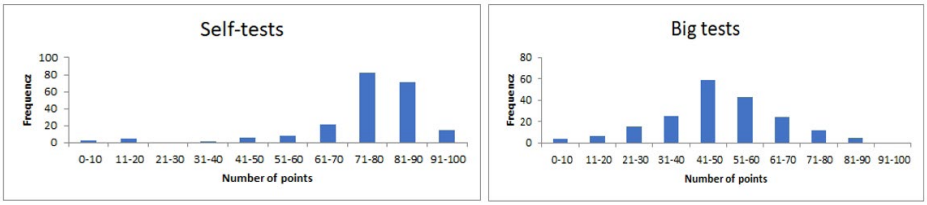


Figure 3: Histograms of achieved points from the Self-tests and Big-tests

By rejecting the null hypothesis H_{01}, we conclude that the Big-tests are more difficult than currently used Self-tests, and so the Big-tests may possibly force students to better preparation for the final examination.

Analysis of the two types of Big-tests

We created two basic types of Big-tests, one type for linear programming models and the other for transportation problems. We wanted to find out whether the two types of tests were identical in their difficulty. The mean evaluation of the Big-test - Linear programming is 39.81 and the mean evaluation of the Big-test – Transportation problem is 43.50. Bartlett's test showed the variances are equal across groups. So, we used the ANOVA test. The null hypothesis H_{02}: "There is no significant difference between the results of both types of the Big-tests" is not rejected, because p-value = 0.09 ≤ 0.05.

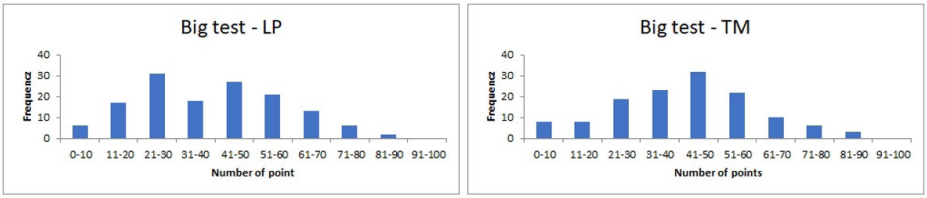


Figure 4: The mean of the final marks

The null hypothesis H_{02} was not rejected in this case, this means that there is no statistically significant difference between the difficulty of both types of Big-tests. In this case, both types of Big-tests are equally demanding and it does not matter which of them the student gets in the University Test Centre.

Analysis of tests questions of Big-tests

Furthermore, we wanted to find out whether the tests were properly designed, i.e. how much it is difficult to answer individual test questions (RQ_1) and whether the individual questions of both tests have the ability to distinguish between more prepared and less prepared students (RQ_2).

LP	Difficulty index	Discrimination index	TM	Difficulty index	Discrimination index
Globally	**0.398**	**0.416**	Globally	**0.435**	**0.396**
Question 1	0.475	0.872	Question 1	0.809	0.512
Question 2	0.527	0.309	Question 2	0.611	0.465
Question 3	0.879	0.167	Question 3	0.481	0.419
Question 4	0.414	0.326	Question 4	0.192	0.419
Question 5	0.214	0.447	Question 5	0.634	0.442
Question 6	0.553	0.489	Question 6	0.454	0.616
Question 7	0.043	0.128	Question 7	0.211	0.264
Question 8	0.237	0.055	Question 8	0.058	0.013
Question 9	0.331	0.271	Question 9	0.341	0.450
Question 10	0.348	0.278	Question 10	0.387	0.422
Question 11	0.329	0.273	Question 11	0.319	0.326
Min	0.043	0.055	Min	0.058	0.013
Max	0.879	0.872	Max	0.634	0.616

Table 3: Quality of individual questions of Big-tests

The difficulty analysis of the individual questions of the Big-test Linear optimization (Figure 5) shows that all questions are approximately equally slightly difficult and have a good ability to distinguish between prepared and less prepared students. Only the question Q3 is not difficult enough at all and therefore has only little ability to distinguish between students. Furthermore, questions Q5, Q7, and Q8 are too difficult to be correctly answered but only Q7 and Q8 have small ability to distinguish between students. These questions need to be further analysed and reformulate to increase their difficulty and their ability to distinguish between students.

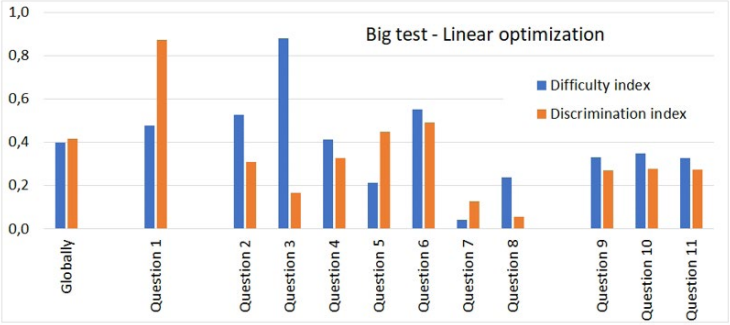


Figure 5: Difficulty and discrimination of the Big-test - Linear optimization

In the Big-test – Transportation problem (Figure 6) the questions Q4 and Q7 are quite difficult but have a good ability to distinguish between students. The questions Q8 is also very difficult and has no ability to distinguish the students. The reason can be also that only a small number of students solved this question. These questions need to be analysed and reformulated to increase their difficulty and their ability to distinguish the students. The value of the difficulty index of all other questions in the interval $[0.3;0.8]$ and the value of the discrimination index is higher than 0.25, it means the overall structure and contents of this test is satisfactory.

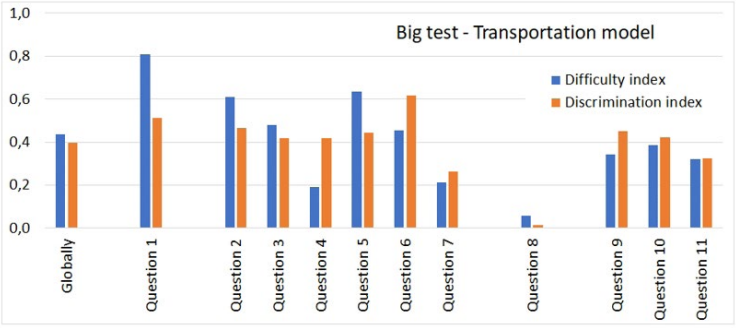


Figure 6: Difficulty and discrimination of the Big-test - Transportation problem

Discussion

Based on the conducted analysis, there is a slight improvement in the students‘ results of AMIT by the final examination. This improvement is caused by the newly implemented Big-test, which forced students to prepare for the matter of the subject. The difficulty and

discrimination analysis show the desirability of the Big-test, even because it contains more types of questions and not just multiple-choice questions. The advantage of more types of questions confirmed Nicol (2007). However, this improvement is only very small, which is probably due to the fact that the Big-test included only two topics (Linear programming and Transportation problem). In the final examination, there are more topics included, therefore it is necessary to complete the test with the remaining topics and if necessary to improve or reformulate the test questions. We want the set of questions to be dynamically changeable and customizable and not to remain static. A similar conclusion, the continuous improvement of the set of questions by an e-test, can we see in the research by Nicol (2007) and by Alruwais, Wills and Wald (2018).

Conclusion

To participate in the final exam (to be enrolled for the exam), students have to pass the Big-tests at the University Test Centre reflecting selected areas of the subject AMIT in addition to the self-tests. The complexity of the Big-test and the University Test Centre environment make these Big-tests far more difficult and that forces students to prepare more carefully and thoroughly for the final examination. In summary, we can say that the Big-tests are well-prepared, and their difficulty is higher than the difficulty of current used self-tests, they have a good ability to distinguish between well prepared and less prepared students. Therefore, they can serve as a good motivation for better students' preparation for the final examination. After the reformulation of the questions mentioned above the test could be successfully applied not only as the credit test but also as the exam test.

References

Alruwais, N., Wills, G. and Wald, M. (2018) 'Advantages and Challenges of Using e-Assessment', *International Journal of Information and Education Technology*, vol. 8, no. 1, pp. 34–37. http://dx.doi.org/10.18178/ijiet.2018.8.1.1008

Anderson, D.R., Sweeney, D.J., Williams, T.A., Freeman, J. and Shoesmith, E. (2014) *Statistics for business and economics*, London, UK: Cengage Learning.

Brozova, H., Rydval, J. and Horakova, T. (2014) 'Self-Test and Exam Test Results in the Subject Applied Mathematics for IT', *Proceedings of the 11th International Conference Efficiency and Responsibility in Education 2014*, Prague, pp. 40–46.

Jacobs, L.C. (1991) *Test Reliability*, [Online], Available: http://www.indiana.edu/ ~best/bweb3/test_reliability.shtml [3Aug 2013].

Miller, I. (2012) *Edukometrie*, [Online], Available: http://www.miller.wz.cz/ [15 May 2012].

Nicol, D. (2007) 'E-assessment by design: using multiple-choice tests to good effect', *Journal of Further and Higher Education*, vol. 31, no. 1, pp. 53–64. http://dx.doi.org/10.1080/03098770601167922

Rydval, J. and Brozova, H. (2017) 'Analysis of Self-Test Improvement for Increasing the Quality of Education Process', *Proceedings of the 14th International Conference Efficiency and Responsibility in Education 2017*, pp. 347–354.

Silva, R.M., Guan, Y., Swartz, T.B. (2017) 'Bayesian Diagnostics for Test Design and Analysis', *Journal on Efficiency and Responsibility in Education and Science*, vol. 10, no. 2, pp. 44-50. http://dx.doi.org/10.7160/eriesj.2017.100202

Škoda, J., Doulík, P. and Hajerová-Müllerová, L. (2006) *Zásady správné tvorby, použití a hodnocení didaktických testů v přípravě budoucích učitelů*, [Online], Available: http://cvicebnice.ujep.cz/cvicebnice/FRVS1973F5d [25 May 2012].

Wells, C.S., Wollack, J.A. (2003) *An Instructor's Guide to Understanding Test Reliability*, [Online], Available: http://testing.wisc.edu/Reliability.pdf [8 Mar 2013].

WHERE TO INVEST IN ONLINE MARKETING EDUCATION IN MICRO AND SMALL ENTERPRISES

[1]Francesca Cabiddu, [1]Ludovica Moi, [2]Pia Jaaskelainen, [3]✉Ladislav Pilař, [4]Jana Pitrová, [5]Rosen Petkov

[1] Department of Economic and Business Science, Università degli studi di Cagliari, Italy

[2]South-Eastern Finland University of Applied Sciences, Finland

[3]Department of Management, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, pilarl@pef.czu.cz

[4]Department of Management, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

[5]Technical university of Sofia, Bulgaria

Abstract

The aim of this paper is to identify the educational needs of small and medium enterprises (SMEs) in the field of online marketing. This paper extends a local Czech study via international research (Bulgaria, Finland, Hungary, Italy). Primary data was gathered using an electronic questionnaire (n = 376) focused on the enterprise side and semi-structured interviews (n = 18) with online marketing agencies. Based on a comparison of questionnaire survey results and semi-structured interviews the main problem areas in the effective use of the online marketing tools were identified (complexity of the individual tools; lack of human resources, time and finance, bad previous experience; lack of knowledge and competencies). The research results indicate the definition of recommendations for micro and small enterprises - the main emphasis should be given to create a course that will create specialists for communication with online marketing agencies with the general knowledge of each online marketing tool.

Keywords

Education, on-line marketing, micro enterprise, small and medium enterprise, outsourcing

Introduction

SMEs play an important role in the national economics of all countries (Gancarczyk and Gancarczyk, 2018). They support the country's economy (Macpherson and Hold, 2007) and play an important role in reducing the country's unemployment (Woźniak et al., 2019). In the current globalized society with the highly linked markets, these SMEs face major challenges (Paul and Rosado-Serrano, 2019). SMEs have many strengths and weaknesses. Adequate financial resources like lack of liquid capital (Masroor and Asim, 2019), lack of personnel education connected to environmental management (Lee, 2009), and low staff education (Nikolaou et al., 2016) are commonly considered as main weaknesses.

The world is getting more and more globalized and people have started to change their buying behaviour (Sobol et al., 2018). Internet usage and internet purchasing are increasing (Pernot, 2020) and the path of purchase is changing overall (Xu et al., 2014). Individual online marketing channels increase complexity and start to be a challenge for companies (Anderl et al., 2016). Each of the online marketing tools are already so highly complex, that it is not possible to manage them effectively by one person (Pokorná and Pilař, 2014). Companies are often focused on the activities in which they have very good knowledge, such as offline advertising and sales support, but they still lack the sufficient knowledge to reflect the modern technological environment, such as online

marketing tools like Websites, Social Sites, E-mail marketing, PPC advertising etc. (Semerádová and Vávrová, 2016; Claudiu-Dan, 2015; Pauwels et al., 2016).
The great advantage of using individual online marketing tools is the possibility of shortening the supply chain and selling products directly to consumers, which is exactly the advantage that can be obtained through selling online (Chakraborty et al., 2018; Sui and Rejeski, 2002). One of the reasons why most companies do not sell their products or services directly to the final customers is the lack of financial resources to carry out direct marketing (Kiang et al., 2000). Online marketing, however, is a way to target the end consumer financially highly effectively (Lessmann et al., 2019).
Against this backdrop, this paper´s aim is to elucidate the problematic areas in the use of the online marketing tools, to identify the main educational needs of small and medium enterprises (SMEs) in the field of online marketing.

Materials and Methods

For the data, an electronic questionnaire was administered to the employees and the CEOs of firms with different sizes (i.e., <10 employees; <50 employees; <250 employees). A total of 376 responses were received from five countries (Bulgaria, Czech, Finland, Hungary, Italy), for details see table 1. The data was collected from December 2019 to February 2020. The questionnaire aimed at investigating two crucial topics. Firstly, what online marketing activities are created internally or externally. Secondly, in what areas do companies recognize the greatest opportunities for improvement. The questionnaire contained 3 categorization questions, focusing on sector, company size, location and 6 questions focused on the use of individual online marketing tools in the company (see table 2) and 6 questions focused on the need to improvement in individual online marketing tools (see table 3), both of these areas were possible to answer through a 5-degree Likert scale. The Kruskal-Wallis test was used to confirm the difference based on the size of the enterprise.
Concurrently, randomly selected marketing agencies were contacted with semi-structured interviews. A total of 18 interviews were conducted. The aim of this interview was to identify problems in working with SMEs companies in the implementation of online marketing activities.

	Czech	Bulgaria	Finland	Hungary	Italy	Sum
micro <10	70	14	34	25	44	187
small <50	46	10	28	4	18	106
medium <250	56	4	16	1	6	83
Online marketing agencies	9	3	3	3	3	21

Table 1: Structure of the questionnaire survey

Result and Discussion

In the questionnaire survey, micro enterprises (<10 employees) prevailed in all countries. The first analysis area by the enterprises was focused on segmentation online marketing activities which are created internally, externally, partly internally or not being used at all. The results revealed that in the micro enterprises segment they mostly deal internally with following online marketing tools - websites, social media, email marketing and analytics. On the other hand, they don´t handle all the tools as SEO and PPC (see table 2). Small enterprises handle internally most of the areas (Website, SEO, Social Media, E-mail marketing and Analytics) except PPC, which is usually not addressed at all. Most of the medium-sized enterprises outsource SEO and handle internally Websites, PPC, Social Media, Email Marketing and Analytics. On the contrary for PPC there is a consensus where 33% of companies deal with activities internally and 33% do not deal at all.
Based on these results, it is possible to identify that the websites are handled by SMEs through

internal resources. The micro enterprises do not solve the SEO, the small and medium-sized enterprises through outsourcing. The least used is PPC, both for micro and small enterprises. For medium-sized enterprises, there is a match between the use of internal resources and non-use. For Social Media, e-mail Marketing and Analytics, the situation for micro, small and medium-sized businesses is relatively the same, with the most internal resources used for these activities.

Category	Areas					
< 10 employees	Website	SEO	PPC	Social Media	E-mail	Analytics
We do internally	**55.61%**	33.16%	26.20%	**75.94%**	**52.41%**	**55.61%**
We use outsourcing	14.97%	18.18%	17.11%	3.74%	6.42%	14.97%
Partly internally and partial outsourcing	14.97%	5.35%	6.42%	6.95%	3.21%	14.97%
Not being used	14.44%	**43.32%**	**50.27%**	13.37%	37.97%	14.44%
< 50 employees	Website	SEO	PPC	Social Media	E-mail	Analytics
We do internally	**68.87%**	**43.40%**	25.47%	**71.70%**	**65.09%**	**68.87%**
We use outsourcing	16.04%	23.58%	15.09%	5.66%	7.55%	16.04%
Partly internally and partial outsourcing	12.26%	8.49%	5.66%	7.55%	2.83%	12.26%
Not being used	2.83%	24.53%	**53.77%**	15.09%	24.53%	2.83%
< 250 employees	Website	SEO	PPC	Social Media	E-mail	Analytics
We do internally	**59.04%**	31.33%	**33.73%**	**65.06%**	**68.67%**	**59.04%**
We use outsourcing	4.82%	**33.73%**	10.84%	2.41%	1.20%	4.82%
Partly internally and partial outsourcing	36.14%	25.30%	22.89%	4.82%	26.51%	36.14%
Not being used	0.00%	9.64%	32.53%	27.71%	3.61%	0.00%

Table 2: Usage of online marketing tools

These results need to be put in the context of the second part of the questionnaire survey, which was focused on identification of the needs for improvement (see Table 3). From this part of the research results that micro-enterprises and medium-sized enterprises need major improvement based on self-evaluation in all areas. Medium-sized enterprises need major improvements in Website and SEO, on the other hand they need a little improvement in the area of PPC, social marketing, email marketing and Analytics.

Category	Areas					
< 10 employees	Web	SEO	PPC	SM	E-mail	Analytics
We need major improvements	**29.95%**	**43.32%**	**36.90%**	**39.57%**	**35.83%**	**38.50%**
We need improvements	29.41%	25.67%	22.46%	26.74%	26.20%	33.16%
We need a little improvement	23.53%	11.76%	13.37%	20.32%	16.04%	11.23%
We handle fine	17.11%	19.25%	27.27%	13.37%	21.93%	17.11%
< 50 employees	Web	SEO	PPC	SM	E-mail	Analytics
We need major improvements	**59.43%**	**64.15%**	**63.21%**	**48.11%**	**54.72%**	**70.75%**
We need improvements	18.87%	14.15%	10.38%	21.70%	16.98%	10.38%
We need a little improvement	11.32%	11.32%	10.38%	20.75%	14.15%	9.43%
We handle fine	10.38%	10.38%	16.04%	9.43%	14.15%	9.43%
< 250 employees	Web	SEO	PPC	SM	E-mail	Analytics
We need major improvements	**54.22%**	**53.01%**	25.30%	28.92%	38.55%	36.14%
We need improvements	32.53%	7.23%	27.71%	30.12%	14.46%	16.87%
We need a little improvement	10.84%	37.35%	**42.17%**	**34.94%**	**43.37%**	**40.96%**
We handle fine	2.41%	2.41%	4.82%	6.02%	3.61%	6.02%

Table 3: Self-evaluation in the area of on-line marketing activities improvement

The Kruskal-Wallis test was used to confirm the difference based on the size of the enterprise. As can be seen in Table 4, there are statistical differences in three areas. Websites and Analytics in category of management (insource or outsource) and PPC in area of improvement.

In area of Website, is possible to identify statistical difference between micro-enterprises and small businesses, and the difference between small businesses and medium-sized businesses (see table 4). This is due to the fact that in small businesses, about 69% of websites are designed as internal activities. This is the largest share of all categories. Another area is analytics, namely the difference between micro and medium-sized enterprises, which is mainly due to the fact that about 15% of micro-enterprises do not use analytics at all.

In the area of improvements, it is the PPC area where a distinction can be found between micro and small enterprises and between small and medium-sized enterprises. This is due to the fact that about 63% of small businesses need major improvements.

	A vs. B		A vs. C		B vs. C	
	W	**p**	**W**	**p**	**W**	**p**
Website	-3.851	**0.033**	0.983	0.899	3.776	**0.038**
Analytics	-0.396	0.992	-4.152	0.018	-3.619	0.051
PPC	-5.399	**<.001**	-0.784	0.945	3.773	**0.038**

**A – micro-enterprise; B – small enterprise; C – medium enterprise*

Table 4: The difference based on the size of the business in the use of online marketing tools and the need to improve them in the business

The third part of the questionnaire survey was focused on identifying the main problem for effective use of online marketing in their company.

Based on this question, the following barriers could be identified across countries:

- Staff competence is missing
- Lack of human resources

- Lack of financial resources
- Distrust of a quality service provider
- Bad past experience
- Poor management's willingness to invest in new communication channels
- Distrust in the effectiveness of online marketing
- High initial investment
- Lack of creativity

From the enterprises perspective, the biggest identified problem results from the combination of several factors. Among them, missing employee in-depth competencies, the lack of adequate human resources in terms of the time capacity of the current employees, and the lack of financial resources to recruit new employees, or selecting employees who would only take care of online marketing. There is also a lack of trust in online marketing agencies because of poor past experience, supported by management's idea of the need for high initial investment which prevents from pushing online marketing activities effectively.

Additionally, we extended and deepened the analysis of the problem through semi-structured interviews with experts from online marketing agencies. Notably, they were asked to explain what they see as a biggest obstacle in cooperating and working with the SME businesses. According to their perspective, crucial issues can be related to:

- **Lack of human resources and time** - The most common problems are associated with human resources. In the micro and small companies is often managing the online marketing activities of a person who does not have proper competencies. Also, since this person is not assigned fully for online marketing activities, another important factor is the lack of time by such a person to properly dedicate to these activities.
- **High cost pressure** - The client does not thoroughly understand the complexity of individual options and tools of online marketing. In order to use individual tools of online marketing effectively, it is necessary to dedicate a specialized professional figure in this field to each tool.
- **Unrealistic demands -** There is a great difficulty in finding a match between budget and client expectations. In many cases, the budget rarely meets the needs and wants that clients would like to achieve.
- **Lack of ability to articulate fundamental business** - Companies' issues often translate into troubles in setting up a suitable business vision and strategy, given the inability to define target groups, people and related marketing strategies
- **Lack of knowledge** - In most cases, companies do not catch the relevance of using online marketing tools from a business perspective. They do not understand their potential in terms of advantages, disadvantages, possibilities of targeting and measuring.
- **Bad experience** - The client tries individual tools of on-line marketing without the necessary knowledge. For example, Google often offers a $ 40 voucher to try PPC. The client does not have the necessary knowledge, the campaign sets up badly and is subsequently disappointed.
- **Wrong/insufficient problem definition** - The client often does not have an overview of the need to define the objectives of individual activities. Whether the goal is to win customers, get followers, educate, or inform social network users.
- **Unwillingness to test new things** - Online marketing tools today offer a wealth of techniques to target a customer and how to link individual tools to reach a user. The client often is not aware about these options, thus is reluctant to trust them.
- **Unwillingness to invest money in analyses** - Analyses are an important step before starting any marketing campaign. The client does not want to put money into conducting such analyses and insists on his or her opinion, which may not obstacle to reach the predefined goal.

- **Selling services to companies, when you speak "different" language** - The client does not know the terms such as CPC, CTR, retargeting, etc. Then, the communication is led to the wrong direction, without appreciating the real benefits of segmentation and targeting of PPC advertising.

By comparing the questionnaire survey on the part of entrepreneurs and the semi-structured interviews on the part of experts from online marketing agencies, the main problems can be identified as lack of human resources, time and financing and from others bad previous experience. These results are confirmed by studies by Cerratio and Piva (2012), which identify the lack of human resource as one of the main problems in entering international markets, which is due to online (Reuschke and Mason, 2020). Nowadays, the tools of online marketing are so sophisticated and digital technology has been transforming globally (Sharma et al., 2020). They offer so many options that are not possible to use effectively their full potential by using just the internal sources of the micro and small enterprises, often represented by a single person, that is operating all these areas in just part time of his working activity.

The problem of human resource has been identified from both sides. The low-cost attitude of SME leads to dedication of the online marketing tools management to an employee who is in charge also of other company activities and therefore has no time to be following the current trend and options of each online marketing tools, which leads to the non-effective use of the online tools. That also results in the bad experience with the tools and entrepreneurs are getting distrustful. These facts are also supported by the result of the questionnaire survey, where both micro and small entrepreneurs on the basis of self-evaluation need major improvement in all online marketing tools, but at the same time do not have human resources and time.

One solution to the lack of human resources could be outsourcing, that is often used by the Medium Enterprises especially. The study of Porto and Abreu (2018) showed, that decisions to outsource pays off for the companies when there is an increase in advertising spending, but low levels of investment bring the highest return on sales. The decision not to outsource to an advertising agency with low advertising expenses seems to be the most satisfactory to generate profit return for a small firm.

Given the lack of money and human resources, it is possible to recommend courses that applicants will be able to complete online in accordance with their workload. Here, LMS Moodle is an ideal solution, which is currently an important tool for teaching (Beranek and Remes, 2016).

Conclusion

Individual online marketing tools are an effective means of attracting and retaining customers and increasing their competitiveness in today's global market. The main problem of the online marketing tools for micro and small enterprises lies in their complexity, which exceeds the capacities of one employee. This employee is supposed to be able to manage all these tools together with following the newest trends and managing also other activities of his scope of work. In the other words, the main recommendation based on the research results is that micro and small companies should be using the services of professional marketing agencies and provide their employees which are responsible for managing the online marketing necessary training in the field of general orientation in online marketing tools, campaign goals and their measurements. Conclusion of the research supports the results of the local CZ study of Pokorná and Pilař (2012), which suggested a need of focusing on the micro enterprises employees´ education in their ability to communicate with the online marketing agencies and leave the management of these tools on the marketing agencies. This research confirms and extends these results to small entrepreneurs (<50 employees) and evaluates these results through the international study.

Acknowledgement

This project has been funded with support from the European Commission. This article reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein. Project reference number: 2019-1-CZ01-KA204-061365.

References

Anderl, E., Schumann, J.H. and Kunz, W. (2016) 'Helping Firms Reduce Complexity in Multichannel Online Data: A New Taxonomy-Based Approach for Customer Journeys', *Journal of Retailing*, vol. 92, no. 2, pp. 185–203. http://dx.doi.org/10.1016/j.jretai.2015.10.001

Porto, B.R and Abreu, F. (2018) 'Investment in online advertising and return on sales: Does it pay to outsource the services to an advertising agency? ', *Journal of Marketing Communications*, vol. 25, pp. 843-860. http://dx.doi.org/10.1080/13527266.2018.1482558

Beranek, L. and Remes, R. (2016) 'Prediction of unsuccessful students based on their activities in the LMS moodle', *Proceedings of the 13th International Conference on Efficiency and Responsibility in Education (ERIE 2016)*, Prague, pp. 35-42.

Chakraborty, R., Lee, J., Bagchi-Sen, S., Upadhyaya, S. and Raghav Rao, H. (2016) 'Online shopping intention in the context of data breach in online retail stores: An examination of older and younger adults', *Decision Support Systems*, vol. 83, pp. 47–56. https://doi.org/10.1016/j.dss.2015.12.007

Cerrato, D. and Piva, M. (2010) 'The internationalization of small and medium-sized enterprises: the effect of family management, human capital and foreign ownership', *Journal of Management & Governance*, vol. 16, no. 4, pp. 617–644. https://doi.org/10.1007/s10997-010-9166-x

Claudiu-Dan, G. (2015) 'Internet Involvement and Metrics in Adult Education Services Online Marketing in Romania. An Evaluation Study', *Procedia Computer Science*, vol. 65, pp. 950–960. http://dx.doi.org/10.1016/j.procs.2015.09.067

Gancarczyk, M. and Gancarczyk, J. (2018) 'Proactive international strategies of cluster SMEs', *European Management Journal*, vol. 36, no. 1, pp. 59–70. http://dx.doi.org/10.1016/j.emj.2017.03.002

Kiang, M. Y., Raghu, T. and Shang, K.H.-M. (2000) 'Marketing on the Internet — who can benefit from an online marketing approach?', *Decision Support Systems*, vol. 27, no. 4, pp. 383–393. http://dx.doi.org/10.1016/s0167-9236(99)00062-7

Lee, K. (2009) 'Why and how to adopt green management into business organizations?', *Management Decision*, vol. 47, no. 7, pp. 1101–1121. http://dx.doi.org/10.1108/00251740910978322

Lessmann, S., Haupt, J., Coussement, K. and De Bock, K.W. (2019). 'Targeting customers for profit: An ensemble learning framework to support marketing decision-making', *Information Sciences*. https://doi.org/10.1016/j.ins.2019.05.027

Macpherson, A. and Holt, R. (2007) 'Knowledge, learning and small firm growth: A systematic review of the evidence', *Research Policy*, vol. 36, no. 2, pp. 172–192. http://dx.doi.org/10.1016/j.respol.2006.10.001

Masroor, N. and Asim, M. (2019) 'SMEs in the Contemporary Era of Global Competition', *Procedia Computer Science*, vol. 158, pp. 632–641. http://dx.doi.org/10.1016/j.procs.2019.09.097

Nikolaou, I.E., Nikolaidou, M.K. and Tsagarakis, K.P. (2016) 'The response of small and medium-sized enterprises to potential water risks: an eco-cluster approach', *Journal of Cleaner Production*, vol. 112, pp. 4550–4557. http://dx.doi.org/10.1016/j.jclepro.2015.09.068

Paul, J. and Rosado-Serrano, A. (2019) 'Gradual Internationalization vs Born-Global/International new venture models', *International Marketing Review*, Emerald, vol. 36, no. 6, pp. 830–858. http://dx.doi.org/10.1108/imr-10-2018-0280
Pauwels, K., Aksehirli, Z. and Lackman, A. (2016) 'Like the ad or the brand? Marketing stimulates different electronic word-of-mouth content to drive online and offline performance', *International Journal of Research in Marketing*, vol. 33, no. 3, pp. 639–655. http://dx.doi.org/10.1016/j.ijresmar.2016.01.005
Pernot, D. (2020) Internet shopping for Everyday Consumer Goods: An examination of the purchasing and travel practices of click and pickup outlet customers, *Research in Transportation Economics*, 100817. https://doi.org/10.1016/j.retrec.2020.100817
Pokorná, J. and Pilař, L. (2012) 'The Education Needs of Micro Enterprises in On-Line Marketing', *Proceedings of the 13th International conference on Efficiency and Responsibility in Education (ERIE 2012),* Prague, pp. 472-478.
Reuschke, D. and Mason, C. (2020) 'The engagement of home-based businesses in the digital economy', *Futures*, 102542. https://doi.org/10.1016/j.futures.2020.102542
Semerádová, T. and Vávrová, J.N. (2016) 'Using a systemic approach to assess Internet marketing communication within hospitality industry', *Tourism Management Perspectives*, vol. 20, pp. 276–289. http://dx.doi.org/10.1016/j.tmp.2016.09.007
Sobol, K., Cleveland, M. and Laroche, M. (2018) 'Globalization, national identity, biculturalism and consumer behavior: A longitudinal study of Dutch consumers', *Journal of Business Research*, vol. 82, pp. 340–353. http://dx.doi.org/10.1016/j.jbusres.2016.02.044
SUI, D.Z. and REJESKI, D.W. (2002) 'Environmental Impacts of the Emerging Digital Economy: The E-for-Environment E-Commerce?', *Environmental Management*, vol. 29, no.2, 155–163. https://doi.org/10.1007/s00267-001-0027-x
Sharma, A., Sharma, S. and Chaudhary, M. (2020) 'Are small travel agencies ready for digital marketing? Views of travel agency managers', *Tourism Management*, vol. 79, 104078. https://doi.org/10.1016/j.tourman.2020.104078
Woźniak, M., Duda, J., Gąsior, A. and Bernat, T. (2019) 'Relations of GDP growth and development of SMEs in Poland', *Procedia Computer Science*, vol. 159, pp. 2470–2480. http://dx.doi.org/10.1016/j.procs.2019.09.422
Xu, L., Duan, J.A. and Whinston, A. (2014) 'Path to Purchase: A Mutually Exciting Point Process Model for Online Advertising and Conversion', *Management Science*. Institute for Operations Research and the Management Sciences (INFORMS), vol. 60, no. 6, pp. 1392–1412. http://dx.doi.org/10.1287/mnsc.2014.1952

USING VIRTUAL AND AUGMENTED REALITY IN GRAPHIC SUBJECT

[1]✉Ivana Čermáková, [2]Ivo Martiník

[1]Department of Applied Informatics, Faculty of Economics, VSB - Technical University of Ostrava, Czech Republic, ivana.cermakova@vsb.cz

[2]Department of Applied Informatics, Faculty of Economics, VSB - Technical University of Ostrava, Czech Republic

Abstract

The paper is focused on concept of pilot using of virtual and augmented reality technologies in Processing of Graphic Information subject based. The implementation of this subject to the education process at the Faculty of Economics of VSB-Technical University of Ostrava was provided in winter semester of the current academic year. SWOT analysis of this subject determined its future advancement (e.g. minimization of weaknesses and maximization of opportunities). Lego AR and UNITY software systems are currently used in the education process. The main objective of the article is to describe the deployment of the augmented and virtual reality technologies into the Processing of Graphic Information subject and its evaluation. The process of successful implementation is evaluated through qualitative method of research, namely questionnaires. The process of implementation the augmented and virtual reality to the education is provided as training with cooperation of students and teacher. It can also be stated that the success of the students after the deployment of virtual and augmented reality technologies increased to 100% by completing this course. Popularity of the subject among the students then increase twice for next period a thus the implementation of other samples of the virtual and augmented reality will be continued.

Keywords

Augmented reality, education of graphic, qualitative research of education, processing of graphic information subject, virtual reality

Introduction

Using information and communication technologies (ICT) everywhere in the educational process has still rapidly increasing trend (Blackwell, Lauricella and Wartella, 2014). This can be explained for many reasons. Mainly provide the information more easily understanding for the students and create the education process more creative, amazing and effective (Domingo and Garganté, 2016). The augmented reality (AR) and virtual reality (VR) technologies are increasingly used in the present (Martín-Gutiérrez et al, 2015). AR technologies are explained as technologies implement digital elements to the real life in real time (Nincarean et al, 2013). The AR is common part of today-life. It is widely used in various fields such as in the fields of marketing, military, games and education, of course (Saidin et al, 2015). VR is defined as model of real world that is maintained in real-time, sounds and feels reals and the users of the model can manipulate with the objects and so on realistically, e.g. driving a car (Sutherland, 1970). Area of interest is similar as in AR. Using digital elements is similar for both realities. The most advantages of implementation of the "new" concept of the reality in education are attracting student to learn, increasing student's motivation to attend classes, concretizing abstract concept and support authentic learning (Sirakaya and Kilic Cakmak, 2018). Implementation of AR, VR or both realities motived the students to be more active and engaged (Serio, Ibanez and Klook, 2013). Combining the technologies can have multiple benefits of better learning experiences that using only one technology is not able to

achieve (Kamarainen et al, 2013). Application of AR or VR have positive impact not only on student. It has a positive impact on overall learning and learner´ s attitude towards education (Saltan and Arslan, 2016).
The main objective of the article is to describe the deployment of the augmented and virtual reality technologies into the Processing of Graphic Information subject at the Faculty of Economics VSB-Technical University of Ostrava and its evaluation. The evaluation of the successful implementation is provided through qualitative type of research. In this case, it means the questionnaires are evaluated. The process of implementation the AR an VR to the education is provided as training with cooperation students and teacher. Processing of Graphic Information subject is learned in the authorized training center within an Apple Authorised Training Centres for Education (AATCe, 2020) worldwide program with the current statutes of Media Focused AATCe and IT Focused AATCe. The AATCe training center has a non-commercial character with the whole university scope of operation and its mission is the education and preparation of the top-class certified professionals primarily in the areas of multimedia technologies, operating systems and development of the programming systems and the educational process in the chosen bachelor and master study programmes. Lego AR and UNITY software systems are currently used in the education process. It can also be stated that the success of the students after the deployment of virtual and augmented reality technologies increased to 100% by completing this course. Popularity of the subject among the students then increase twice for next period a thus the implementation of other samples of the virtual and augmented reality will be continued.

Materials and Methods

SWOT analysis

SWOT analysis is a strategic planning method used to evaluate the **S**trengths (characteristics of the business, or project team that give it an advantage over others), **W**eaknesses (characteristics that place the team at a disadvantage relative to others), **O**pportunities (external chances to improve performance in the environment) and **T**hreats (external elements in the environment that could cause trouble for the business or project) involved in a project or in a business venture (Armstrong, 1996). It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favourable and unfavourable to achieve that objective. Identification of SWOTs is essential because subsequent steps in the process of planning for achievement of the selected objective may be derived from the SWOTs.

Processing of Graphic Information subject

Processing of Graphic Information is one-semester subject in the bachelor study at the Faculty of Economics VSB-Technical University of Ostrava. This subject has the 1-hour donation for lecture and 2-hours donation for exercise per week. This semester has 20 students. The subject is learned in the AATCe classroom that is equipped with the iMac computers, iPad and iPhone mobile devices, large format multi-touch display 65” NEC MultiSync V651 TM, Apple TV and AirPort Express devices. The AATCe centre supply Windows, MacOS and iOS operation systems. The software used in Processing of Graphic Information subject is the following: Adobe Photoshop, Adobe Illustrator, Lego AR (available for iPad mobile devices) and UNITY. The subject is learned as subject not compulsory for the marketing studies. Next academic year is compulsory for marketing communications too. The subject is focused on photos, editing photos, creating advertising and advertising projects. Introduction to AR and VR technologies,

creating simple digital elements and creating advertising campaign with using AR and VR are topics contained in the subject this academic year.
The students started with raster representation of the data. Firstly, the students learn how work with the graphic software (in this case it is Photoshop). The possibilities of the software and connection with other software are learned in the first lesson. Basic editing of the photos as colours highlighting or elimination of "red eyes" on the photo are learned then. Advanced editing of the photos is next. Collection of the photos with using overlay when the overlay is not visible is learned after. Then are learned basics in vector graphic (in Adobe Illustrator). Because in the previous years the pass of the subject contains creating the advertising using the vector and raster representation and editing of the data, e.g. advertising poster. Combining of vector and raster graphic formats is learned after. The 3-D models of real objects are created also (still in Photoshop).
Creating the 3-D models prepared the student for AR. When the students know how to create the 3-D models it is time for connected the 3-D models with real world. Lego AR is suitable for this. Because it is user friendly and creating basic models or creating basic cities is possible there. When the semester stared it was not available on Android, but in these days, it is available. Lego AR is used in the lessons, but for next years can be used Lego Hidden Side (the software available for iOS and Android) which uses the concept of computer games based on catching something. Lego Hidden Side used the ghosts for catching. For students it is fun introduction to the AR. If the learning of AR started with programming and so on, it will have not so important and not in favour for the students. It is founded from other subjects where the programming is necessary. The motivation for creating and learning subjects which are not in favour is the key factor for this problematic. In the lessons of the graphic subjects is primarily visible the possibilities what all the students can do if they want. It is more motivating for them. And when they must do the thing which from their view are not amazing, e.g. programming or revision code, they still have the vision of the complete project. Using Lego AR is for students the ideal choice for introduction to the AR. Application Place (made by IKEA for implementation of their products to interior) and Figment AR (application made by Viro Media for implementation of animation interactive objects to the real world) will be used as other examples of AR in next academic year also. Introduction to VR is next. Because the subject will more focused on VR. At the first lesson of the VR the students try the VR on two various devices. Example from the introduction to VR is visible as Figure 1. The Figure 1 is imagery from The Open Day 2020 where the applicants can use the VR technology. The applicant in front use the VR technology which have implement sound, view and move (with using the handlers). Behind the picture is visible the second VR technology. The applicant has VR glasses where smart phone is integrated. The sound is connected by separable headset. The handlers are not used. The button at the right side of the VR glasses is used for moving.
Introduction in UNITY is next step after introduction to VR. The base elements are created after basics in the UNITY. Because of one semester subject it is not possible to create whole product or some longer interaction in VR. But students know the basics, know how it works. All the knowledge can help them in marketing of the products (mainly in future, but in these days some big corporations use the AR and VR) also.

Figure 1: Example of introduction to VR

Questionnaires research

The implementation of AR and VR to education is provided through training method. The training method is ideal for this because of cooperation of students and teacher. The motivation is the key factor of the successful implementation. Students love to be studying something new by watching and active connection to the problematic rather than typical listening and reading (Morrison et al, 2011). Increasing of creativity is another benefit (Sirakaya and Kilic Cakmak, 2018). One of the earliest possibilities how to evaluate the implementation the AR and VR to the graphic subject is via questionnaires research (Alsadoon and Alhussain, 2019). Questionnaires contains 6 questions and are available each student of the subject. The results will be compared with Evaluation of Education in Winter Semester of Academic Year 2019/2020 which is traditional method how evaluate the education at the university. The evaluation should be available in spring 2020.

Results and Discussion

Processing of Graphic Information subject was launched in 2007/2008 academic year and the following SWOT analysis of this subject was performed in the last year:

Strengths:

- longtime experiences with subject teaching,
- maintenance of AATCe classroom with mobile technologies accessories directly supporting AR technologies,
- longtime experiences with programming language learning,
- availability of the central Augmented Reality Lab that is equipped with all the necessary hardware and software equipment,

- establishment of conditions for collaboration with other faculties of our university during implementation of the VR and AR technologies,
- existence of the Sunflower Centre organizing support services of students with special needs at professional level,
- direct support provided by university management in all the areas of support of students with special needs which is embodied in a long-term plan of university as one of its priorities,
- practical realization of the complex rich-media visualization of the learning process and its availability in the form of standard services and technologies used in routine in the frame of the MERLINGO project,
- cooperation with external commercial firms in the areas of VR and AR technologies.

Weaknesses:

- relatively high purchase price of VR and AR equipment (especially AR glasses) and the necessity of annual payment for programming support to supplier,
- difficult creating of inherent software support for the educational purposes,
- technical difficulties in realization of presentations of records in locations which are not equipped with a necessary infrastructure requiring relatively expensive and time-consuming technical support,
- impossibility to outfit each teaching staff with their own mobile VR and AR devices that could be used for preparation of the lectures,
- VR and AR programming systems used for learning process do not have Czech localization,
- study materials of all kinds are not adapted for the students with special needs.

Opportunities:

- so far unused possibility of cooperation with the universities in the Czech Republic during implementation of the VR and AR technologies in the learning process,
- possibility of own development of VR and AR software components that will be deployed in the learning process,
- a possibility of implementation of new progressive mobile VR and AR technologies and their application in the learning process,
- development of the methodology enabling adaptation of the learning objects based on the VR and AR technologies for the students with special needs.

Threats:

- potential difficulty with further funding of the VR and AR activities in the present economic situation of the faculty,
- termination of the commercial firms whose VR and AR products are used in the frame of the learning process,
- unpredictable development in the area of VR and AR technologies,
- actual absence of established and accepted international standards and APIs in the VR and AR areas.

Firstly, the analysis of available AR and VR software and devices were provided. The main indicators were defined: price, possibilities of the software and devices and service. Lego AR and UNITY were chosen as available for start education in area of AR and VR. If it will be successful, the possibilities and budget can be increasing, and the area of AR and VR can be developed. Next step is Learn with the software and devices. In this case, the software is user-friendly. Learn with it was easy. Mainly the Lego AR, because there are not available some changes or programming. For students which have not programming anytime it is good. Contain the AR and VR to graphic

subject is next step. It means find the available weeks when will be the AR and VR will be learned in the semester. Because the students learn the basic of graphic and video in the first part of semester. The VR and AR were sorted to the end of the semester. Contain of the AR and VR lessons is next: explain the basic information about AR and VR, base tasks in the software and creating own applications if it will be possible. Evaluation of the implementation the AR and VR to graphic subject is next. The students invited the introduction to the AR and VR basics. Mainly their own possibilities to try the technologies. Creating the elements in the software was important for them, because they own want to create something as what they saw in the examples of VR. Most of them would as to continue with learning about AR and VR with creating the elements next semester if it was available. During the semester students which haven´t listed the subject come to the teacher and want to invite the lessons. It was enabled up to full capacity of the room. All of student's successful pass the graphic subject. All of them pass through the subject at first term of exam. The successful pass through the subject increase from 90% to 100%. Student Interest of the subject increase twice (counted for students which have not the subject next academic year compulsory). The capacity of the room is not enough, so the subject will be learned in more lessons. The chosen software stays the same for the next academic year. Only in area of AR will be extended about Place and Figment AR. Extending of area of interest of AR and VR is planned in next academic years. And if it will be possible will create special subjects focused on it. All findings are founded from questionnaires evaluation and surrounding information. The questionnaire has 6 questions:

1. Have you ever used AR or VR before this subject?
2. Have you been motivated to try AR or VR technology to choose this subject?
3. Do you find lessons more interesting because of implementation of AR and VR?
4. Do you think that you will increase your ability to work in practise because of knowledge of AR and VR?
5. Do you find the scope of AR and VR teaching sufficient for this subject?
6. Would you appreciate a separate subject focused only on AR and VR?

Students can choose only 2 answers for each question: Yes or No. 20 students attends the lessons. All counts are converted to percentages. Answers of the students are visible in the Tab. 1.

Answer	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6
Yes	40%	80%	90%	60%	50%	70%
No	60%	20%	10%	40%	50%	30%

Table 1: Questionnary research of Processing of Graphic Information (source: own calculation)

Interest in AR and VR, increasing favour about the subject and possibility of own AR and VR subject are the base conclusion from the first testing provided through questionnaires. It is interesting that students are thinking about the work in practice with using the AR and VR after the first few tasks in this branch. Knowledge of AR and VR increase area of possible future jobs for the students also. Cooperation with companies regarding AR and VR is communicated now. The students can cooperate on projects of the companies or create their bachelor or master thesis on this topic in the future. The implementation of AR and VR to graphic subject is only positive just now. One disadvantage of this is the price of equipment for AR and VR. But in this case the faculty have gained project for funding the base equipment.

Process of the implementation the AR or VR to the education is solved often now (Alsadoon and Alhussain, 2019). Some teachers just implemented the AR and VR to their subjects and now connect these technologies with other technologies, e.g. QR codes (Kamarainen et al, 2013). Faculty of Economics of VSB – Technical University of Ostrava solves this problematic first time.

Process of implementation AR and VR for the Processing of Graphic Information was chosen as training method. It is one of the most used method of implementation of these technologies in the education (Alsadoon and Alhussain, 2019). The process allows connection of teacher and student in education. This have many positive effects and create the lessons more interesting for students (Saltan and Arslan, 2016). The positive impact is visible from the answers in the questionnaires also. AR and VR have potential for next development at the university. First step is next semester with extending of range of teaching of AR and VR and capacity of the subject increase (based on the students' interest and other conditions).

Conclusion

The paper is focused on implementation of AR and VR to the graphic subject. Because of increasing implementation ICT to education (thought except ICT subjects) gives education more effective and understandable for students. AR and VR are chosen because the development of the technologies is rapid and their using in the future is clear. Graphic subject was chosen for implementation of AR and VR. Because in this subject the students work with objects of the real world or create their own. AR and VR are implemented via training method (cooperation students and teacher) to the subject after raster and vector graphics. Firstly, the students try the applications using the AR (Lego AR). Then the students try the applications using the VR (UNITY). After this student try to make their own elements in UNITY. Firstly, the introduction to the software is provided. Students try their own elements after the basics. Evaluation of the implementation was provided through questionnaires. Pass through the subject increase to 100% after implementation of AR and VR. The students are motivated, and they enjoy the lessons. The interest of subject is twice bigger than before. The next academic year the capacity of the subject will be increased. Students which absolve the subject would as to continue with AR and VR. The creating of special subject is proposed. Knowledge of AR and VR is interesting for students from job searching view. The cooperation between university and companies using AR and VR is communicated now. Students can have more possibilities of using this knowledge in the future. Extending of the learning of AR and VR and cooperation with companies is the way for the future.

Acknowledgement

This research was financially supported by RPP2020/132 project at VSB-Technical University of Ostrava.

References

AATCe, (2020) *Apple Authorized Training Center for Education,* [Online], Available: http://training.apple.com/aatc/education [10 Feb 2020].

Alsadoon, H. and Alhussain, T. (2019) 'Faculty of Saudi Electronic University Attitudes towards Using Agumented Reality in Education', *Education and Information Technologies*, no. 24, pp. 1961-1972. https://doi.org/10.1007/s10639-018-9826-z

Armstrong, M. (1996) *Management Processes and Functions*, London: CIPD.

Blackwell, C.K., Lauricella, A.R. and Wartella, E. (2014) 'Factors influencing digital technology use in early childhood education', Computer Education, vol. 77, pp. 82-90. https://doi.org/10.1016/j.compedu.2014.04.013

Domingo, M.G. and Garganté, A.B. (2016) 'Exploring the use of education technology in primary educations: Teachers perception of mobile technology learning impacts and applications use in the classroom', *Computer Human Behaviour*, vol. 56, pp. 21-28. https://doi.org/10.1016/j.chb.2015.11.023

Kamarainen, A.M., Metcalf S., Grotzer, T., Browne, A., Mazzuca, D., Tutwiler, R.S. and Dede, C. (2013) 'EcoMOBILE: Integrating Augmented Reality and Probeware with Enviromental Education Field Trips', *Computers & Education*, vol. 68, pp. 789-799. https://doi.org/10.1016/j.compedu.2013.02.018
Martín-Gutiérrez, J., Fabiani, P., Benesova, W., Meneses, M.D. and Mora, C.E. (2015) 'Augmented reality to promote collaborative and autonomous leraning in higher education', *Computer Human Behaviour*, vol. 51 part B, pp. 752-761. https://doi.org/10.1016/j.chb.2014.11.093
Morrison, A., Mulloni, A., Lemmela, S., Oulasvirta, A., Jacucci, G., Peltonen, P., Schmalstieg, D. and Regenbrecht, H. (2011) 'Collaborative Use of Mobile Augmented Reality with Paper Maps. *Computers & Graphics*, vol. 35, no. 4, pp. 789-799. https://doi.org/10.1016/j.cag.2011.04.009
Nincarean, D., Ali, M.B., Halim, N.D.A. and Rahman, M.H.A. (2013) 'Mobile Augmented Reality: The Potential for Education', *Procedia - Social Behaviour Sciences*, vol. 103, pp. 657-664. https://doi.org/10.1016/j.sbspro.2013.10.385
Saidin, N.F., Halim, N.D.A. and Yahaya, N. (2015) 'A Review of Research on Augmented Reality in Education: Advantages and Applications', *International Education Studies*, vol. 8, no. 13, pp. 1-8. https://doi.org/ 10.5539/ies.v8n13p1
Saltan, F. and Arslan, R. (2016) 'The Use of Augmented Reality in Formal Education: A Scoping Review', *Jornal of Mathematics Science and Technology Education*, vol. 13, no. 2, pp. 503-520. https://doi.org/10.12973/eurasia.2017.00628a
Serio, A.D., Ibanez, M.B. and Kloos, C.D. (2013) 'Impact of an Augmented Reality Systém on Students Motivation for a Visual Art Course', *Computers & Education*, vol. 68, pp. 586-596. https://doi.org/ 10.1016/j.compedu.2012.03.002
Sirakaya, M. and Kilic Cakmak, E. (2018) 'Investigating Students Attitudes toward Augmented Reality', *Malaysian Online Journal of Educational Technology*, vol. 6, no. 1, pp. 30-44.
Sutherland, L.E. (1970) 'Computer displays', *Scientific American*, vol. 6, no. 222, pp. 56-81.

TOLERANCE OF AMBIGUITY AND READING COMPREHENSION IN FOREIGN LANGUAGE EDUCATION

[1]✉Anikó Ficzere, [2]Eva Stranovská, [2]Zdenka Gadušová

[1]Constantine the Philosopher University in Nitra, Slovakia, aniko.ficzere@ukf.sk
[2]Constantine the Philosopher University in Nitra, Slovakia

Abstract

Foreign language reading comprehension helps the individual to recognize language structure and perceive the cultural specificities of the target while encountering ambiguities. To what extent an individual tolerates the ambiguity, on the one hand, affects text understanding as well as the whole educational process, and, on the other hand, the educational process helps them to tolerate ambiguity. The aim of the paper is to point out the importance of tolerance of ambiguity in the educational context of developing reading comprehension in a foreign language. In our research we focus on the correlations of foreign language reading comprehension and the tolerance of ambiguity, and its different sub-factors, such as tolerance of novelty, complexity and insolubility. The research was carried out in different parts of Slovakia with 305 students of secondary vocational schools. The findings have shown that ambiguity, novelty and complexity are closely linked to success in reading comprehension.

Keywords

Complexity, comprehension, education, foreign language, reading, tolerance of ambiguity

Introduction

Tolerance of ambiguity is a broad spectrum concept that describes an individual's response to stimuli or situations that cannot be clearly understood and explained on the basis of available information (Furnham and Marks, 2013). The phenomenon of tolerance of ambiguity also plays an important role in the context of learning a foreign language. The learner is regularly exposed to unknown meanings and rules, so some degree of tolerance for ambiguous impulses is essential for the success of the long-term and often challenging process of foreign language learning and acquisition. Despite this relevance, the link between tolerance of ambiguity and foreign language skills belongs to one of the less researched areas.

The concept of the tolerance of ambiguity was introduced by Frenkel-Brunswick (1948), who characterizes it as a personality variable of perceptual and emotional character. The tolerance of ambiguity is manifested in different areas of an individual's functioning: their perception, cognitive style of thinking, attitudes, emotional responses, interpersonal relationships and problem solving (Ehrman, Leaver and Oxford, 2003; Furnham and Marks, 2013; Oxford, 1992). According to Furnham and Ribchester (1995: 179), the tolerance of ambiguity 'refers to the way an individual (or a group of them) perceives and processes information about ambiguous situations. A person with low tolerance of ambiguity experiences stress, reacts prematurely, and avoids ambiguous stimuli. At the other extreme of the scale, however, a person with high tolerance of ambiguity perceives ambiguous situations/stimuli as desirable, challenging, and interesting and neither denies nor distorts their complexity of incongruity'. Budner (1962) divided ambiguous situations into three groups: new (for which an individual does not have appropriate processing or solution patterns), complex (in which there are too many cues which could be used to resolve the situation) and contradictory (in which possible solutions are incompatible with each other).

In the field of foreign language learning, tolerance of ambiguity has most widely been studied in relation to different the personality characteristics of learners (Dewaele and Wei, 2013; Oxford, 1992), the use of different learning strategies (Qingzong, 2004) and anxieties and risk taking in foreign language performance (Dewaele and Ip, 2013; Oxford and Ehrman, 1992). The tolerance of ambiguity allows individuals not just to confine themselves to the perception and use of already known language elements, but it enables them to differentiate other layers of a foreign language, as, for example, communication strategies and patterns of conversational units typical for native speakers (Stranovská, 2011). Gudykunst (2005) assumes that the mid-range of tolerance of ambiguity creates ideal conditions for effective foreign-language communication. While a person with too low tolerance of ambiguity is experiencing anxieties and avoids ambiguous situations, a person with too high tolerance of ambiguity may be passive and lose sensitivity to foreign language and its culture. Pupils with ideal tolerance of ambiguity can process incomplete and ambiguous information; they experience less stress during learning, use more effective learning strategies, and show better results in foreign language performance (Dewaele and Ip, 2013; Oxford and Ehrman, 1992 and many others). Tolerance of ambiguity is also related to cultural competence and faster adaptation to a new culture (Herman et al, 2009). Recent research shows the interaction of foreign language learning and tolerance of ambiguity: not only a moderate and slightly higher tolerance of ambiguity value has a positive effect on foreign language performance, advanced foreign language learners and multilinguals also show higher tolerance of ambiguity. In this respect, experience with a foreign language or contact with the culture of the target language develops the openness of pupils to unknown, uncertain stimuli and a sense of a more comprehensive perception of language and culture (Dewaele and Wei, 2013; Erten and Topkaya, 2009).

Ambiguity is undoubtedly also present in the process of understanding a foreign-language text. Meireles (2006) identifies three important areas in which the specifics of foreign-language reading manifest themselves. They are: linguistic prerequisites, knowledge and conventions in stylistics, and socio-cultural knowledge of the reader. Foreign language readers are characterized by reduced reading fluency compared to their mother tongue reading. The reason for this slower reading pace is limited vocabulary knowledge and a lack of automation of basic language skills. The lack of knowledge about writing conventions in the target language also makes it more difficult to understand a foreign text. The challenge for the reader is to recognize grammatical and stylistic markers in a foreign language (e.g. specific grammatical phenomena, occurrence of non-standard expressions in the text, and others). The interpretation of the text is also influenced by cultural assumptions and knowledge. Authors of texts usually assume this cultural knowledge with the reader and it therefore remains unspoken in the text. A foreign-language reader in the process of text comprehension must reflect and compare one's own cultural norms with those of the target culture, which may also cause ambiguity during the understanding of it (Erten and Topkaya, 2009). Moreover, the factors of the cultural awareness of the reader and their cultural outlook also influence reading comprehension. These factors can be applied latently in communities characterized by ethnic, religious, geographical, and economic diversity (Králik, Lenovský and Pavlíková, 2018). In a way, there is some parallel to acquiring understanding of different forms of communication in the field of technology (Hašková, Manduľáková and Van Merode, 2017).

By applying the characteristics of ambiguous situations indicated by Budner (1962), we can assume that reading in a foreign language raises a variety of challenges for the reader:

- novelty of unknown words and language structures;
- complexity of word formation, sentence formulation and formulation of larger units of text, unknown stylistic markers;
- insolvability of conflicting information in the text, which can be caused both by the characteristics of the text itself and by different cultural standards in the native and target languages, which allow different interpretations of the meaning of the text.

Despite the outlined specificities, reading comprehension in connection with tolerance of ambiguity is one of the less explored research areas. While several studies have focused on the link between tolerance of ambiguity and overall foreign language performance (Oxford, 1992; Oxford and Ehrman, 1992), there is still a lack of research in foreign language text comprehension to further clarify the relationship between tolerance of ambiguity and text understanding on greater research samples. Existing research in this field has so far produced controversial results. In the El-Kouma research (2000, in Liu, 2015), a group of students with average tolerance of ambiguity performed significantly better in understanding foreign language texts compared to students with low and high tolerance of ambiguity. Erten and Topkaya (2009) found a significant correlation between tolerance of ambiguity and student self-assessment of their reading comprehension: students with a higher level of tolerance of ambiguity experienced more success and rated more positively their performance in foreign language reading comprehension. However, the research of Grace (1998) did not confirm the link between tolerance of ambiguity and vocabulary remembering performance in beginners.

The aim of the paper is to point out the importance of tolerance of ambiguity in the educational context of developing reading comprehension in a foreign language and at the same time the connection between tolerance of ambiguity and the process of understanding a foreign language text. We have been trying to find out the correlations between tolerance of ambiguity and understanding in more detail in relation to individual tolerance of ambiguity sub-factors, i. e. tolerance of novelty, complexity and insolubility.

The paper is structured into the following parts: introduction, where the theoretical basis of tolerance of ambiguity and understanding of foreign language text is analyzed; a methodology in which variables are operationalized, hypotheses are defined, the research set and research methods are characterized and research results are analyzed, interpreted and discussed. The last part of the paper is a conclusion, a summary of the research results and an outline of further research direction.

Materials and Methods

Research sample

The research was carried out at secondary grammar and vocational schools in all regions of Slovakia on a sample of 305 students. They were full-time students in the 3rd year of upper secondary vocational schools (hotel academies, business academies, schools of commerce, polytechnic schools, veterinary schools, and electro-technical schools) and grammar schools who are obliged to study English as their first foreign language. Their level of CEFR is B1. The average age of students was 17.5 years. The students have been learning English for 10 years in average.

Hypotheses

In our study, we set out four hypotheses which were verified by correlation analysis. The relationship between the variable *reading comprehension* in foreign language and the variable *tolerance of ambiguity* were examined.

- H01: We assume no relationship between English *reading comprehension* and *tolerance of ambiguity*.
- H02: We assume no relationship between *reading comprehension* and the sub-factor *tolerance of novelty*.
- H03: We assume no relationship between *reading comprehension* and the sub-factor *tolerance of complexity*.
- H04: We assume no relationship between *reading comprehension* and the sub-factor *tolerance of insolvability*.

Methods

The Tolerance of Ambiguity Scale determines *tolerance of ambiguity*. The 16-item Tolerance of Ambiguity Scale was developed by Budner (1962). All responses were based on a seven-point scale, from 1 (Strongly Disagree) to 7 (Strongly Agree). Ambiguity arises from three basic sources: *novelty*, *complexity*, and *insolvability*. These three sub-scales are included in the presented ambiguity measurement tool. Lower scores indicate greater *tolerance of ambiguity*.
The reading comprehension test in English was developed by a team of experts within the project APVV-17-0071 Promoting Reading Literacy in Mother Tongue and Foreign Language (Gadušová et al., 2019). The development of the test was based on the Slovak language policy documents, the State Educational Program and the Common European Framework of Reference (CEFR). The didactic test measured students' performance in *reading comprehension* at B1 level. The test consisted of four texts - two of them ranging up to 250 words and the other two up to 320 words, which is the appropriate text extent for B1 students. The total number of items was 21 (5 items per text with the exception of task number three which included six items designed for the information transfer task). For each of the four tasks different testing techniques were used to satisfy different preferences of the test taking students when writing the test.

Results

Pearson's correlation analysis was used to test the research hypotheses. Using correlation, we tried to find a link between *reading comprehension* and selected cognitive characteristics, in particular, *tolerance of ambiguity* and its sub-factors. We used Pearson correlation, suitable for metric variables, to determine the linear relationship between selected variables. We also tested the correlation strength, or coefficient of determination r^2. The coefficient of determination r^2 (squared Pearson's r) determines what percentage of the total variance in *reading comprehension* can be explained by the variable *tolerance of ambiguity*. Values of r^2 below 0.01 characterize a weak relationship between the variables, values up to 0.09 are moderate ones, and values above 0.25 indicate a strong relationship (Schwartz, Wilson and Goff, 2015).
Correlation analysis confirmed a statistically significant positive relationship between *reading comprehension* and *tolerance of ambiguity* (p =.0001***), based on which we can reject the first null hypothesis. Most of our respondents were in the middle to slightly higher band of *tolerance of ambiguity*. In parallel with lower values of tolerance, the *reading comprehension* performance in our sample slightly decreased (Tab. 1).

		Tolerance of Ambiguity	Novelty	Complexity	Insolvability
Reading comprehension	Pearson Correlation	.213**	.135*	.210**	.014
	Sig. (2-tailed)	.000	.019	.000	.802
	r^2	.045	.018	.044	–

The values of statistical significance p =.05(*), p =.01(**), p =.001(***).

Table 1: Correlations (Pearson r) between reading comprehension and the sub-factors of tolerance of ambiguity, 2018-2019 (source: own calculation)

In our research, we also tested the relationship between *reading comprehension* and individual sub-factors of *tolerance of ambiguity* according to Budner (1962); i.e. *novelty*, *complexity* and *insolvability*. A statistically significant relationship was confirmed for *tolerance to novelty* (p =.01*) and *complexity* (p =.0001***). The strength of the relationship between *reading comprehension* and *tolerance to complexity* is moderate, in the case of *tolerance to novelty*, it is

relatively moderate. The statistically significant relationship between *reading comprehension* and *tolerance to insolvability* has not been confirmed in our research.

Discussion

The results of our research are in line with previous studies that have shown a possible link between tolerance of ambiguity, language proficiency and communication success (Dewaele and Ip, 2013; Oxford and Ehrman, 1992; Oxford, 1992). The personality characteristic of tolerance of ambiguity is considered as one of the possible factors explaining the research question of many experts in applied psycho-linguistics, i.e. what is behind the different performance of foreign language pupils who study a foreign language under the same conditions. We agree with the findings of Ehrman, Leaver and Oxford (2003) and Furnham and Marks (2013) that tolerance of ambiguity has a complex impact on the process of understanding, on selected learning strategies, on the cognitive functioning and on the emotional experience of the individual. The learner is regularly exposed to unknown word meanings and grammar rules, so some degree of tolerance of ambiguous stimuli is essential for the success of the long-term and often challenging process of foreign language acquisition. We believe that the degree of tolerance of ambiguity is associated with risk-taking, because the risk factor in reading comprehension means an individual‘s ability to break away from the use of established means of expression, to experiment with new language phrases and sentence structures while developing linguistic creativity (Dewaele and Ip, 2013; Oxford and Ehrman, 1992).

Among the sub-factors of tolerance of ambiguity, the relationship with performance in reading comprehension was most evident in the case of tolerance of the complexity of the stimulus. In this respect, tolerance is reflected in thought flexibility. The individual is not limited to the perception and use of already known elements of the language, but is able to simultaneously process other layers of a foreign language, such as, for example, communication strategies and patterns of conversational units (Stranovská, 2011). A positive response to the complexity of the text is also important in terms of processing information from the text: the complexity-tolerant learner can flexibly manipulate a variety of information in order to form the information core of the read text.

Tolerance of ambiguity is one of the relatively accessible personality traits that not only affects the success of the educational process, but can also develop itself in this process (Dewaele and Wei, 2013; Erten and Topkaya, 2009). In this context, we consider the systematic work of the educator and targeted intervention in this area to be extremely important (Gadušová and Ďurková, 2018). By developing a flexible perception of language means and structures, by promoting inferential and divergent thinking, by encouraging personal contact with the culture of the target language, the educator can guide pupils to a more comprehensive and accurate understanding of a foreign language text. Khonamri and Ahmadi (2015) recommend the application of metacognitive strategies in the process of development of understanding.

Tolerance of ambiguity can be applied not only in reading comprehension or learning a foreign language, but also in the context of other subject education, because tolerance of ambiguity proves to be not only a perceptual variable in the educational process, but also an affective and personality variable (Ehrman, Leaver and Oxford, 2003; Furnham and Marks, 2013). In addition to cognitive and personality predispositions, it is closely connected with the social level of learning. Tolerance of ambiguity can therefore be seen as a complex personality variable involved in cognitive structuring processes, or cognitive processing of a foreign language.

The processes of cognitive structuring in acquiring reading comprehension can be used to anticipate and predict the situational context of a foreign language text. In this sense, experience with a foreign language or contact with the culture of the target language develops the openness of individuals to unknown, uncertain impulses and a sense of a more comprehensive perception of language and culture.

As a limit of our research, we perceive the selection of the research sample that included upper-secondary school students with advanced level of foreign language proficiency. Further research should therefore examine the dynamics of tolerance of ambiguity and its relationship to reading comprehension at other levels of foreign language proficiency and in different age groups. Based on our results, we cannot comment on the issue of lower and upper thresholds of uncertainty.

Conclusion

The aim of the study was to discover the correlations of foreign language reading comprehension and tolerance of ambiguity and its different sub-factors such as tolerance to novelty, complexity and insolvability.

The presented research identified that tolerance of ambiguity is significantly related to reading comprehension in English; therefore we rejected the first null hypothesis. Tolerance of ambiguity and its two factors which are tolerance of novelty and tolerance of complexity appear as predictors in developing reading comprehension of English language texts. No statistically significant relationship was found in the third factor - tolerance of insolvability. Hypotheses assuming no correlation of reading comprehension, tolerance of ambiguity, tolerance of novelty and tolerance of complexity have been rejected. The hypothesis assuming no correlation between reading comprehension and tolerance of insolvability has not been rejected. It emerged that tolerance of ambiguity fostered understanding of the text in English and predicted success in learning English. New impulses and their complexity, such as new vocabulary in a text where one word has multiple meanings, or grammar where there is more than one correct form of utterance support the ability to work with new information in the text and process it without feeling frustrated. In this respect, we consider tolerance of ambiguity to be not only beneficial, but also necessary in the process of foreign language education. In the presented research, the focus was on correlations in general. A possible direction for further research could be a more detailed analysis of this relationship in connection with Gudykunst‘s theory of lower and upper thresholds of uncertainty (Gudykunst, 2005). Another perspective of the research is perceived in determining the dynamics of tolerance of ambiguity and its factors in the process of developing reading comprehension, or in determining the dynamics of reading comprehension with respect to the intervention of tolerance of ambiguity in the educational process.

Acknowledgement

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-17-0071 and VEGA 1/0062/19.

References

Budner, S.N.Y. (1962) ‘Intolerance of ambiguity as a personality variable’, *Journal of Personality*, vol. 30, pp. 29 – 50.

Dewaele, J.-M. and Ip, T.S. (2013) ‘The link between Foreign Language Classroom Anxiety, Second Language Tolerance of Ambiguity and Self-rated English proficiency among Chinese learners’, *Studies in Second Language Learning and Teaching*, vol. 3, no. 1, pp. 47 – 66. http://dx.doi.org/10.14746/ssllt.2013.3.1.3

Dewaele, J.-M. and Li, W. (2013) ‘Is multilingualism linked to a higher tolerance of ambiguity?’, *Bilingualism: Language and Cognition,* vol. 16, no. 1, pp. 231 – 240. http://dx.doi.org/10.1017/S1366728912000570

Ehrman, M.E., Leaver, B.L. and Oxford, R.L. (2003) ‘A brief overview of individual differences insecond language learning’, *System*, vol. 31, no. 3, pp. 313 – 330. http://dx.doi.org/10.1016/S0346-251X(03)00045-9

Erten, I.H. and Topkaya, E.Z. (2009) 'Understanding tolerance of ambiguity of EFL learners in reading classes at tertiary level', *Novitas-ROYAL*, vol. 3, no. 1, pp. 29 – 44.
Frenkel-Brunswik, E. (1948) 'Intolerance of Ambiguity as an Emotional and Perceptual Personality Variable', *Journal of Personality*, vol. 18, no. 1, pp. 108 – 123. http://dx.doi.org/10.1111/j.1467-6494.1949.tb01236.x
Furnham, A. and Marks, J. (2013) 'Tolerance of Ambiguity: A Review of the Recent Literature', *Psychology*, vol. 4, no. 9, pp. 717 – 728. http://dx.doi.org/10.4236/psych.2013.49102
Furnham, A. and Ribchester, T. (1995) 'Tolerance of ambiguity: A review of the concept, its measurement and applications', *Current Psychology*, vol. 14, Fall, pp. 179 – 199. http://dx.doi.org/10.1007/BF02686907
Gadušová, Z. and Ďurková, S. (2018) 'Responsible Self-Assessment as Part of Teacher Assessment', *Proceedings of the 15th International Conference (ERIE 2018),* Prague, pp. 61-68.
Gadušová, Z., Hvozdíková, S., Klimková, S., Hricková, M. and Ďurišová, S. (2019) *Reading comprehension test in English*. Internal document, Constantine the Philosopher University, Nitra. Unpublished.
Grace, C. (1998) 'Personality Type, Tolerance of Ambiguity, and Vocabulary Retention in CALL', *CALICO Journal*, vol. 15, no. 1-3, pp. 19 – 46. http://dx.doi.org/10.1558/cj.v15i1-3.19-45
Gudykunst, W.B. (2005) 'An Anxiety / Uncertainty Management (AUM) theory of strangers' intercultural adjustment', In *Theorizing about intercultural communication,* Thousand Oaks, CA: Sage.
Hašková, A., Manduľáková, S. and Van Merode, D. (2017) 'Problematic Aspects of Technology Education in Slovakia', *Communications: scientific letters of the University of Žilina*, vol. 19, no. 1/2017, pp. 75 – 80.
Herman, J.L., Stevens, M.J., Bird, A., Mendenhall, M., and Oddou, G., (2009) 'The Tolerance Ambiguity Scale: Towards a more refined measure for international management research', *International Journal of Intercultural Relations*, vol. 34, no. 1, pp. 58 – 65. http://dx.doi.org/10.1016/j.ijintrel.2009.09.004
Khonamri, F. and Ahmadi, F. (2015) 'The effect of metacognitive strategy training and raising EFL learners' Metacognitive knowledge on listening performance', *Indonesian Journal of Applied Linguistics*, vol. 5, no. 1, pp. 19 – 28.
Králik, R., Lenovský, L. and Pavlíková, M. (2018) 'A few comments on identity and culture of one ethnic minority in Central Europe', *European Journal of Science and Theology*, vol.14, no.6, pp. 63 – 76.
Meireles, S.M. (2006) 'Leseverstehen aus der Perspektive des Nicht-Muttersprachlers', in Blühdorn, H., Breindl, E. and Wassner, U.H. (eds.) *Text-Verstehen*, Berlin, New York: Walter de Gruyter.
Liu, C. (2015) 'Relevant Researches on Tolerance of Ambiguity', *Theory and Practice in Language Studies*, vol. 5, no. 9, September, pp. 1874 – 1882. http://dx.doi.org/10.17507/tpls.0509.15
Oxford, R. (1992) 'Who are our students? A synthesis of foreign and second language research on individual differences with implications for instructional practice', *TESL Canada Journal*, vol. 9, no. 2, pp. 30 – 49. http://dx.doi.org/10.18806/tesl.v9i2.602
Oxford, R.L. and Ehrman, M. (1992) 'Second language research on individual differences', *Annual Review of Applied Linguistics*, vol. 13, pp. 188 – 205. http://dx.doi.org/10.1017/S0267190500002464
Qingzong, Z. (2004) 'Effects of tolerance of ambiguity on the selection of language learning strategies', *Foreign Language Teaching and Research*, vol. 6, pp. 10 – 22.
Schwartz, B.M., Wilson, J.H. and Goff, D.M. (2015) *An EasyGuide to research design & SPSS*, Los Angeles, London: SAGE.
Stranovská, E. (2011) *Psycholingvistika: Determinanty osvojovania si a učenia sa cudzieho jazyka a kultúry*, Brno: MSD.

ARE STUDENTS ABLE TO IDENTIFY AN IMAGE OF A STRAIGHT LINE IN ROTATION?

[1]✉Zdeněk Halas, [2]Vlasta Moravcová, [2]Jarmila Robová, [2]Jana Hromadová

[1]Department of Mathematics Education, Faculty of Mathematics and Physics, Charles University, Czech Republic, halas@karlin.mff.cuni.cz

[2]Department of Mathematics Education, Faculty of Mathematics and Physics, Charles University, Czech Republic

Abstract

This article focuses on whether students are able to identify a straight line image in a particular rotation. A straight line is one of the basic geometric figures and the ability to rotate a straight line is a prerequisite for solving more complex tasks, according to the Czech national curriculum. Additionally, we were interested in gender differences in solving this task, which can contribute to research into the differences in spatial ability between males and females. Contemporary Czech mathematics textbooks were analysed in order to determine possible causes for frequent mistakes. Finally, we present some recommendations for pre-service mathematics teachers' education.

Keywords

Gender differences, mathematics education, rotation, spatial ability, straight line

Introduction

We have been researching Czech students' understanding of various geometric terms for a long time (e.g., Moravcová et al, 2019; Halas et al, 2019; Robová et al, 2019). In this article, we deal with rotation. Rotation in a plane is a part of the Czech national curriculum for general upper secondary schools (grammar schools). According to the curriculum prepared by Research Institute of Education (VÚP, 2007), one of the expected outcomes is that a pupil shall solve construction exercises using loci, isometries and constructions based on calculation. The isometries mentioned are axial and central symmetries, translation and rotation (in this order). In accordance with the curriculum, these four transformations are included in all contemporary Czech mathematics textbooks for upper secondary schools. Understanding the concept of rotation is important because it can facilitate students' understanding of other mathematics terms (such as trigonometric functions). Moreover, geometric transformations are widely used in many practical areas of human activity (e.g., in programming the movement of robotic devices or figures in computer games).

The process of forming geometrical concepts has been the focus of many theories. One of them is the Theory of Generic Models, which analyses mathematical understanding from the constructivist perspective (Hejný, 2012): the students encounter abstract knowledge via motivation, experience with the isolated models and via the creation of the generic models. Students' preconcepts or their informal understanding play an important role during this process (Gülkılık, Uğurlu and Yürük, 2015; Jagoda and Swoboda, 2011). In order to understand a rotation as a transformation, it is important to connect both a static (e.g., two figures are congruent) and a dynamic approach (i.e., to conceive the movement that is transforming the first figure into the second one) to this concept (Thaqi, Giménez and Rosich, 2011; Jagoda and Swoboda, 2011).

Research studies (Ada and Kurtulus, 2010; Turgut, Yenilmez and Anapa, 2014; Kambilombilo and Sakala, 2015; Mainali and Heck, 2017) revealed that not only secondary school students but also pre-service and in-service mathematics teachers did not appropriately adopt the concept of

rotation. In the above-mentioned studies, neither students nor pre-service teachers paid attention to the angle or the centre of rotation; they did not consider distances of points; i.e., they did not understand the geometric meaning of *rotation*. The tasks in which the centre of rotation was not part of initial figure were usually more difficult for them. Mainali and Heck (2017: 499) discovered that 'it is not just a matter of being a point on or disjoint from the object to be rotated. What matters is whether a student perceives the configuration in this way or not.' Kambilombilo and Sakala (2015) found that in-service teachers had serious problems in transformational geometry including rotation.

In the presented part of our research, we focused on two research problems:

1. Are students able to identify a straight line image in ±90° rotation?
2. Are there any significant gender differences in solving this task?

Materials and Methods

For the purposes of this research, 516 students in two age groups were given an anonymous written test (see Table 1). The participating students were selected purely on the basis of their availability. The test was given to three groups of participants: students in the last grade of upper secondary school (USS), students in the first grade of university (UNI), and pre-service mathematics teachers (PST) in the last two years of their studies. The students were differentiated by gender.

Groups of students	Number of students	Typical age	Testing date
USS	311	19	2018 Apr.
UNI	161	19	2017 Oct.–Nov.
PST	44	22–23	2017 Oct.–Nov.

Table 1: Overview of tested students (source: own data)

The test was based on the Czech national curriculum (VÚP, 2007). One of the ten tasks in the test was as follows: 'Circle the pictures in which the straight line p' is formed by ±90° rotation of the straight line p about the centre S' (see Fig. 1). We have abandoned the examination of a point image because it is too elementary; thus we decided to investigate an image of other basic geometric figure — a straight line. Furthermore, the ability to rotate a straight line is a prerequisite for solving more complex tasks.

The comprehensibility of the test, as well as the time limit, were verified and determined on the basis of a pre-test given to a small group of students and subsequent semi-structured interviews between researchers and students.

The tests were assessed qualitatively. Each student's answer for each task was assigned a code. For purposes of data analysis in the rotation task we assigned letters *a*, *b*, *c*, *d*, *e* from the left to the right, line by line, to the five pictures (see Fig. 1). The correct answer (*a*, *c*, *d*) was assigned the code *OK*; for other answers the codes corresponded to the circled pictures. The *OA* column included other answers with low frequencies (i.e., combinations of answers not listed in Tables 2 and 3). The tests from every group were coded independently by pairs of researchers. Any discrepancy in the coding of a specific student's answer was discussed among the whole research team until a consensus was reached. From this data, the absolute and relative frequencies of the codes were determined for the rotation task, and the χ^2 independence test, odds ratio and Fisher's exact test were used for statistical analysis of data obtained in the study.

To enable a deeper analysis of the obtained data, we investigated in detail the contents of several current Czech mathematics textbooks. We concentrated on the following aspects: the definition of *rotation*; the order of the topic of rotation among other isometries; the occurrence of ±90° rotation; the occurrence of any example on rotation of a straight line.

For a better understanding of the test results, we gave a posttest consisting of two tasks. In Posttest task 1, the students solved the tasks *a*, *c*, *d* from the original test, but they had to draw the rotated line themselves (rotated just by +90°) while in the main test they only recognized the ±90° rotation. Posttest task 2 was identical to the one from the test (Fig. 1).

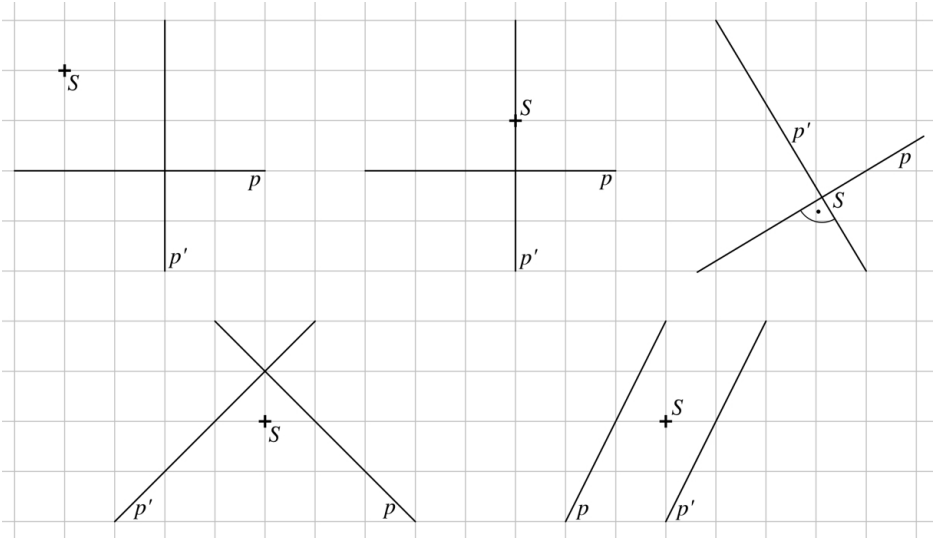


Figure 1: Assignment of the task about rotation (source: own data)

Results

First, we introduce textbook analysis. Then we focus on the results of the test and the posttest.

In most mathematics textbooks for upper secondary schools (Pomykalová, 1993; Pomykalová, Gergelitsová and Schovancová, 2012; Vondra, 2013; Molnár, 2011), the definition of rotation is the same (i.e., with use of the terms *oriented angle* and *the centre of rotation*). The exception is the textbook (Kadleček, 1996) in which rotation is defined without using the term *oriented angle*. The terms *angle* and *oriented angle* are mixed in (Vondra, 2013) because the term *oriented angle* includes the term *angle* there.

Concerning ±90° rotation, only one task (rotate the pentagon) occurs in (Pomykalová, 1993); another textbook (Pomykalová, Gergelitsová and Schovancová, 2012) contains one example which shows how to rotate a polyline and some exercises (rotate a line segment, a circle, an equilateral triangle). In (Vondra, 2013) and (Molnár, 2011), there are neither examples nor exercises on ±90° rotation. The textbook (Kadleček, 1996) contains only one exercise on ±90° rotation (rotate a triangle).

In all the textbooks, there are examples of rotation of a straight line. In the textbook (Kadleček, 1996), the rotation of a straight line is realized by the rotation of two points belonging to the straight line. In all other textbooks, the rotation of a straight line is realized with the use of the foot of the perpendicular from the centre of rotation to the rotated straight line.

Students' solutions of the test task on rotation are summarized in Tables 2 and 3, which show the frequency of occurrence (in percent) of each code.

Groups of students	*OK*	*cd*	*c*	*abcd*	*bc*	*ac*	*bcd*	*ad*	*OA*
USS	52.41	8.68	6.75	6.75	6.43	3.86	3.54	3.86	7.72
UNI	45.30	10.21	12.34	3.54	7.69	3.16	6.45	3.76	7.55
PST	52.27	15.91	2.27	9.09	2.27	6.82	2.27	0.00	9.09
Total	**50.19**	**9.11**	**8.72**	**5.81**	**5.43**	**4.65**	**3.68**	**3.49**	**8.91**

Table 2: Relative frequencies of students' answers by groups (source: own data)

Table 2 shows the differences between the groups. Students in the USS and PST groups had a similar result for code *OK* (corresponding to the answer *a*, *c*, *d*). The second most common answer was the one coded by *cd* (both *c* and *d* are correct, but students omitted the correct answer *a*), which PSTs chose more frequently. The occurrence of combinations of two correct options (codes *cd*, *ac*, *ad*) was 17.25% in total.

No. of students per groups		*OK*	*cd*	*c*	*abcd*	*bc*	*ac*	*bcd*	*ad*	*OA*
USS	M – 171	63.16	8.19	3.51	5.26	4.09	4.68	2.34	2.34	6.43
	F – 140	39.29	9.29	10.71	8.57	9.29	2.86	5.00	5.71	9.29
UNI	M – 108	45.37	6.48	15.74	2.78	1.85	7.41	2.78	3.70	13.89
	F – 53	45.28	11.32	11.32	3.77	9.43	1.89	7.55	3.77	5.66
PST	M – 12	66.67	0.00	0.00	16.67	0.00	0.00	0.00	0.00	16.67
	F – 32	46.88	21.88	3.13	6.25	3.13	9.38	3.13	0.00	6.25
Total	M – 291	56.70	7.22	7.90	4.81	3.09	5.50	2.41	2.75	9.62
	F – 225	41.78	11.56	9.78	7.11	8.44	3.56	5.33	4.44	8.00

Table 3: Relative frequencies of students' answers by groups with numbers of males (M) and females (F) (source: own data)

In accordance with the second research question, we also examined the gender differences in solving the rotation task in the test. Males in the USS and PST groups chose all three correct answers (*OK*) more frequently than females; we obtained similar result for the group of all 516 students. Only in the UNI group were the results of males and females comparable (see Table 3).

We verified these findings by the χ^2 independence test at the significance level of 0.01. For all the groups together, the hypothesis that the results of this task were sex-independent was rejected (the test criterion value 11.304 is greater than the critical value of 6.635). Further, we analysed the groups separately. The test criterion value for the USS group was 17.588 which is greater than the critical value of 6.635, thus the results of this task were not sex-independent. Moreover, the measure of association was the strongest in the USS group, as was shown by the odds ratio. The test criterion value for the UNI group was very low: 0.0001; thus the results were sex-independent. The χ^2 test conditions were not satisfied for the PST group (and its M subgroup); therefore, statistical analysis was carried out by Fisher's exact test. The Fisher's exact test statistic value was 0.3182, thus the hypothesis that the results are sex-dependent could be rejected at the significance level of 0.01.

In the posttest, we were interested in whether it is more difficult for students to construct a straight line rotated by +90° than to simply identify it. For this purpose, the posttest was given to an additional 71 students of USS and 32 PSTs. We tested the null hypothesis that correctly executed constructions in Posttest task 1 and the correct choice of a rotated straight line by ±90° in Postest task 2 are independent. The Fisher's exact test statistic value was $2.6 \cdot 10^{-5}$, which is less than 0.01, thus we could reject the null hypothesis at the significance level of 0.01: it was not merely a coincidence that students answered both tasks correctly. The association between correct constructions and correct identification of the rotated straight line was found to be extremely statistically significant.

Students achieved a high success rate in the posttest: 80.58% of them identified the rotated

straight line correctly (see Table 4). Concerning sketching the rotated straight line, students had no difficulty drawing a rotated line in problem *c*, where the centre of rotation was on the straight line. In the other two problems, the success rate was significantly higher for *a*, and lower for *d*.

	Posttest task 1			Posttest task 2
	a	c	d	
USS	61.97	97.18	39.44	73.24
PST	96.88	100	96.88	96.88
Total	72.82	98.06	57.28	80.58

Table 4: Relative frequencies of correct answers in posttest by groups (source: own data)

It is worth mentioning that 57% of respondents sketched the solution without indicating the procedure. In general, students from the USS group did not indicate the procedure. However, PSTs suggested the procedure in almost half of the cases: 11 PSTs used a perpendicular to the rotated straight line through the centre of rotation, and 4 PSTs rotated two different points of the straight line.

Discussion

Students solved the test task about rotation with a 50% success rate. Based on the analysis of the textbooks, it was confirmed that this task was a standard task, since the example of the rotation of a straight line is presented in all the analysed textbooks. On the other hand, the ±90° rotation is not so frequently presented in them.

Males were more successful than females in the solution of the rotation task, which is in agreement with other studies (e.g., Lombardi et al, 2019). For the UNI and PST groups the sex-dependence was not confirmed; a similar result for in-service math teachers was obtained by Kambilombilo and Sakala (2015). The possible cause could be that PSTs were in mathematics teacher training, and the students in the UNI group (including females) were oriented towards technology and mathematics teaching.

The results of the rotation task in the test showed that students circled the correct option *c* most frequently; it occurred in the vast majority of answers (see Table 2). Task *c* (where the rotation centre was a part of the rotated object) was the simplest for students, which is in agreement with (Mainali and Heck, 2017).

In the posttest, PSTs made almost no mistakes. The USS students made various types of mistakes. When they correctly solved the case *c* in Posttest task 1, a quarter of them drew a perpendicular through point *S* in the cases *a* and *d*. This confirms the fact that these students were fixed on the centre of rotation.

The respondents of the main test chose the correct answer *d* more frequently than the correct answer *a*, but the respondents of the posttest correctly sketched *a* more frequently than *d*. The cause could be that in the case of *a* in the posttest it was necessary to draw the straight line rotated by –90° which would be out of the given grid, therefore the students could intuitively turn to the rotation by +90°, assuming that the unsuitable outcome was incorrect. In the case of *d*, many students sketched the straight line rotated by –90°. In agreement with (Ada and Kurtulus, 2010; Turgut, Yenilmez and Anapa, 2014; Mainali and Heck, 2017), we also observed errors in constructions related to not preserving the distances of points from the centre of rotation and of points mutually in the posttest.

The results showed that when students were successful in sketching a straight line rotated by 90°, they rarely identified the wrong rotated line. Furthermore, it turned out that even if they sketch it erroneously, they could still identify the rotated straight line correctly. Moreover, we observed that students solved the drawing task with understanding. On the other hand, in the main

test (recognition without sketching), only 50.19% of students were successful. This implies that sketching the rotated straight line can have a positive effect on recognizing the rotated straight line.

In textbooks, rotation is included in the chapters on isometry in various places. In (Pomykalová, 1993; Pomykalová, Gergelitsová and Schovancová, 2012), a separate chapter is devoted to rotation; this chapter is the last of the chapters devoted to isometries. In (Vondra, 2013), rotation is in the last chapter along with translation. In (Molnár, 2011), there is a separate chapter devoted to rotation immediately after the chapter on axial symmetry; central symmetry and translation are discussed after rotation. The textbook (Kadleček, 1996) placed the chapter on rotation and central symmetry after translation. This variability of the placement of rotation in the teaching sequence suggests that the authors are not unanimous in their evaluation of the difficulty of the topic of rotation.

Conclusion

The results of the rotation task in the test showed that half of the participating students recognized all situations of the ±90° rotated straight line. The easiest task was the one in which the centre of rotation belonged to a straight line. The posttest showed that the success of recognition of a rotated straight line increases if it is immediately preceded by drawing a rotated straight line. In addition, testing has shown substantial gender differences in solving the rotation task.

Concerning textbooks, authors should consider the difficulty of the topic of rotation and unify its position in the context of other isometries.

Some recommendations for pre-service mathematics teachers' education and for authors of secondary school textbooks follow from our research: simple examples on rotation are important; their omission can cause misunderstandings. However, a single elementary example of rotation of one point is not sufficient. It is important to show examples of the rotation of a straight line and more complex figures. Moreover, presentation of an example of rotation by ±60° or other 'complicated' angles is not sufficient; this should be preceded by a simple example of rotation by ±90°.

Acknowledgement

The paper has been supported by Charles University Research Centre program No. UNCE/HUM/024 and by the project PROGRES Q17 Teacher preparation and teaching profession in the context of science and research.

References

Ada, T. and Kurtulus, A. (2010) 'Students' misconceptions and errors in transformation geometry', *International Journal of Mathematical Education in Science and Technology*, vol. 41, no. 7, pp. 901–909. https://doi.org/10.1080/0020739X.2010.486451

Gülkılık, H., Uğurlu, H. H. and Yürük, N. (2015) 'Examining Students' Mathematical Understanding of Geometric Transformations Using the Pirie-Kieren Model', *Educational Sciences: Theory & Practice,* vol. 15, no. 6, pp. 1531–1548. https://doi.org/10.12738/estp.2015.6.0056

Halas, Z., Robová, J., Moravcová, V. and Hromadová, J. (2019) 'Students' concepts of the trapezoid at the end of lower secondary level education', *Open Education Studies,* vol. 1, no. 1, pp. 184–197. https://doi.org/10.1515/edu-2019-0013

Hejný, M. (2012) 'Exploring the Cognitive Dimension of Teaching Mathematics through Scheme-oriented Approach to Education', *Orbis scholae*, vol. 6, no. 2, pp. 41–55. https://doi.org/10.14712/23363177.2015.39

Jagoda, E. and Swoboda, E. (2011) 'Static and Dynamic Approach to the Forming the Concept of Rotation', In M. Pytlak, T. Rowland, E. Swoboda (eds.) *Proceedings of CERME 7*, University of Rzeszów, Poland, pp. 558–567.
Kadleček, J. (1996) *Geometrie v rovině a v prostoru pro střední školy*. Praha: Prometheus.
Kambilombilo, D. and Sakala, W. (2015) 'An Investigation into the Challenges In-Service Student Teachers Encounter in Transformational Geometry, "Reflection and Rotation". The Case of Mufulira College of Education.', *Journal of Education and Practice*, vol. 6, no. 2, pp. 139–149.
Lombardi, C. P., Casey, B. M., Pezaris, E., Shadmehr, M. and Jong, M. (2019) 'Longitudinal Analysis of Associations between 3-D Mental Rotation and Mathematics Reasoning Skills during Middle School: Across and within Genders', *Journal of Cognition and Development*, vol. 20, no. 4, pp. 487–509. https://doi.org/10.1080/15248372.2019.1614592
Mainali, B. R. and Heck, A. (2017) 'Comparison of Traditional Instruction on Reflection and Rotation in a Nepalese High School with an ICT-Rich, Student-Centered, Investigative Approach', *International Journal of Science and Mathematics Education*, vol. 15, issue 3, pp. 487–507. https://doi.org/10.1007/s10763-015-9701-y
Molnár, J. (2011) *Matematika pro střední odborné školy. Planimetrie*, Praha: Prometheus.
Moravcová, V., Robová, J., Hromadová, J. and Halas, Z. (2019). 'The development of the concept of axial symmetry in pupils and students.' *Proceedings of the 16th International Conference Efficiency and Responsibility in Education 2019* (ERIE 2019), Prague, pp. 351–357.
Pomykalová, E. (1993) *Matematika pro gymnázia. Planimetrie*, Praha: Prometheus.
Pomykalová, E., Gergelitsová, Š. and Schovancová, J. (2012) *Matematika pro střední školy. Planimetrie III. Čtyřúhelníky*, Plzeň: Fraus.
Robová, J., Moravcová, V., Halas, Z. and Hromadová, J. (2019) 'Žákovské koncepty trojúhelníku na začátku druhého stupně vzdělávání', *Scientia in educatione*, vol. 10, no. 1., pp. 68–89. https://doi.org/10.14712/18047106.1211
Thaqi, X., Giménez, J. and Rosich, N. (2011) 'Geometrical Transformations as viewed by Prospective Teachers'. In M. Pytlak, T. Rowland, E. Swoboda (eds.) *Proceedings of CERME 7*, University of Rzeszów, Poland, pp. 578–587.
Turgut, M., Yenilmez, K. and Anapa, P. (2014) 'Symmetry and rotation skills of prospective elementary mathematics teacher', *Bolema: Boletim de Educação Matemática*, vol. 28, no. 48, pp. 383–402. http://dx.doi.org/10.1590/1980-4415v28n48a19
Vondra, J. (2013) *Matematika pro střední školy – 3. díl: Planimetrie – Učebnice*, Brno: Didaktis.
VÚP (2007) *Framework Education Programme for Secondary General Education (Grammar Schools)*, Praha: VÚP.

USING A SIMULATION GAME IN THE EDUCATION OF AN AGILE APPROACH

[1]✉Ondřej Havazík, [2]Petra Pavlíčková

Department of Systems Engineering, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, havazik@pef.czu.cz

Department of Systems Engineering, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

Nowadays, many companies move to a modern agile project management approach. It is a very flexible approach that has many frameworks and extensions. In order to improve the quality of teaching and better understanding the functioning of the agile project management in practice, we create and use an agile game in education. This game helps students to understand the Scrum approach used for IT projects. The game can be played within 90 minutes during a seminar. The students must go through a lecture where will be explained in detail the rules and concept of the whole game. Upon successful finish the game, students received questionnaires containing specific questions that should point to the game itself and its influence on understanding agility. The paper focuses on the analysis of student's feedback. The goal of this paper was to teach students an agile approach using the agile game in the Scrum framework and also to find out which parts of the agile game should be improved in the future based on the student's answers. Based on feedback from students, recommendations for improving the game for future players will be implemented, as described at the conclusion of the paper.

Keywords

Agile game, education, project management, Scrum, students

Introduction

Nowadays, the development of information technology is growing exponentially, and some software controls most devices. As a result, the software has become a key component of human life. Nidagundi and Novickis (2016) said, that is crucial to understand that software development is one of the most difficult and time- consuming activities. According to Ghuman (2013) in the software development process, there are many steps from analyses, writing code through testing to rollout to production. It is important to realize that the computer is completely useless without computer software.

According to Ghunman (2013) for the creation of fully functional software, its necessary concerted effort and teamwork a group of people to achieve a goal. Nowadays, an essential part of successful software development is its proper testing. According to Richardson (2012) his definition of the project team is also related to the choice of approach in which software development will be managed. There are two basic types of approaches that can be used to solve projects, either waterfall or agile. Each company can choose which approach will use. In this article, the game will be solved by an agile approach that is more modern and more dynamic than the classic waterfall approach.

An agile framework Scrum was used for creating the agile game. It was chosen mainly because it is probably the most widespread application of agile methodology developed by Jeff Sutherland and Ken Schwaber today (2017;1997). It can also be said that this methodology is best suited for IT project management according to her specific characteristics.

Pinto et al. (2009) identified four basic problems of graduate students in the application of projects, the most critical was that students are not prepared to manage and to be managed. They also argue that the Scrum methodology is best suited for group projects. According to Anslow and Maurer (2015), various agile methodologies for project development and management can be found almost everywhere within the industry. They also say that teaching agile software development at universities is difficult. When teaching agile software development, it is important to take into account the following factors such as student collaboration in teams, customer communication, and well-defined scope. Kropp and Meier found that using agile methodologies in teaching had a positive impact on student learning outcomes, based on experiments with these methods (Kropp and Meier, 2013).
Heikkilä, Paasivaara and Lassenius (2016) created a collaborative board game to teach one of the agile methodologies, namely Kanban, at the Aalto University in Finland. The exact name of this game is GetKanban v4.0, a 3-6 player game played by 31 and 43 students in 2014 and 2015. After playing and evaluating the results, they concluded that learning using games might not be more effective as traditional teaching methods but at least won't be worse.
It can, therefore, be said that when teaching agile management, it is appropriate to use a practical way of teaching. The goal of this paper is to teach students an agile approach using the agile game and the second goal is to make suggestions for improvement that are also made based on student feedback. Feedback will be collected in the form of a questionnaire from which a detailed analysis of the results will take place.

Materials and Methods

Agile game description

The agile game is understood, like a simulation game that simulates an agile approach to project management in the Scrum framework. The simulation game will, in this article, be referred to as the "agile game".
Design of the agile game is very important part of the team`s research. This agile game helps students to understand the agile approach of the project in a Scrum. The successfully played agile game will serve as a basis for the research paper.
The game begins with a description of what the game will be about. After the introduction to the game follows the introduction of two functional companies, one of them represents a customer company, and the second one is a supplier company. The supplier company name is ExpertView s.r.o., and deals with the design and creation of graphics, UX and UI for websites, e-shops, information systems, and mobile applications. Furthermore, by creating business cards, posters, banners, logos, etc. This company represents the scrum team, which will be composed of students. Customer company is a company that deals with the training of companies, schools, and individuals, and this company represents a facilitator in the agile game, which name is Learn2Go a.s.
After introducing both companies, there is the most critical part of the whole game, and it is a project assignment, which should be delivered by the Scrum team to the customer. The issue of the entire project will be the creation of graphic design and the creation of a complete web wireframe, which will be created by the supplier company. Their task will be to design and create a complete design of the entire site, including a wireframe for frontend and backend developers, to create a new logo, business cards, and banner.
The project assignment is divided into five more significant parts, and then is every part of it describes in detail. The bigger parts are the following: (i) creating a wireframe of the whole web, including graphics, (ii) design of the mobile application, (iii) logo, (iv) banner, (v) business cards. Each scrum team should at least approximately achieve according to the textual input, user stories, epics, and communication with the game facilitator (customer).

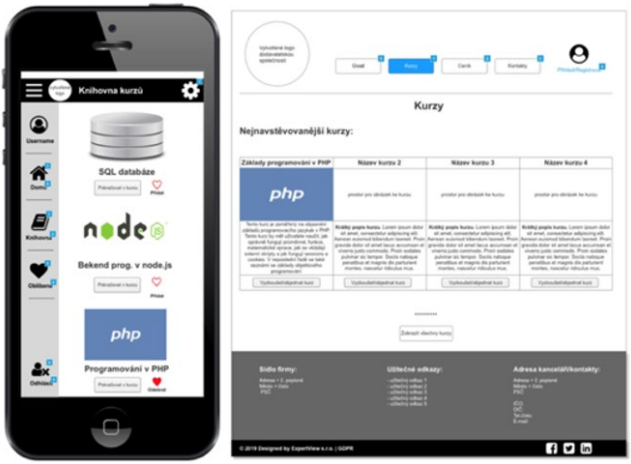


Figure 1: Sample design (source: own creation)

For each of these parts, a final graphic design has been successfully created (see Figure 1), which scrum teams should at least approximately achieve according to the textual input, user stories, epics, and communication with the game facilitator (customer). The project will be completely realized with a pencil and crayons on paper. Pencil drawing on paper according to the specifications can handle almost everyone.

Before the launch of any project, a risk analysis should never be missing, so risk analysis has been created for the participants of the game. Upon receiving the risk analysis, all members of the scrum team should discuss how to deal with each of the risks, whether to avoid it, minimize the impact, or accept it. The risk cards have been created, each of these cards contains the name of the trigger event, a description of the risk, the impact (including financial), prevention, and its cost. The entire Scrum team gets a certain budget to use to eliminate some of the risks. During each sprint, users pick a single event card that triggers the risk. If the risk is eliminated by avoiding or minimizing the impact, the scrum team does not have a problem with the risk. However, if it does not have this risk treated, it has a major impact on the sprint run and, eventually, the project shift.

Before starting the project, it is necessary to have a defined product backlog that includes all the required activities to complete the project, and these single items are called PBI (Product Backlog Item). The product backlog can consist of epics, user stories, tasks, etc. In the game, the user will only work with epics and user stories for simplicity. As individual epics, five project development areas were selected, described in the project description chapter. A template for user stories has been created to break down the individual scrum team epics. (see Figure 2)

Before starting to prioritize PBI and then move them to the individual sprint backlog, each member of the scrum team members must have a team role assigned. Each card contains a description of the team's role, authority, responsibilities, competencies, and special know-how. That means that everyone has a specific purpose in the scrum team and will not be able to perform every type of job. For example, a Scrum master will not be able to design wireframes, etc. The project must be divided into a reasonable number of sprints, and each sprint must be divided into several weeks. Every game has five sprints, and the length of every sprint in the game is eight minutes. The agile game also includes a Kanban board, where the project team will record the status of each task within each sprint. A sprint backlog should be defined on the Kanban board for each sprint before his start. All tasks in the backlog sprint should be completed at the end.

Figure 2: User Stories cards (source: own creation)

At the end of the explanation of the game, there definitely should not be forgotten the scrum events. The scrum master should primarily drive scrum events. The most important events that will be used in the game are sprint, sprint planning and sprint review. In the game document with instructions and rules, there is a description of each event, what is their subject, purpose, and time range.

At the end of each game, each team member received a questionnaire with a set of questions about the game, for better feedback and possible follow-up recommendations. The questionnaire also provided space for member's own opinions, comments, and recommendations. The research part is primarily about analyses answers from students based on the questionnaires above.

Results

The research was carried out on students of the 2nd year of the follow-up master's degree in study program informatics on Faculty of Economics and Management, Czech University of Life Sciences in Prague. This game was played with all students in the subject IT project management. The total number of players participating in the game was 63 students. The 63 students were divided into 12 teams, each team consisting of 5 players (some teams consisted of 6 players). Every team has one person who represented the customer in the game (usually teacher). This person also provides advice, explanations, and help with unclear parts of the rules of the agile game and also helping his group of students with managing the whole game. The game was played with students on two different days; each day, about 30 students came; one customer was assigned to each group.

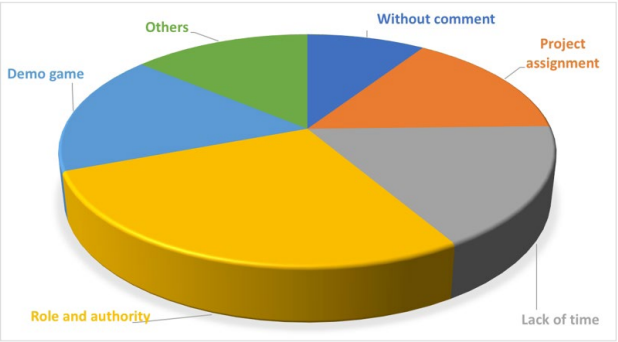
After completing the game, the students completed a detailed questionnaire in which they were asked to answer the specific questions (and also describes by their own words):

As the research would be too extensive, only 2 the most important questions will be analyzed and described.

- What did students not like about the agile game? (disadvantages and weaknesses)
- How much did the game help students understand the agile approach of PM?

Disadvantages and weaknesses

This section is about answers to the questions about the weaknesses (or disadvantages) of the agile game. The total number of answering students was 63, but one student can report several disadvantages. The total number of responses thus increased from 63 to 65. Thus, research on this question is conducted on 65 answers (not 63 students). Individual qualitative answers from students were combined into different sections. A total of six of these sections were based on responses.



Graph 1: Disadvantages and weaknesses (source: own creation)

As you can see from the graph no.1, section without comment has only 9,23% votes, which means six answers. On the other hand, a section with the most votes is section "role and authority", which has 27,69% votes = 18 answers. The other four remaining sections have a relatively even distribution of votes. Section "Demo game" and "Lack of time" are equals, both have 16,92% votes, which is precisely 11 answers. "Project assignment" section has 15,38% = 10 answers, and the last section is section "Others" with 13,85%, equal 9 answers.
The above sections may contain the following answers:

- **Without comment** – no comments
- **Project assignment** - unclearly written assignment, inconsistency between assignment and user stories, grammatical errors, misspellings or unintelligible sentences
- **Lack of time** - little time to accomplish all the tasks, short sprints and the game was played in time pressure
- **(Scrum)Role and authority** - role overload, lack of work for specific roles, and poor roles description
- **Demo game** - absence of sample game or zero iteration of the game
- **Others** - customer problems, inconsistencies in risk analysis, and lack of resources (the answers in this section cannot be merged into a larger groups)

Understanding an agile approach

In this section, the students had to evaluate, how much the agile game helped them to understand the agile approach. They had five possible qualitative responses that were quantified on a scale of 1 to 5. (1 is the best; 5 is the worst)

Quantitative	Qualitative
1	It helped me to understand an agile approach and Scrum framework in practice
2	It helped me to understand a basic concept of the agile approach and Scrum framework
3	It helped me to understand a small part of the agile approach and Scrum framework
4	It helped me a little
5	It didn t help me at all

Table 1: rating scare of understanding an agile approach (source: own creation)

An overwhelming majority of students (over 85%, exactly 53 students) report that the agile game had helped them understand the basic concepts of an agile approach or even in a practical way. Only 15.87% rated that the agile game helped them understand a small part of the agile approach, a total of 10 students. No one voted for points 4 and 5, which is a very positive feedback for the author of the game.

Project assignment

An essential part of the whole game is the assignment of the project that the students create in the game. The assignment of the project is crucial for the effective playing of the game. So, it was necessary to evaluate, how comprehensible the assignment of the project was to students. As in the previous section, the qualitative responses were quantified here. The qualitative expression can be found in the table below.

Quantitative	Qualitative
1	I fully understood the project assignment, it was understandable, clear, and easy to understand.
2	I fully understood the project assignment, it was understandable, clear, and easy to understand.
3	I understood the project assignment, but sometimes it was unclear
4	I did not understand the project assignment much
5	I did not understand the project assignment at all

Table 2: Rating scale of project assignment (source: own creation)

Nearly half of the students (49,21%, which are 31 students) said the assignment was understandable and clearly written (rated 2). 7 students, which is 11.11% stated that the assignment was fully understood (rated 1). That the project assignment was unclear or totally unintelligible (rated 4 and 5) voted by a total of 3 students, which is 4,76%. A large part of the evaluation (34.92% which is 22 students) was also represented by the opinion that the assignment was clear but sometimes incomprehensible (rated 3). Overall it is possible to say that project assignment had some shortcomings.

Discussion

As Ghuman (2013) says for the creation of fully functional software, its necessary concerted effort and teamwork a group of people to achieve a goal. That is why our team designed the agile game, which is described in Materials and Methods.

Tests on this topic indicate that you only remember about 20% of what you hear and only 30% of what you read or are shown. But 50% of the information is remembered if he has the opportunity to see and hear the information offered. Around 70% of the information is then remembered when one has the opportunity to see, listen and then talk about it. If we add the option of active execution to these three activities, we get up to 90% chance to remember the information (Hermechova, 2006).

So if you want to teach someone Scrum, you have to explain how to do it, but that‘s not enough. To make it all sense, the participants Scrum try for yourself and re-evaluate how they did it go, what was good and what to improve to the next time (Šochová and Kunce, 2019).

Šochová (2010) in her article wrote many games can be played, they can be complex, but basically it is about trying a few basic principles - planning, teamwork, communication with customers, reaction to change and retrospective. One of the possible games focused on the Scrum experience was designed with Petr Olmer to build a railway. The basis is to build a rail link between US cities and lead the customer where he / she wants. The product with the backlog is declared the goal of connecting cities A, B and C. The team chooses ScrumMaster and the game can start.

The above literature suggests that it is the right direction for teaching agile methodologies, and especially Scrum to use games. The basic building blocks of the game are described in the Material and Methods chapter. The game was deployed in the IT Project Management at the CULS course from October to December 2019.

Conclusion

Based on the student’s evaluation of the agile game, it can be said that the game was designed conceptually very well with some shortcomings. The game showed the greatest shortcomings in project assignment and time distribution. The whole article could also be extended to the results of

the questionnaire survey on other issues. Students were also asked not only about questions about the agile game itself but also about issues that will be used in the future to analyze team roles and follow-up recommendations on who is suitable for what team role.
As described in the chapter "Disadvantages and weaknesses" the biggest problems in the game were in the poorly defined competences of the individual roles. Also, the students lacked a sample game for better understanding. In the future, it is planned to create a so-called "demo game" for better understanding and better define the competence cards of the individual roles of the team members. Alternatively, change the organization structure in teams (each role in the team) or modify created role cards.

Acknowledgment

The results and knowledge included herein have been obtained owing to support from the following institutional grants. Internal grant agency of the Faculty of Economics and Management, Czech University of Life Sciences in Prague, grant no. 2019A0008, „Analýza týmových rolí v IT projektech pomocí speciální hry AGILNĚ".

References

Anslow, C. and Maurer, F. (2015) 'An experience report at teaching a group based agile software development project course', *SIGCSE 2015 - Proceedings of the 46th ACM Technical Symposium on Computer Science Education*, no. Cmmi, pp. 500–505. https://doi.org/10.1145/2676723.2677284
Ghuman, S.S. (2013) 'SDLC Models- A Survey', *International Journal of Computer Science and Mobile Computing (IJCSMC)*, vol. 2, no. 1, pp. 33–38.
Heikkilä, V.T., Paasivaara, M. and Lassenius, C. (2016) 'Teaching university students Kanban with a collaborative board game', *Proceedings - International Conference on Software Engineering*, pp. 471–480. https://doi.org/10.1145/2889160.2889201
Hermechova, S. (2006) *Teambuilding*. Grada.
Kropp, M. and Meier, A. (2013) 'Teaching agile software development at university level: Values, management, and craftsmanship', *Software Engineering Education Conference, Proceedings*, san Francisco, CA, pp. 179–188. https://doi.org/10.1109/CSEET.2013.6595249
Nidagundi, P. and Novickis, L. (2016) 'Introduction to Lean Canvas Transformation Models and Metrics in Software Testing', *Applied Computer Systems*, vol. 19, no. 1, pp. 30–36. https://doi.org/10.1515/acss-2016-0004
Pinto, L., Rosa, R., Pacheco, C., Xavier, C., Barreto, R., Lucena, V., Caxias, M. and Figueiredo, C.M. (2009) 'On the use of scrum for the management of practcal projects in graduate courses', *Proceedings - Frontiers in Education Conference, FIE,* San Antonio, pp. 1-6. https://doi.org/10.1109/FIE.2009.5350404
Richardson, I., Casey, V., McCaffery, F., Burton, J. and Beecham, S. (2012) 'A process framework for global software engineering teams', *Information and Software Technology*, vol. 54, no. 11, pp. 1175–1191. https://doi.org/10.1016/j.infsof.2012.05.002
Schwaber, K. and Sutherland, J. (2017) *The Scrum Guide™ The Definitive Guide to Scrum: The Rules of the Game,* [Online], Available: https://www.scrumguides.org/docs/scrumguide/v2017/2017-Scrum-Guide-US.pdf#zoom=10
Sutherland, J., Patel, D., Casanave, C., Hollowell, G. and Miller, J. (1997) *Business Object Design and Implementation* (Jeff Sutherland, C. Casanave, J. Miller, P. Patel and Hollowell, G. Eds.), London: Springer London. https://doi.org/10.1007/978-1-4471-0947-1
Šochová, Z. (2010) *Scrum hra*, [Online], Available: https://soch.cz/blog/management/agile/scrum-management/scrum-hra/
Šochová, Z. and Kunce, E. (2019) *Agilní metody řízení projektů*. Computer press.

DIMENSIONS OF LEARNING CULTURE AND EMPLOYEES' IDENTIFICATION IN AN ORGANIZATION

[1]Miloslava Hiršová, [2]Lenka Komárková, [3]✉Martina Glaserová

[1]Department of Social Sciences, Faculty of Management, University of Economics Prague, Czech Republic

[2]Department of Exact Methods, Faculty of Management, University of Economics Prague, Czech Republic

[3]Department of Exact Methods, Faculty of Management, University of Economics Prague, Czech Republic, martina.glaserova@vse.cz

Abstract

Organizational learning is currently a vital condition for the effectiveness and development of organizations. An analysis of the dimensions of the organizational learning culture makes it possible to identify the strengths and weaknesses of this process and, thus, to take action to improve it. We assume that learning organizations allow for better self-fulfilment of employees and increase the level of their identification with the organization. We examined this assumption using quantitative research in one healthcare organization, in which 1,451 persons participated. We used the Dimensions of Organizational Learning Questionnaire (DLOQ) and the Organizational Identification Scale to collect data. For data processing, the multiple regression model was applied. The results show that DLOQ allows good diagnosis of organizational learning culture. Our study suggests that better links between organizational and individual levels of learning can improve not only the learning culture but also the degree of organizational identification.

Keywords

DLOQ, health care organization, organizational identification, organizational learning

Introduction

The 1990s represent the period of the rapid development of knowledge-based economies, and, based on these changes, the concept of learning organization or organizational learning is gaining increasing importance (Serrat, 2017). In this turbulent and competitive environment, knowledge and the ability to learn are a precondition for survival or the key to further development and growth (Zuo et al., 2019). The need to know the processes and conditions that make organizational learning possible has become an impetus for scientists' growing interest in this field. Their interest is focused on defining organizational learning or learning organization constructs (e.g. Pedler and Boydell, 1996; Vince, 2018; Senge, 1990), or finding theoretical foundations for their further investigation (e.g. Argote, 2011; Crossan et al., 1999). An overview of the state of the art in this field is provided by Watkins and Kim (2018).

The importance of organizational learning and its proven impact on organizations' efficiency and competitiveness (e.g. Brockman and Morgan, 2003) entails a demand of practice for knowledge to enable organizational learning to develop and support. As Wooldridge (2006: 20) noted: 'Clearly the best way for companies to win talent wars is to turn themselves into learning organizations. The trouble is that few of them know how to do this'. The prerequisite for this is the ability to diagnose the characteristics of organizational learning. Organizational learning culture (OLC) is an important construct that can serve this purpose. Many general definitions of this construct can be found, for example according to Marquardt (2002: 27) OLC means that 'learning is recognized

as absolutely critical for business success; in such an organization, learning has become a habitual and integrated part of all organizational functions'. More specific approaches to OLC seek to understand the organization's approach to learning systemically and to include important process and structural elements that operate there (Xie, 2019).

Marsick and Watkins (2003) build on this approach to construct a questionnaire on the dimensions of organizational learning culture (DLOQ). The basic prerequisite is that learning in an organization takes place at three levels that are interconnected. An individual in the organization solves problems, responds to unexpected situations, and participates in the training activities of the organization. These processes and learning outcomes at the individual level are mingled with the team or group level in communication. This collective experience is influenced by organizational culture – the organization's interest in using it, by promoting the sharing of experience and linking collective experience to the organization's vision and strategy. According to Marsick and Watkins (2003), each of these levels is characterized by key imperatives (dimensions).

At the individual level, it is necessary to constantly create learning opportunities, i.e. promoting learning on the job. Another imperative is inquiry and dialogue, i.e. promoting the development of skills focused on the ability to express oneself, listen to others and the competence to insight into their opinions. At the collective level, cooperation and team learning is expected to be supported and appropriately rewarded and taken as a part of an organizational culture. This is done by creating and maintaining technological systems that facilitate knowledge sharing and participating in learning (Fatorachian and Kazemi, 2018). At the organizational level, employees are involved in formulating and implementing an organizational vision, and a close link between decision-making and responsibility motivates them to learn how to accomplish their assigned tasks. The organization also helps employees perceive the benefits of their work for the entire organization and the importance of the organization to its environment. These activities are also supported by a leadership style in which learning is strategically used to achieve organizational goals (Xie, 2019).

DLOQ is one of the most commonly used methods of assessing the level of organizational learning culture. An overview of its use is provided by Song et al. (2013). Their study lists sixty articles, which are geographically predominantly from the USA and East Asia, the Czech Republic is not represented here. Thematically, they deal mainly with the relationship between OLC and organizational performance, job satisfaction, turnover intentions or leadership style. Among these variables, we have not found identification with the organization that we consider to be a significant factor that influences employee behaviour related to the effectiveness of the organization. In fact, there are not many studies focusing on the relationship between OLC and the degree of organizational identification. We have only found studies by Wang et al. (2011) from Taiwan and Reese (2014) from the USA. We could not find any European study.

Although constructs similar to the present concept of organizational identification have already appeared in the middle of the last century, the main wave of interest in this issue has been observed since the turn of the 20th and 21st centuries. Organizational identification is most often considered to be a process in which certain attributes of an organization become part of an individual's self-concept and, thus, create a sense of unity between the individual and the organization (Ashforth and Mael, 1989). The reason for the growing interest in organizational identification lies in its impact on the performance or effectiveness of the organization and on many other factors related to performance (Ashfort et al., 2008; Bednar et al., 2020). Based on the above presented findings, our paper aims to answer the following research question: *How does the degree of identification relate to the individual dimensions of organizational learning culture?*

The next part of the paper will be divided into three consecutive sections. The section Materials

and Methods presents tools for measuring learning culture and organizational identification, the way of data collection and methods for investigating a considered relationship. In the Results and Discussion section, we focus on the obtained results, their interpretation and discussion, including possible limitations. The final section summarizes the basic findings of our study and suggests a possible direction for further research.

Materials and Methods

The study was based on the questionnaire survey in a large Czech health care organization wishing to remain anonymous. In autumn 2018, after getting the approval of the top management, the questionnaire was distributed online to all employees, of whom 1,451 (less than 50 %) persons agreed to participate.

According to Pantouvakis and Bouranta (2013), we used Yang's (2003) short version of Marsick and Watkins's (2003) DLOQ to assess seven dimensions (*Continuous Learning, Inquiry & Dialogue, Collaboration & Team Learning, Systems to Capture Learning, Empower People, Connection to Environment, Strategic Leadership for Learning*) of organizational learning culture. In this short version, there is only one item with the six-point scale (1 – completely unlike, 6 – totally similar) for each of the seven dimensions. Verbal anchoring of the scale was slightly modified against the original to reflect the research design. According to Mael and Ashforth (1992), the *Organizational identification degree* (*OID*) was evaluated by averaging five items. We used the six-point scale for measuring (1 – totally disagree, 6 – totally agree). A double translation was used for the Czech version of the items.

The questionnaire also contained identification and demographic questions for employees. In particular, we asked about the type of their job position (*Position – type*) in four categories: 1/ *physicians*, 2/ *NHS* – non-medical healthcare staff, 3/ *TAS* – technical-administrative staff, and 4/ *others*; the level of their job position (*Position – level*) in three categories: 1/ *managers*, 2/ *ordinary workers*, and 3/ *others*; their *Job Duration* in three categories: 1/ *Short* – up to one year, 2/ *Medium* – more than one but not more than three years, 3/ *Long* – more than three years; and, finally, their *Age* in three categories (*30-* denotes the age category up to 30 years, the second category is *31–50* years, and the last one *51+* denotes respondents aged 51 and more). In particular, 344 physicians, 804 non-medical healthcare workers, 186 technical-administrative workers, and 117 other workers participated in the survey. The distribution of the respondents according to the *Age* and the *Job Duration* categories can be found in Table 1.

The dependence of the *OID* variable on the learning culture dimensions adjusted for effects of employee characteristics was investigated using a multiple regression model with both numerical and categorical explanatory variables. Furthermore, we performed post hoc multiple comparisons using the method of Hothorn et al. (2008). We performed statistical analysis in the R software version 3.6.2 (R Core Team, 2019) using R-package 'multcomp'.

Position – type	Physicians			NHS			TAS			Others		
Job Duration	30-	31–50	51+	30-	31–50	51+	30-	31–50	51+	30-	31–50	51+
Short	18	4	4	52	26	15	4	6	3	4	6	1
Medium	34	13	2	74	34	14	10	16	10	6	9	4
Long	19	145	105	64	320	205	7	51	79	10	40	37
Total	**71**	**162**	**111**	**190**	**380**	**234**	**21**	**73**	**92**	**20**	**55**	**42**

Table 1: Distribution of respondents by their characteristics, 2018 (source: own calculation)

Results and Discussion

Table 2 shows descriptive statistics for the considered numerical variables. The average of respondents' *OID* was 3.95 while the centre of the scale was 3.5. The mean values of the

learning culture dimensions ranged from 3.09 to 3.99 on the six-point scale. The lowest sample mean was reached for *Empower People* and *Continuous Learning*, the highest for *Strategic Leadership.* While employees perceive most strongly their leaders' efforts to engage learning in the organization's strategic goals, they lack the willingness to involve them in setting and implementing a joint vision. Surprisingly, there is also the low assessment of continuous learning, which could be considered a duty for medical staff. Anyway, we got similar results as Leufvén et al. (2015). Their study from the health care sector had the mean values from 3.09 (*Empower People*) to 3.75 (*Strategic Leadership*). Moreover, their study suggested that the perception differs between physicians and nurses in these two dimensions.

The results show a positive relationship between the learning culture dimensions and *OID*. In particular, Pearson correlation coefficient values ranged from 0.31 to 0.40. This supports the results of Wang et al. (2011), who demonstrated a positive effect of organizational learning on the organizational identification in the sector of educational institutions. Besides, Tsai (2014) showed a positive correlation between the learning culture and organizational commitment in the hospital environment. Given the fact that identification and commitment are closely related (Chen et al., 2015), we are also in line with Tsai (2004)'s findings.

Variable	Mean	SD	Cor
Continuous Learning	3.09	1.34	0.31
Inquiry & Dialogue	3.25	1.29	0.40
Collaboration & Team Learning	3.60	1.23	0.31
Systems to Capture Learning	3.72	1.28	0.31
Empower People	3.09	1.37	0.32
Connection to Environment	3.65	1.17	0.38
Strategic Leadership	3.99	1.20	0.35
OID	3.95	0.99	1.00

Table 2: Means, standard deviations (SD) and correlations (Cor) with the *Organizational identification degree* (*OID), 2018* (source: own calculation)

In particular, *Inquiry & Dialogue* is the variable most correlated ($r = 0.40$) with *OID.* Since this variable is also linked to the need for informal relationships and affects the group atmosphere, this result is not surprising. This is not fully consistent with the Reese's (2014) study, where *OID* correlated most strongly with *Collaboration & Team Learning*. This dimension has the lowest correlation ($r = 0.31$) in our study. However, we assessed the identification with the whole organization, not the identification with a working group or team, and both studies relate to another sector of an economic activity. In addition, the differences in pairwise correlations in our study are not too high. Partial correlations were examined using a multiple linear regression model.

Table 3 gives a basic overview of the regression analysis results. Statistically significant predictors are marked in bold. The results demonstrate statistically significant relations between OID and three learning culture dimensions (the *p*-value is lower than 0.001 in all three cases). Specifically, these are two dimensions of the organizational level of learning culture – *Strategic Leadership, Connection to Environment,* and one dimension of the individual level of learning culture *Inquiry & Dialogue*. As the extent of these dimensions grows, *OID* increases.

The role of *Inquiry & Dialogue* in this relationship was explained above. Beside this, Apker and Fox (2002) found that health care personnel have a higher identification with their profession than with an organization, but communication can strengthen organizational identification. Further, it can be assumed that *Strategic Leadership* focused on supporting learning gives an individual a sense of opportunity for personal development and, thus, increases his/her willingness to identify with the organization. In the case of *Connection to Environment*, this willingness is reinforced by the perceived meaningfulness

and importance of the work. Moreover, according to Yang (2003), *Connection to Environment* affects knowledge performance, while *Strategic Leadership* affects the financial performance of organizations.

Predictor	Effect	95% CI	*p*-value
Continuous Learning	0.01	(-0.04, 0.06)	0.735
Inquiry & Dialogue	0.15	(0.10, 0.20)	< 0.001
Collaboration & Team Learning	0.03	(-0.02, 0.07)	0.274
Systems to Capture Learning	0.03	(-0.02, 0.08)	0.200
Empower People	-0.01	(-0.06, 0.04)	0.690
Connection to Environment	0.16	(0.11, 0.21)	< 0.001
Strategic Leadership	0.09	(0.04, 0.14)	< 0.001
Position – type	---	---	< 0.001
Position – level	---	---	< 0.001
Job Duration	---	---	0.023
Age	---	---	< 0.001

Table 3: Results of multiple linear regression for the *Organizational identification degree* (*OID*), 2018 (source: own calculation)

In addition to the learning culture, the job position variables *Position – type* and *Position – level* ($p < 0.001$ for both), *Job Duration* ($p = 0.023$) and *Age* ($p < 0.001$) also influence *OID*. Post hoc multiple comparison was also made for these categorical variables to identify the differences between categories. The results of this comparison are presented in Table 4.

Predictor / Comparison groups	Difference	95% family-wise CI	Adj. *p*-value
POSITION – TYPE			
NHS vs physicians	-0.13	(-0.27, 0.01)	0.090
TAS vs physicians	0.13	(-0.07, 0.33)	0.329
Others vs physicians	-0.29	(-0.52, -0.06)	0.008
TAS vs NHS	0.26	(0.08, 0.44)	0.001
Others vs NHS	-0.16	(-0.37, 0.05)	0.207
Others vs TAS	-0.42	(-0.67, -0.16)	< 0.001
POSITION – LEVEL			
Managers vs Ordinary	0.40	(0.26, 0.53)	< 0.001
Others vs Ordinary	0.38	(0.05, 0.71)	0.020
Others vs Managers	-0.02	(-0.36, 0.33)	0.994
JOB DURATION			
Medium vs Short	0.17	(-0.04, 0.39)	0.127
Long vs Short	0.22	(0.03, 0.42)	0.016
Long vs Medium	0.05	(-0.10, 0.21)	0.729
AGE			
31–50 vs 30-	0.19	(0.04, 0.34)	0.008
51+ vs 30-	0.39	(0.22, 0.56)	< 0.001
51+ vs 31–50	0.20	(0.07, 0.32)	< 0.001

Table 4: Results of multiple comparison with Tukey's contrasts and related adjusted *p*-values, 2018 (source: own calculation)

The limitation of the research is that we have focused only on one organization representing the health sector. Although the number of respondents is quite high, the results may be biased due to the unwillingness of more than a half of the employees to participate in the survey. Furthermore, we have examined the effect of learning culture on the measure of identification,

but the relationship between constructs can be bidirectional (Reese, 2014). The study assessed the degree of identification with the organization as a whole. This, however, may be affected by the satisfaction within the department where the respondent works, which was not the subject of the study. Given the sample size, the study is based on a quantitative approach. Moreover, a qualitative approach would also be appropriate to better understand the identified relationships and their causes.

Conclusion

As a whole, four dimensions of OLC were assessed higher than the centre of the scale, three of them remained below it. This ratio deserves more attention. It seems that the core of the learning culture lies at the organizational level and consists mainly of the dimensions of *Strategic Leadership* and *Connection to Environment*. On the other hand, a low score in the *Empower People* dimension suggests that employees are not fully satisfied with their opportunities to be involved in setting and implementing the organizational vision and with the distribution of responsibilities in relation to decision-making processes. The organization does not seem to have any major problems at the team level of the learning culture, but achieves the lowest results for both the dimensions at the individual level and one dimension at the organizational level. It should also be noted that the two relevant dimensions at the individual level have also the highest standard deviation. Thus, we can assume that in this respect the learning culture will differ from department to department.

These results show the organization where it should direct its interest and activities, not only to be a good learning organization, but also to strengthen the employees' identification with the organization. It is positive that the two highest-ranking dimensions at the organizational level (*Strategic Leadership* and *Connection to Environment)* correlate significantly with *OID*, but so does *Inquiry & Dialogue*, which achieved the second lowest score. The organization should consider whether a better link between organizational and individual learning levels in the form of *Empower people* and *Inquiry & Dialogue* dimensions could be a way to improve not only the learning culture but, at the same time, the degree of the employees' identification with the organization. Therefore, our paper shows that, from a practical perspective, analyzing OLC can be an important tool to identify problems at a particular level of the organizational structure and, by doing that, allow targeted intervention to improve the situation. The theoretical contribution consists in finding the relationship between different dimensions of OLC and *OID*. This opens the way to further exploring the causes and processes that affect this relationship

We are aware of the fact that organizational learning as well as organizational identification are complex processes and for a better understanding of their relationship it is necessary to include other variables in the research. The need to learn is closely linked to the individual's motivation and value system. Understanding their role in organizational learning and organizational identification processes should, therefore, be part of further research into this issue.

Acknowledgement

This work was financially supported by the Czech Science Foundation (GA ČR) under Grant number 18-01159S.

References

Apker, J. and Fox, D.H. (2002) 'Communication: Improving RNs' organizational and professional identification in managed care hospitals', *JONA: The Journal of Nursing Administration*, vol. 32, no. 2, pp. 106-114.

Argote, L. (2011) 'Organizational learning research: Past, present and future', *Management Learning*, vol. 42, no. 4, pp. 439-446. https://doi.org/10.1177/1350507611408217

Ashforth, B.E. and Mael, F. (1989) 'Social identity theory and the organization', *Academy of Management Review*, vol. 14, no. 1, pp. 20-39. https://www.jstor.org/stable/258189
Ashforth, B.E., Harrison, S.H. and Corley, K.G. (2008) 'Identification in organizations: An examination of four fundamental questions', *Journal of Management*, vol. 34, no. 3, pp. 325-374. https://doi.org/10.1177/0149206308316059
Bednar, J.S., Galvin, B.M., Ashforth, B.E. and Hafermalz, E. (2020) 'Putting Identification in Motion: A Dynamic View of Organizational Identification', *Organization Science*, vol. 31, no. 1, pp. 200-222. https://doi.org/10.1287/orsc.2018.1276
Brockman B.K. and Morgan R.M. (2003) 'The role of existing knowledge in new product innovativeness and performance', *Decision Science*, vol. 34, no. 2, pp. 385-419. https://doi.org/10.1111/1540-5915.02326
Chen, S.Y., Wu, W C., Chang, C.S., Lin, C.T., Kung, J. Y., Weng, H.C., Lin, Y.T. and Lee, S.I. (2015) 'Organizational justice, trust, and identification and their effects on organizational commitment in hospital nursing staff', *BMC health services research*, vol. 15, no. 363, pp. 1-17. https://doi.org/10.1186/s12913-015-1016-8
Crossan, M.M., Lane, H.W. and White R.E. (1999) 'An organizational learning framework: From intuition to institution', *Academy of Management Review*, vol. 24, no. 3, pp. 522-537. https://doi.org/10.5465/amr.1999.2202135
Fatorachian, H. and Kazemi, H. (2018) 'A critical investigation of Industry 4.0 in manufacturing: theoretical operationalisation framework', *Production Planning & Control*, vol. 29, no. 8, pp. 633-644. https://doi.org/10.1080/09537287.2018.1424960
Hothorn, T., Bretz, F. and Westfall, P. (2008) 'Simultaneous inference in general parametric models', *Biometrical Journal: Journal of Mathematical Methods in Biosciences*, vol. 50, no. 3, pp. 346-363. https://doi.org/10.1002/bimj.200810425
Leufvén, M., Vitrakoti, R., Bergström, A., Ashish, K.C. and Målqvist, M. (2015) 'Dimensions of Learning Organizations Questionnaire (DLOQ) in a low-resource health care setting in Nepal', *Health research policy and systems*, vol. 13, no. 6, pp. 1-8. https://doi.org/10.1186/1478-4505-13-6
Mael, F. and Ashforth, B.E. (1992) 'Alumni and their alma mater: A partial test of the reformulated model of organizational identification', *Journal of Organizational Behavior*, vol. 13, no. 2, pp. 103-123. http://dx.doi.org/10.1002/job.4030130202
Marquardt, M.J. (2002). *Building the learning organization: Mastering the 5 Elements for Corporate Learning*. Palo Alto: Davies-Black Publishing.
Marsick, V.J. and Watkins, K.E. (2003) 'Demonstrating the value of an organization's learning culture: the dimensions of the learning organization questionnaire', *Advances in Developing Human Resources*, vol. 5, no. 2, pp. 132-151. http://dx.doi.org/10.1177/1523422303005002002
Pantouvakis, A. and Bouranta, N. (2013) 'The link between organizational learning culture and customer satisfaction', *The Learning Organization*, vol. 20, no. 1, pp. 48-64. https://doi.org/10.1108/09696471311288528
Pedler M.B.J. and Boydell, T. (1996) *The learning company: a strategy for sustainable development*, London: McGraw-Hill.
R Core Team (2018). *R: A language and environment for statistical computing*, Vienna: R Foundation for Statistical Computing, [Online], Available: https://www.R-project.org/ [31 Jan 2020].
Reese, S.R. (2014) 'Examining the relationship between organizational identification and learning organization dimensions: a study of a US franchise', *Management and Organizational Studies*, vol. 1, no. 1, pp. 7-20. http://dx.doi.org/10.5430/mos.v1n1p7
Senge P. (1990) *The fifth discipline: the art and practice of the learning organization*, New York: Currency Double Day.

Serrat, O. (2017) *Knowledge Solutions: Tools, Methods, and Approaches to Drive Organizational Performance*, Singapore: Springer. https://doi.org/10.1007/978-981-10-0983-9
Song, J.H., Chermack, T.J. and Kim, W. (2013) 'An Analysis and Synthesis of DLOQ-Based Learning Organization Research', *Advances in Developing Human Resources*, vol. 15, no. 2, pp. 222-239. https://doi.org/10.1177/1523422313475995
Tsai, Y. (2014) 'Learning organizations, internal marketing, and organizational commitment in hospitals', *BMC health services research*, vol. 14, no. 152, pp. 1-8. https://doi.org/10.1186/1472-6963-14-152
Vince, R. (2018) 'The learning organization as paradox: Being for the learning organization also means being against it', *The Learning Organization*, vol. 25, no. 4, pp. 273-280. https://doi.org/10.1108/TLO-08-2017-0083
Wang, H.K., Tseng, J.F., Yen, Y.F. and Huang, C. (2011) 'University staff performance evaluation systems, organizational learning, and organizational identification in Taiwan', *Social Behavior and Personality*, vol. 39, no. 1, pp. 43-54. http://dx.doi.org/10.2224/sbp.2011.39.1.43
Watkins, K.E. and Kim, K. (2018) 'Current status and promising directions for research on the learning organization', *Human Resource Development Quarterly*, vol. 29, no. 1, pp. 15-29. https://doi.org/10.1002/hrdq.21293
Wooldridge, A. (2006) 'The battle for brainpower: A survey of talent', *The Economist*, vol. 10, no. 1, pp. 1-24.
Yang, B. (2003) 'Identifying valid and reliable measures for dimensions of a learning culture', *Advances in Developing Human Resources*, vol. 5, no. 2, pp. 152-162. http://dx.doi.org/10.1177/1523422303005002003
Xie, L. (2019) 'Leadership and organizational learning culture: a systematic literature review', *European Journal of Training and Development*, vol. 43, no. 1/2, pp.76-104. http://dx.doi.org/10.1108/EJTD-06-2018-0056
Zuo, L., Fisher, G.J. and Yang, Z. (2019) 'Organizational learning and technological innovation: the distinct dimensions of novelty and meaningfulness that impact firm performance', *Journal of the Academy of Marketing Science*, vol. 47, no. 6, pp. 1166-1183. https://doi.org/10.1007/s11747-019-00633-1

CAREER ADVANCEMENT OF BUSINESS FACULTY IN THE UNITED STATES AND CZECHIA

[1,2]✉Alena Höfrová, [3]Pavla Rymešová, [3]Dana Benediktová, [4]Mark A. Small

[1]Department of Psychology, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, hofrova@pef.czu.cz

[2]Institute on Family and Neighborhood Life, Clemson University, United States

[3]Department of Psychology, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

[4]Department of Psychology, Clemson University, United States

Abstract

Universities worldwide are analyzing their tenure and promotion processes to redefine the guidelines to be more objective, consistent, and transparent. Guided by a social cognitive career theory and an ecological model of career development, this study examined the differences and similarities in the systems of faculty career advancement in two specific business colleges, one in the United States (Clemson University) and another in Czechia (Czech University of Life Sciences Prague). Using a comparative case study design, this paper utilized a qualitative deductive content analysis of the tenure and promotion guidelines and related documents in both colleges. From a review of existing literature, an unconstrained matrix of different categories was created and used to code the documents. Similarities and differences in the two systems were discussed. The authors conclude with recommendations for future research.

Keywords

Content analysis, ecological model of career development, faculty career advancement, social cognitive career theory, tenure, promotion and reappointment guidelines (TPR)

Introduction

Understanding how faculty careers advance is an important and timely question. Currently, universities worldwide are analyzing their tenure, promotion and reappointment (TPR) processes to be more objective, consistent, and transparent. Most of the relevant research is focused on higher education institutions in the United States (U.S.) or Canada. For example, Schimanski and Alperin (2018) synthetized tenure and promotion guidelines in the U.S. and Canada and discussed issues related to an overemphasis on research and inappropriate measures of the quality of publications. They stressed the importance of better understanding of written guidelines in order to create better processes. More recently, Alperin et al. (2019) compared the tenure and promotion guidelines between a sample of 129 universities in the U.S. and Canada. They specifically focused on the criteria that evaluate faculty community and public service and pointed out that service is an undervalued dimension of faculty work while the greatest emphasis is put on faculty research.

Despite the overrepresentation of U.S. institutions in the field of academic career advancement research, there is a growing worldwide interest in understanding and improving academic performance measures (Schimanski and Alperin, 2018). As pressure builds for universities to meaningfully increase faculty productivity, it has become critical to understand the factors that influence faculty career advancement (Tien, 2008). One strategy is to compare and learn best practices from other universities (Youn and Price, 2009). In one example, Tanaomi and Asaadi (2017) compared promotion and tenure guidelines from Portland State University and the University of

Tehran. A clear quantitative evaluation criteria and faculty participation on others faculty promotion decisions were recognized as effective practices. Still, most countries lack strategic planning for faculty professional development and there is a need for building an empirical foundation for universities to draw from in establishing ideal guidelines (Crosier et al., 2017).

As recommended by Witte and López-Torres (2017), to enhance the research of efficiency and effectiveness in education, it is necessary to undertake studies that compare differences and similarities across countries and educational systems. Therefore, the aim of this study was to examine the differences and similarities in the systems of faculty career advancement in two specific business colleges, one in the U.S. (Clemson University) and the other in Czechia (Czech University of Life Sciences Prague). These two specific colleges were chosen due to similarities in their classification of being business colleges within public research universities with an agricultural legacy and their differences in the centralization of the TPR process.

In order to compare faculty career advancement between the two business colleges, we focused on two major promotions in the careers of faculty. The first promotion is from assistant professor to associate professor. This promotion stage is known as habilitation in Czechia and in the U.S. is often accompanied by the granting of tenure (lifetime employment). The second promotion stage is from associate professor to full professor.

A systematic literature review conducted by Zacher et al. (2019) pointed out that previous faculty career development research was not theoretical and predominantly focused on the evaluation of specific programs rather than on the identification of factors influencing faculty career advancement. To address this gap, two frameworks guided the analysis of factors influencing career development in the present study. An Ecological Model of Career Development (Cook, Heppner and O'Brien, 2002) focuses on the role environmental factors play in career advancement. Additionally, a Social Cognitive Theory (Lent, Brown and Hackett, 1996) focuses on how the internal processes within an individual influence career advancement. Combined, the two frameworks provide a comprehensive and complementary understanding of career advancement.

This study was guided by the following research questions: How do the guidelines for faculty career advancement differ between the College of Business (CB) at Clemson University and at the Faculty of Economics and Management (FEM) at the Czech University of Life Sciences Prague? What factors influence faculty career advancement at CB and at FEM?

Materials and Methods

In this study, a comparative case study design was used to analyze faculty career advancement. Two specific business colleges, one in the U.S. (Clemson University) and another in Czechia (Czech University of Life Sciences Prague) were analyzed as single cases. Both universities are public institutions with an agricultural legacy and are performing at the highest level of research activity within their country. FEM has a larger number of departments than CB. FEM consists of twelve departments (economic theories, economics, humanities, information engineering, information technologies, languages, trade and finance, law, psychology, management, statistics, and systems engineering) and CB consists of six departments (accountancy, economics, finance, graphic communication, management, and marketing). Similarly, the student enrollment is greater at FEM; FEM had 8584 undergraduate and graduate students while CB had 4762 undergraduate and graduate students in 2018. The gender composition of all enrolled students also differs among the colleges; female students represented about 53% of enrolled students at FEM and about 43% at CB in 2018. The two business colleges are similar in numbers of their faculty members; CB had 184 faculty members and FEM had 220 faculty members in 2018. In addition, both colleges have higher numbers of male faculty as compared to female faculty; CB had 33% of female faculty and FEM had 45% of female faculty (Clemson University, 2020; CULS, 2018).

Data collection

Publicly available TPR documents from CB and FEM colleges were identified. Documents such as TPR departmental and university guidelines, faculty manual, and departmental and university by-laws were collected from both universities' websites. All the documents were coded using the qualitative data analysis software NVivo 12 Plus.

Data analysis

The content analysis approach by Elo and Kyngäs (2008) was used to conduct deductive coding while using an unconstrained matrix that included categories identified from the literature. All the documents were coded line by line by applying the categories from the unconstrained matrix. The deductive coding was followed by principles of inductive content analysis. The process included line by line open coding, categorization, and abstraction. The coding was performed by one bilingual researcher and validated by a second bilingual researcher, therefore, there was no need for document translation. Accuracy of codes and categories was achieved by consensus between the two researchers. After finishing the coding of the documents from both colleges, cross-case synthesis was used to identify differences and similarities between the two departments (Yin, 2009).

Results

The content analysis revealed a number of differences and similarities in the TPR guidelines that influence faculty career advancement at the two business colleges in the U.S. and in Czechia.

The goals of the TPR guidelines

At both colleges, the TPR guidelines include the minimal criteria for faculty to be able to start the promotion process, but these minimal criteria do not guarantee a positive outcome of the promotion process. According to FEM guidelines: *"The criteria stated in this document are the minimal requirements for the promotion procedures and may be higher for different colleges."* The goal of the TPR guidelines at CB is to establish standards for faculty performance and professional development that enable the departments to achieve national recognition in their disciplines. However, FEM does not define what is the essential goal of the TPR guidelines.

Flexibility in the TPR processes

The TPR guidelines at CB reflect the importance of faculty interests and strengths in measuring their performance: *"The guidelines outline indicators of excellence for teaching, scholarship, and service which recognize that performance evaluations must be flexible enough to accommodate differences among faculty interests and strengths."* CB's faculty in collaboration with the departmental chair set individual goals that are congruent with departmental, college, and university interests. The achievement of the goals is evaluated during the faculty annual performance review that indicate an individual's progress toward their promotion. For example, the guidelines in the Accountancy Department state: *"A faculty member's annual review shall be one factor considered by the Director and the TPR Committee in making tenure, promotion and reappointment decisions."* Across CB departments, each promotion process requires an individual approach: *"Performance expectations for reappointment, promotion, and tenure may change over time. Thus, personnel decisions made in a given year are not necessarily precedents for decisions made in subsequent years."* In contrast, FEM guidelines do not include any reference to an individuals' career goals or the influence of annual performance review on faculty promotion.

Dimensions of faculty performance

The dimensions of faculty performance evaluation include teaching, research, and service at both colleges. Given the fact, that both universities are research institutions, both universities put more emphasis on research and teaching in the evaluations. The CB's Economics Department recognizes the importance of research and teaching in the following: *"While success in all areas of responsibility is expected, greater emphasis will be placed upon the research and teaching performance of candidates for promotion to Associate Professor." Both colleges have lower minimal service requirements for faculty promotion and the evidence of service activities is not even included in the minimal criteria for promotion from assistant professor to associate professor at FEM.*

Promotion criteria

The FEM promotion criteria are developed in accordance with the Higher Education Act (Act No. 111/1998 Coll., 2017) and are approved by the Ministry of Education, Youth and Sport of Czechia. The promotion criteria are uniform for the entire university and faculty can be promoted only in disciplines that are accredited by the state. Like most U.S. universities, CB's guidelines are more decentralized—each department has its own departmental TPR guidelines that are developed in accordance with the college and university guidelines, the Policy for Best Practices for Performance Review issued by the South Carolina Commission on Higher Education, and the Statement of Principles on Academic Freedom and Tenure of the American Association of University Professors. The Department of Graphic Communications offers an explanation of the discipline specific promotion criteria: "*The uniqueness of this department, its mission, and its established national and international position within the realms of educational, professional, technical, and industrial entities in which it functions must all be understood for any evaluative guidelines to be meaningful, realistic, practical, and fair."* Table 1 shows the promotion criteria for FEM and each department at CB. Criteria such as invited speaker, journal editor and reviewer, thesis and dissertation chairs and committees, and textbooks are evaluated under a different dimension of faculty performance depending on a particular department. Other CB criteria include student evaluations of teaching, recognition of awards, community and public service, unpublished manuscripts, submitted grants, and collegiality.

A main difference in promotion criteria between CB and FEM is the habilitation thesis and lecture at FEM. A successful defense of the habilitation thesis is one of the requirements for an assistant professor's promotion. A habilitation thesis can have multiple forms: (1) written thesis that includes new scientific knowledge, (2) a collection of published scientific or engineering papers accompanied with a commentary, or (3) a published monograph that includes new scientific knowledge. The promotion committee names three habilitation thesis reviewers, with a maximum of one from the same university. Another requirement for promotion at FEM is a habilitation lecture. The topic of the habilitation lecture is chosen by the promotion committee. The habilitation thesis defense and the habilitation lecture are held at a public meeting of the College Scientific Board. During the meeting, the faculty undergoing the promotion process has an opportunity to address the habilitation thesis reviewers' comments, defend their thesis, and comment on their research and teaching activities. The promotion decision made by the promotion committee is confidential.

Form of evaluation

The form of evaluation differs between the two business colleges. FEM guidelines include quantitative matrices with points assigned to the specific criteria within the three dimensions of

faculty performance. Therefore, FEM faculty are required to submit their performance points for research, teaching, and service with higher points necessary for the promotion from associate professor to full professor then from assistant professor to associate professor. On the contrary, CB guidelines include nonnumerical categories such as excellence or distinguished success indicating the highest category and effectiveness and marked success as the second highest category. The categories required for different promotion stages differ by departments. For example, the marketing department requires the following: "*Tenure and promotion require a rating of "Excellent" in research and a minimum rating of "Very Good" in teaching and service."*

Transparency

Every promotion process is required to be publicly available at FEM. The public availability is secured in the Higher Education Act (Act No. 111/1998 Coll., 2017). FEM is required to post on its websites the status of the specific promotion process including quantified matrices of specific faculty performance, detailed documents of specific faculty performance, and information about the specific TPR committee. At CB, the process is more confidential with an applicant compiling a dossier of evidence of research, teaching evaluations, service, and letters from independent external reviewers. Although the standards for promotion are explicitly stated, there is some discretion in how the compiled dossier evidence is weighed and whether it meets the standard. The dossier is first reviewed and evaluated by the departmental TPR committee, the TPR chair who writes an evaluative letter to include in the dossier. The dossier is then forwarded to the departmental chair, who writes an independent letter. The dossier is then forwarded to the dean of the college who does an independent evaluation and then on to the provost who makes a final recommendation to the Board of Trustees.

Factors influencing faculty career advancement

Following the Social Cognitive Career Theory (Lent, Brown and Hackett, 1996) faculty career advancement is influenced by (1) faculty career goals defined with the departmental chair (CB); (2) outcome expectations publicly available (FEM) or communicated by the departmental chair and the TPR committee (CB); and (3) learning experiences gained from the annual performance review (CB). Following the Ecological Model of Career Development (Cook, Heppner and O'Brien, 2002), faculty career advancement is influenced by (1) colleagues in TPR committees (CB, FEM), (2) practices within a discipline (CB, FEM), (3) departmental guidelines (CB), (4) college TPR guidelines (CB, FEM), (5) university guidelines and missions (CB, FEM), (6) the state requirements for faculty career advancement (FEM), (7) external reviewers in TPR committees (FEM), (8) external reviewers (CB), (9) students (CB), (10) habilitation thesis reviewers (FEM), (11) deans (CB, FEM), (12) university presidents (CB, FEM), (13) provost (CB), (14) Minister of Education, Youth and Sport (FEM), and (15) full professors appointed by the president of the country (FEM).

	Research	Teaching	Service
FEM	***Habilitation thesis***, journal articles, conference presentations, books, authorship, impact factor, patents, funding, citation analysis	***Habilitation lecture***, **textbooks**, ***articles***, ***teaching abroad***, ***teaching in foreign language***, **thesis and dissertation chair**, funding, ***teaching hours***	Professional organization or associations, funding agency, journal editorial board, board for doctoral program, scientific board, international organization specialist, **invited speaker**
CB Accountancy	Journal articles, conference presentations, books, ***awards***, citation analysis, **invited speaker**, ***technical reports***	***Student evaluation***, ***peer and chair teaching evaluation***, ***awards***, ***development of new class***, ***curriculum changes***, **textbooks**, ***completion of teaching workshop***, ***multi-section courses***, ***course syllabi***, ***course grading comparisons with departmental norms***	***Departmental***, ***college***, ***or university committee***, ***accreditation***, ***awards***, professional organization or associations, **journal editorial board**, funding agency reviewer, conference reviewer, government commission, funding, **thesis and dissertation committee**, ***student's organization***, ***TPR external reviewer***, ***community service***, ***collegiality***
CB Economics	Journal articles, books, funding, ***awards***, ***unpublished manuscripts***	***Student evaluation***, ***peer and chair teaching evaluation***, funding, ***awards***	***Departmental***, ***university***, ***or profession service***, funding, professional organization or associations, ***student's organization***, ***public service***, ***awards***
CB Finance	Journal articles, conference presentations, books, funding, ***awards***, citation analysis, ***technical reports***, **journal editor**	***Student evaluation***, ***peer and chair teaching evaluation***, ***awards***, ***curriculum changes***, ***development of new class***, funding, textbooks, **directing independent student research**, ***course grading comparisons with departmental norms***	***Departmental***, ***college***, ***or university committee***, professional consulting, funding, government commissions, professional organization or associations, **journal editor**, **editorial board member**, **journal reviewer**, funding agency reviewer, ***student's organization***, ***TPR external reviewer***, **thesis and dissertation committee at other institution**, ***community service***
CB Graphic Communications	Journal articles, conference presentations, books, **named into technical societies**, **textbooks**, **thesis and dissertation chair**, **thesis and dissertation committee**, ***awards***, **journal editor**, **journal editorial board**, **journal reviewer**	***Student evaluation***, ***course syllabi***, ***awards***, ***development of new pedagogical methods***, ***development of new class***, ***curriculum changes***, **supervisor for student special projects**, funding	***Departmental***, ***college***, ***or university committee***, funding, ***student's organization***, ***student recruiting activities***, professional organization or associations, ***award***, ***workshop for professionals***, ***WebMaster***, government commission, professional consulting, **invited speaker**, ***collegiality***
CB Management	Journal articles, books, ***awards***, **journal editorial board**, citation analysis, funding, authorship, **thesis and dissertation chair**, **thesis and dissertation committee**, **invited speaker**, **journal reviewer**, ***research accomplishment by graduate student***, ***grant submission***	***Student evaluation***, ***course syllabi***, ***course grading comparisons with departmental norms***, ***awards***, ***development of new pedagogical methods***, **textbooks**, ***curriculum changes***, funding, ***teaching accomplishment by graduate students***, ***Creative Inquiry***	Professional organization or associations, funding, ***departmental***, ***college***, ***or university***, ***coordination of faculty development program***, ***student's organization***, government commission, organization specialist, ***faculty recruiting activities***, **invited speaker**, ***instructor for industry courses***, ***expert witness testimony***, professional consulting
CB Marketing	Journal articles, citation analysis, authorship, ***awards***, conference presentations, funding, ***evidence of requests for revision and resubmissions***	***Student evaluation***, ***awards***, ***development of new class***, ***Creative Inquiry***, ***number and level of course preparations***, **thesis and dissertation chair**, **thesis and dissertation committee**, **textbooks**, ***visiting teaching professor***	***Departmental***, ***college***, ***or university committee***, ***collegiality***, **journal editor**, **journal editorial board**, **journal reviewer**, **conference program chair**, **public and community service**

Table 1: Comparison of promotion criteria between FEM and CB (bolded text indicates criteria that are in different dimensions of faculty performance, bolded and italic text indicates criteria that differ between FEM and CB).

Discussion

This study examined two business colleges from two different countries that compared diverse factors that can influence faculty career advancement. This study was guided by the following research questions: How do the guidelines for faculty career advancement differ between the College of Business (CB) at Clemson University and at the Faculty of Economics and Management (FEM) at the Czech University of Life Sciences Prague? What factors influence faculty career advancement at CB and at FEM?

A primary difference of the guidelines between the two colleges is that minimal promotion criteria are specifically quantified in FEM and every promotion process is required to be publicly available. Therefore, faculty members can easily access the minimal criteria and the standard criteria performed by their colleges who go through the promotion process. The availability of this information about promotion requirements makes the promotion process objective and clear. In contrast, there is more flexibility in the CB's TPR guidelines, both across CB departments in terms of the criteria as well as in the confidential process by which candidates for promotion are evaluated. Sometimes, as Smesny, et al. (2007) pointed out, this lack of clarity in TPR guidelines is perceived as one of the barriers to faculty career advancement. Considering that the clarity in TPR processes can influence faculty job satisfaction (Lee et al., 2017), faculty satisfaction with collegial relationships (Ponjuan, Conley and Trower, 2011), and faculty retention (O'Meara, Lounder and Campbell, 2014), clearer TPR guidelines could also contribute to efficiency and effectiveness in education (Witte and López-Torres, 2017). In addition, transparency in the promotion process can reduce inequalities among faculty (Bradley et al., 2017). Arguably, the more discretion allowed in the CB guidelines and processes place a greater burden on the departmental chair and the TPR committee to communicate clearly the expectations to faculty, especially should the written TPR guidelines deviate from the standard TPR practices (Schimanski and Alperin, 2018). The increased discretion also puts more pressure on faculty to strategically network within their department to access the information about TPR requirements and about the how established standards are met for faculty promotion. According to Pifer and Baker (2013), junior faculty predominantly create a strategic connection with their departmental colleagues to access some specific information or resource. However, making strategic connections with colleagues can be more challenging for female faculty especially in male dominated disciplines (Xu and Martin, 2011). Considering that faculty promotion depends heavily on colleagues and superiors, the networking activities are crucial for their career advancement at both colleges.

There is also difference in the factors that influence faculty career development. Fundamentally, the difference is that TPR criteria are created at different levels of the university structure at each institution. CB is decentralized and employs departmental specific criteria while FEM uses minimal criteria that are identical across the entire university. There is a breadth of criteria across departments in the CB compared to the uniformity of criteria at FEM. For example, student evaluations, departmental guidelines, and the influence of the provost are specific to CB. In contrast, the influence of state requirements, the habilitation thesis reviewers, minister, and the president of the country are specific to FEM.

The evaluation criteria for research counted toward promotion are comparable between CB and FEM. Not surprisingly, the research criteria in terms of journal articles, books, funding, and textbooks are generally recognized as the most common criteria of research for promotion in economics departments (Liner and Sewell, 2009). However, FEM differs by the requirement of the habilitation thesis and habilitation lecture. The second significant dimension of faculty performance is teaching. The biggest difference is that CB heavily relied on students' and peer

teaching evaluations while FEM does not consider them at all. Finding different sources of teaching evaluations rather than student evaluations is appropriate especially when researchers have shown that student evaluations are biased (Mitchell and Martin, 2018). Finally, FEM undervalues the importance of service in the evaluation criteria despite the fact that research has shown that faculty (especially female faculty) spend significant time on service activities (Guarino and Borden, 2017; Mamiseishvili, Miller and Lee, 2016).

Although not fully explicated in the brief paper here, the findings have implications for the development of the social cognitive career theory and ecological model of career development. Basically, the findings suggest that in a system like FEM, where there are clear environmental cues such as explicit criteria for career advancement, future research might focus on the individual differences which allow some people to flourish. In contrast, in a more undefined and complex environment like CB, future research might focus less on individual research attributes and more on how well people can figure out the social environment given the discretion built into the system.

Conclusion

To advance in their careers, faculty from Czechia and the U.S. have similar categories of activities to accomplish, namely, research, teaching and service. What counts as accomplishments within these categories varies between universities, and at CB, even between departments. Moreover, the process by which activities are evaluated to determine whether they meet standards for promotion also differ in the amount of discretion afforded the reviewers. At FEM, there is little subjective judgment in whether metrics in the numerical matrices are met but perhaps more discretion in how the habilitation thesis and lecture are received. In contrast, CB has discretion built into every independent reviewer (e.g., TPR committee chair, chair, dean, provost) of a candidate's dossier. This brief comparison hides many limitations including the broad generalizations of both the criteria and the processes. Moreover, the analysis of the formal documents does not provide the opportunity to examine how these TPR guidelines actually affect faculty careers. Therefore, an additional qualitative analysis that would examine the influence of different TPR practices on faculty lived experience of promotion process is needed to fully understand all aspects of faculty career advancement.

Acknowledgement

This research was supported by the Internal Grant Agency (IGA) of Faculty of Economics and Management, Czech University of Life Sciences Prague (2019MEZ0008).

References

Act No. 111/1998 Coll., (amended and consolidated) on Higher Education Institutions and on Amendments and Supplements to Some Other Acts (the Higher Education Act), Ministry of Education, Youth and Sports of the Czech Republic, 2017. [Online], Available: http://www.msmt.cz/areas-of-work/tertiary-education/the-higher-education-act?lang=2 [1 May 2020].

Alperin, J.P., Nieves, C.M., Schimanski, L.A., Fischman, G.E., Niles, M.T. and McKiernan, E.C. (2019) 'Meta-Research: How significant are the public dimensions of faculty work in review, promotion and tenure documents?', *ELife*, vol. 8. https://doi.org/10.7554/eLife.42254.001

Bradley, D., Yerichuk, D., Dolloff, L.A., Galway, K., Robinson, K., Stark, J. and Gould, E. (2017) 'Examining equity in tenure processes at higher education music programs: An institutional ethnography', *College Music Symposium*, vol. 57, The College Music Society. https://doi.org/10.18177/sym.2017.57.sr.11336

Clemson University. (2020) *Clemson University factbook*. [Online], Available: https://www.clemson.edu/institutional-effectiveness/oir/factbook/ [20 Feb 2020].
Cook, E.P., Heppner, M.J. and O'Brien, K.M. (2002) 'Career development of women of color and white women: Assumptions, conceptualization, and interventions from an ecological perspective', *The Career Development Quarterly*, vol. 50, no. 4, pp. 291-305. http://dx.doi.org/10.1002/j.2161-0045.2002.tb00574.x
Crosier, D., Kočanová, D., Birch, P., Davykovskaia, O. and Parveva, T. (2017) *Modernization of higher dducation in Europe: Academic staff 2017*. European Commission. [Online], Available: https://eacea.ec.europa.eu/national-policies/eurydice/content/modernisation-higher-education-europe-academic-staff-%E2%80%93-2017_en [20 Feb 2020].
CULS. (2018) *CULS annual report*. [Online], Available: https://www.czu.cz/cs/r-7210-o-czu/r-7702-oficialni-dokumenty/r-7812-vyrocni-zpravy [20 Feb 2020].
Elo, S. and Kyngäs, H. (2008) 'The qualitative content analysis process', *Journal of Advanced Nursing*, vol. 62, no. 1, pp. 107-115. http://dx.doi.org/10.1111/j.1365-2648.2007.04569.x
Guarino, C.M. and Borden, V.M. (2017) 'Faculty service loads and gender: Are women taking care of the academic family*?', Research in Higher Education*, vol. 58, no. 6, pp. 672-694. http://dx.doi.org/10.1007/s11162-017-9454-2
Lee, P., Miller, M.T., Kippenbrock, T.A., Rosen, C. and Emory, J. (2017) 'College nursing faculty job satisfaction and retention: A national perspective', *Journal of Professional Nursing*, vol. 33, no. 4, pp. 261-266. http://dx.doi.org/10.1016/j.profnurs.2017.01.001
Lent, R.W., Brown, S.D., and Hackett, G. (1996) 'Career development from a social cognitive perspective', in Brown, S.D. Brooks, L. and Associates (Eds.) (1996) *Career choice and development* (3rd ed., 373-421), San Francisco: Jossey-Bass.
Liner, G.H. and Sewell, E. (2009) 'Research requirements for promotion and tenure at PhD granting departments of economics', *Applied Economics Letters*, vol. 16, no. 8, pp. 765-768. http://dx.doi.org/10.1080/13504850701221998
Mamiseishvili, K., Miller, M.T. and Lee, D. (2016) 'Beyond teaching and research: Faculty perceptions of service roles at research universities', *Innovative Higher Education*, vol. 41, no. 4, pp. 273-285. http://dx.doi.org/10.1007/s10755-015-9354-3
Mitchell, K.M. and Martin, J. (2018) 'Gender bias in student evaluations', *PS: Political Science & Politics*, vol. 51, no. 3, pp. 648-652. http://dx.doi.org/10.1017/S104909651800001X
O'Meara, K., Lounder, A. and Campbell, C.M. (2014) 'To heaven or hell: Sensemaking about why faculty leave', *The Journal of Higher Education*, vol. 85, no. 5, pp. 603-632. http://dx.doi.org/10.1080/00221546.2014.11777342
Pifer, M.J. and Baker, V.L. (2013) 'Managing the process: The intradepartmental networks of early-career academics', *Innovative Higher Education*, vol. 38, no. 4, pp. 323-337. http://dx.doi.org/10.1007/s10755-012-9243-y
Ponjuan, L., Conley, V.M. and Trower, C. (2011) 'Career stage differences in pre-tenure track faculty perceptions of professional and personal relationships with colleagues', *The Journal of Higher Education, vol. 82*, no. 3, pp. 319-346. http://dx.doi.org/10.1353/jhe.2011.0015
Schimanski, L.A. and Alperin, J.P. (2018) 'The evaluation of scholarship in academic promotion and tenure processes: Past, present, and future', *F1000Research*, vol. 7. http://dx.doi.org/10.12688/f1000research.16493.1
Smesny, A.L., Williams, J.S., Brazeau, G.A., Weber, R.J., Matthews, H.W. and Das, S.K. (2007) 'Barriers to scholarship in dentistry, medicine, nursing, and pharmacy practice faculty', *American Journal of Pharmaceutical Education*, vol. 71, no. 5, pp. 1. http://dx.doi.org/10.5688/aj710591

Tanaomi, M.M. and Asaadi, R.R., (2017) 'A comparative study of faculty members' career advancement (promotion) systems in the United States and the Islamic Republic of Iran: Case analysis of the University of Tehran and Portland State University', *International Journal of Higher Education*, vol. 6, no. 4, pp. 111-121. http://dx.doi.org/10.5430/ijhe.v6n4p111
Tien, F.F. (2008). 'What kind of faculty are motivated to perform research by the desire for promotion?', *Higher Education*, vol. 55, no. 1, pp. 17-32. http://dx.doi.org/10.1007/s10734-006-9033-5
Witte, K.D. and López-Torres, L. (2017) 'Efficiency in education: a review of literature and a way forward', *Journal of the Operational Research Society*, vol. 68, no. 4, pp. 339-363. http://dx.doi.org/10.1057/jors.2015.92
Xu, Y.J. and Martin, C.L. (2011) 'Gender differences in STEM disciplines: From the aspects of informal professional networking and faculty career development', *Gender Issues*, vol. 28, no. 3, pp. 134-154. http://dx.doi.org/10.1007/s12147-011-9104-5
Yin, R.K. (2009) *Case study research: Design and methods fourth edition*, Los Angeles and London: SAGE.
Youn, T.I. and Price, T.M. (2009) 'Learning from the experience of others: The evolution of faculty tenure and promotion rules in comprehensive institutions', *The Journal of Higher Education*, vol. 80, no. 2, pp. 204-237. http://dx.doi.org/10.1080/00221546.2009.11772139
Zacher, H., Rudolph, C.W., Todorovic, T. and Ammann, D. (2019) 'Academic career development: A review and research agenda', *Journal of Vocational Behavior*, vol. 110, pp. 357-373. http://dx.doi.org/10.1016/j.jvb.2018.08.006

EXAMINING ENGLISH LANGUAGE SKILLS IN FIRST-YEAR UNIVERSITY STUDENTS

[1]✉Miroslav Hrubý, [2]Eva Staňková

[1]Department of Informatics and Cyber Operations, Faculty of Military Technology, University of Defence in Brno, Czech Republic, miroslav.hruby@unob.cz

[2]Language Centre, University of Defence in Brno, Czech Republic

Abstract

The paper presents the outcomes of a quantitative study analyzing the level of English Language skills assessed by NATO STANAG 6001 examination. The research examines Standardized Language Profiles in the English Language in 291 first-year students at the University of Defence in Brno in the academic year 2019/2020. The aim of the paper is to identify their weakest skills and to compare their representation between students at two faculties, and men and women. The outcomes show that the results in productive skills, Speaking and Writing, are significantly worse than the results in receptive skills, Listening and Reading, at both faculties. The weakest skill is Writing, followed by Speaking. There are differences in the representation of the weakest skills between technically-oriented and leadership-oriented students, as well as between female and male students. The outcomes should influence language teaching at all stages of education in favour of developing productive skills.

Keywords

English language skills, gender, military, NATO STANAG 6001, professional focus, Standardized Language Profile

Introduction

Learning and teaching the English Language (EL) in NATO member states requires permanent attention. Mastering the EL belongs to key requirements in military university students. The Faculty of Military Leadership (FML) and Faculty of Military Technology (FMT) of the University of Defence (UoD) in Brno, the Czech Republic, naturally react to NATO and Czech Republic security demands by incorporating study programmes tailored to the security needs, in which mastering the English Language plays an important role.

Foreign language training and testing is provided by the Language Training Centre (LTC) at the UoD. It involves teaching foreign languages to civilian and military university students in Bachelor's, Master's and Ph.D. study programmes, as well as intensive courses for military professionals, and regular courses for faculty members. Military students and personnel are prepared for language examinations according to NATO STANAG 6001. Teaching languages follows NATO recommendations stated in the Bureau for International Language Co-ordination (BILC, 2020). To ensure linguistic operability, NATO provides guidelines for language curriculum, test development, and for recording and reporting Standardized Language Profiles (SLP). The descriptors for SLP are provided in the document called NATO STANAG 6001 Edition 5, Language Proficiency Levels (NATO, 2014).

The UoD military first-year students, who are the subjects of this research, have to reach at least lower intermediate level in four language skills: Listening, Speaking, Reading and Writing, expressed as SLP 2222, by the end of their fifth semester, and should accomplish SLP 3232 in their tenth semester. Regarding the Common European Framework of Reference for Languages (Council of Europe, 2020), SLP 2222 is comparable to B1, and SLP 3232 to B2.

Such demanding goals, set since the academic year 2019/2020, require sustained effort on the side of educators, such as monitoring and evaluating students' outcomes (Čechová, Neubauer and Sedlačík, 2019), raising students' awareness of a potential danger of failing, and suggesting measures to eliminate unsuccessful students (Hrubý and Staňková, 2019). Concerning teaching methods, LTC teachers favour communicative approach, and blended learning as a means of enhancing students' motivation and self-governed learning (Čechová and Rees, 2013, Zerzánová, Čechová, Beránková, 2017). For this purpose, the teachers have been developing an extensive, tailored e-learning support in Moodle Learning Management System, aimed at both general and specialized English (Staňková, Beránková and Čechová, 2017).
This research paper focuses on the analysis of SLP in the EL in two target groups: FML and FMT first-year students in the academic year 2019/2020. The aim of the paper is to identify their weakest skills and to compare their representation between students at two faculties, and men and women.

Research questions

Based on the UoD requirements for improving students' NATO STANAG 6001 exam results, the following research questions (Q) were formulated.

- Q1: What is the weakest skill out of Listening, Speaking, Reading and Writing rated by the NATO STANAG 6001 exam in the first-year military students at the FML and FMT, UoD?
- Q2: Is there any difference in the representation of the weakest skills between the students at the FML and FVT?
- Q3: Is there any relationship between gender and NATO STANAG 6001 exam result?

Materials and Methods

To monitor the students' EL skills, we used a research sample comprising the results of the examination in English according to NATO STANAG 6001 (NATO, 2014) of 291 first-year military students studying at the FML and FMT, UoD, in the academic year 2019/2020. Almost all the students took the exam in the time span from October to December 2019.
The characteristics of the research sample are stated in Table 1. The research sample contained 166 first-year military students, 136 men and 30 women, studying at the FML; and 125 first-year military students, 120 men and 5 women, studying at the FMT.

	FML	FMT	FML+FMT total
men	136	120	256
women	30	5	35
men+women total	166	125	291

Table 1: Characteristics of the research sample, 2019/2020 (source: own calculation)

Each NATO STANAG 6001 examination result, achieved in a multi-level test, is expressed by a four-digit number, obtained for listening (L), speaking (S), reading (R) and writing (W) skills respectively, e.g. 2 2+ 3 2. Each digit corresponds to a Standardized Language Profile (SLP) defined by NATO descriptors (NATO STANDARD ATrainP-5, 2016). The levels which can be obtained at the LTC, UoD, are as follows:

- 0 No proficiency
- 1 Survival
- 1+ Survival +
- 2 Functional
- 2+ Functional +
- 3 Professional

The research sample included all the above-mentioned levels. The exam results of the FML and FMT students were analyzed separately with the aim to identify the weakest skills in the students at both faculties. The four-digit exam code (L, S, R, W) of each student was scrutinized and the least successful skills in relation to other skills were identified. A record was kept on the numbers of:

- the skill that was rated as the worst result out of all four skills;
- the skill that was part of the worst results, when one or two skills were rated better than this one.

Finally, the percentages of these least successful skills were calculated. Microsoft Excel was used for data collection, analysis, calculations and presentation of graphs.

Results

The percentages of the least successful skills in the NATO STANAG 6001 EL exams in the academic year 2019/2020 are presented in Table 2.

	FML	FMT	FML+FMT total
Listening	10.84%	8.00%	9.62%
Speaking	33.73%	36.80%	35.05%
Reading	10.84%	4.80%	8.25%
Writing	33.13%	42.40%	37.11%

Table 2: Comparison of the percentages of the least successful skills in NATO STANAG 6001 EL exams, 2019/2020 (source: own calculation)

The outcomes show that the exam results in productive skills, Speaking and Writing, are significantly worse than the results in receptive skills, Listening and Reading, at both faculties. The least successful skill at the UoD is Writing.

As presented in Table 2, there is a difference in the percentage of the weakest skills between the students at the FML and FVT. The difference can be noticed between the percentages of the productive and receptive skills. At the FML, Speaking and Writing exam results are almost equal, as well as Listening and Reading exam results. The difference between the percentages of weak receptive and productive skills makes about 22 per cent.

Concerning FVT, the results show that there are more significant differences between the percentages of weak receptive and productive skills than at the FVL. The most considerable difference, almost 38 per cent, is between Reading and Writing. The results demonstrate that technically-oriented FVT students experience serious difficulties in mastering productive language skills. Figure 1 presents the visual comparison of the weak skills between FML and FVT, UoD.

The data in Table 3 have been plotted on the graph in Figure 2. It illustrates almost equal results in speaking and reading for men and women. On the other hand, it shows two differences:

- the female first-year students at the UoD are significantly worse listeners than the male students, the difference makes 18.29%;
- the male first-year students at the UoD seem to be slightly worse writers than the female students, the difference makes 12.96%.

However, the authors are aware of the insufficient number of the female first-year students in the research sample, so the value of this finding is low.

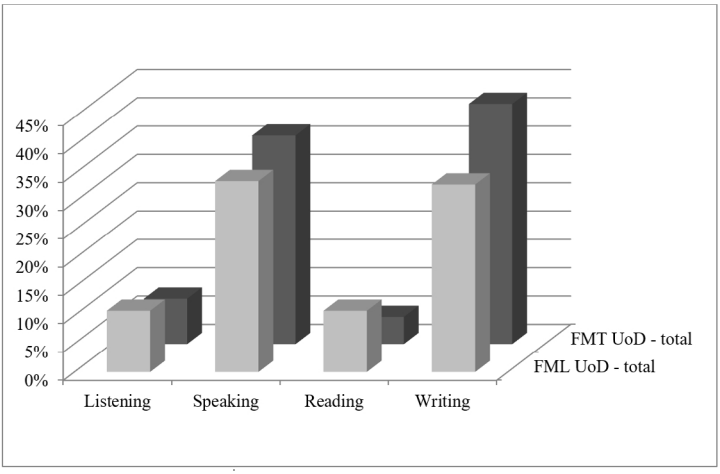


Figure 1: Comparison of the weakest skills in NATO STANAG 6001 EL exams, 2019/2020 (source: own calculation)

Gender comparison of the weakest EL skills is expressed in Table 3 and Figure 2.

	FML men	FMT men	FML+FMT men	FML women	FMT women	FML+FMT women
Listening	8.09%	6.67%	7.42%	23.33%	40.00%	25.71%
Speaking	33.82%	37.50%	35.55%	33.33%	20.00%	31.43%
Reading	11.03%	5.00%	8.20%	10.00%	0.00%	8.57%
Writing	35.29%	42.50%	38.67%	23.33%	40.00%	25.71%

Table 3: Comparison of the weakest skills in NATO STANAG 6001 EL exams between men and women, 2019/2020 (source: own calculation)

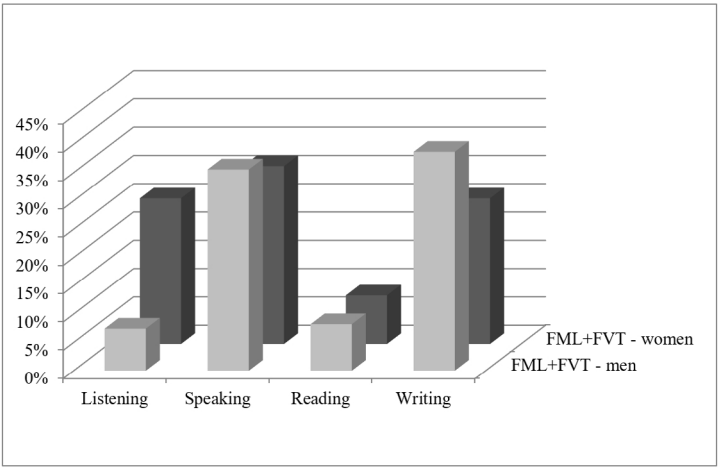


Figure 2: Comparison of the weakest skills in NATO STANAG 6001 EL exams between men and women FML+FVT, UoD, 2019/2020 (source: own calculation)

Summary of findings

The findings are summarized by the answers (A) to the research questions.

- A1: The weakest skill out of Listening, Speaking, Reading and Writing rated by the NATO STANAG 6001 exam in the first-year military students at the FML and FMT, UoD, is Writing, closely followed by Speaking.
- A2: There is a difference in the representation of the weakest skills between the students at the FML and FVT. Students at the FMT experience more difficulties in productive skills in relation to their receptive skills than students at the FML, so the professional focus of students seems to play a role.
- A3: Female students at the University of Defence seem to be slightly better at Writing than male students, but worse at Listening. However, due to the insufficient number of female students, this finding should be confirmed by further research.

Discussion

Although Writing is often considered the most demanding skill to master in a foreign language there are not many studies that objectively confirm this view. Only recently, the research carried out by Kostikova et al. (2020) indicated that Writing is the most difficult skill to progress in university students, which is directly in line with our finding. Tangpermpoon (2008) explains that Writing is a challenging skill because it requires a great deal of lexical and syntactic knowledge as well as principles of developing and organization ideas. He summarizes approaches to writing and suggests an integrated approach, using product, process and genre writing, which reflects our opinion as well. Also, we can confirm the finding stated by Koeller et al. (2019) that students with different educational emphases in their school tracks differ in their writing skills.

Searching for possible differences in foreign language acquisition based on professional orientation or gender assists educators in selecting appropriate teaching methods. Apart from face-to-face and computer based learning, we suggest that more attention should be paid to mobile learning. We agree with Yu (2019), who states that future research on mobile learning should examine relationships between gender differences, learner motivation, achievement goals, and learning outcomes.

Recommendations

- At all stages of an educational process the teachers should keep in mind the necessity to focus on the weakest language skills and to adjust curriculum and teaching methods accordingly. For example, at the UoD, the students are regrouped according to their weakest language skills at the beginning of semesters, so that the instruction can focus on them and improve them. Language educators at the UoD constantly improve curriculum, select course-books with plenty of communicative activities (Jonáková, Mocková and Muto, 2019), and use modern methods based on contemporary research. For instance, valuable research with applications for developing Writing is presented by Hyland (2015) and for Speaking by Hughes and Reed (2017). The most popular course-book series providing many activities for communication, used by UoD EL teachers, are New English File (published by Oxford University Press), Straightforward (Macmillan) and Open Mind (Macmillan).
- It is suitable to consider professional focus of students and be aware of their weaknesses. Technically-oriented students deserve more attention in improving their productive language skills. Further research could focus on methods which would suit technically-oriented minds.
- A possible role of gender in language learning should be verified by a larger data sample.

- Since the research sample consists of first-year university students, it is obvious that they gained their English language skills at primary and secondary schools. Thus this research, showing that students lack in productive skills, is sending a message to teachers at primary and secondary schools.
- Comparing students' skills in English could inspire educators in other NATO countries to conduct a similar research.

Conclusion

The outcomes of the research examining English language skills of first-year university students at the University of Defence show that the results in productive skills, Writing and Speaking, are significantly worse than the results in receptive skills, Listening and Reading. The weakest skill in the first-year students at the University of Defence is Writing, followed closely by Speaking. The students at the Faculty of Military Technology have worse results in productive skills in relation to their receptive skills than the students at the Faculty of Military Leadership. Female students at the University of Defence seem to be slightly better at Writing than male students, but worse at Listening.

The findings should support educational performance and decision-making in choosing the right and effective methods and approaches in EL teaching at the University of Defence. The outcomes deserve attention of primary, secondary and tertiary school language teachers in the Czech Republic. They may also inspire English teachers in other NATO countries to conduct a similar research and to compare the outcomes between countries.

Acknowledgement

This paper was supported by the Ministry of Defence of the Czech Republic via institutional support for research organization development KYBERBEZ (DZRO K-209) and LANGUAGE (DZRO CJV).

References

BILC (2020) *Bureau for International Language Co-ordination.* [Online] Available: https://www.natobilc.org/en/ [30 Jan 2020].

Council of Europe (2020) *Common European Framework of Reference for Languages (CEFR).* [Online] Available: https://www.coe.int/en/web/common-european-framework-reference-languages/level-descriptions [30 Jan 2020].

Čechová, I., Neubauer, J. and Sedlačík, M. (2019) 'Tracking the University Student Success: Statistical Quality Assessment', *Journal on Efficiency and Responsibility in Education and Science*, vol. 12, no. 1, pp. 12-25. https://dx.doi.org/10.7160/eriesj.2019.120102

Čechová, I. and Rees, M. (2013) 'Blended learning as a means to enhance students' motivation and to improve self-governed learning', *Proceedings of the 12th European Conference on e-Learning,* Sophia Antipolis, France: SKEMA Business School, pp. 71-77.

Hrubý, M. and Staňková, E. (2019) 'Searching for the future cream of the crop in the Czech military', *Proceedings of the 16th International Conference Efficiency and Responsibility in Education (ERIE 2019)*, Prague, pp. 90-96.

Hughes, R. and Reed, B.S. (2017). *Teaching and Researching Speaking*. Abingdon and New York: Routledge.

Hyland, K. (2015) *Teaching and Researching Writing*. New York and London: Routledge.

Jonáková, S., Mocková, N. and Muto, F.D. (2019) 'Foreign language syllabus design in military education', *EDULEARN19 Proceedings, 11th International Conference on Education and New learning Technologies*. Valencia: IATED Academy, pp. 1167-1175. https://dx.doi.org/10.21125/edulearn.2019

Koeller, O., Fleckenstein, J., Meyer, J. et al. (2019) 'Writing skills in English as a foreign language in upper secondary school', *Zeitschrift fur Erziehungswissenshaft*, vol. 22, no. 6, pp. 1281-1312. https://dx.doi.org/10.1007/s11618-019-00910-3
Kostikova, I., Holubnycha, L., Miasoiedova, S., Moroz, T., Ptushka, A. and Avdieienko, I. (2020) 'Perspectives on Study abroad Students through Passing FCE Test: Listening Problems', *Revista Romaneasca Pentru Educatie Multidimensionala*, vol. 12, no. 1, pp. 120-134. https://dx.doi.org/134. 10.18662/rrem/203
NATO (2014) *STANAG 6001 Language Proficiency Levels*. [pdf] NATO Standardization office (NSO). [Online] Available: https://www.natobilc.org/files/file/6001EFed05.pdf [30 Jan 2020].
Staňková, E., Beránková, J. and Čechová, I. (2017) 'English for the Armed Forces of the Czech Republic', *Distance Learning, Simulation and Communication 2017*, Brno, pp. 197-204. [Online] Available: http://dlsc.unob.cz/data/DLSC%202017%20Proceedings%20Selected%20papers.pdf [30 Jan 2020].
Tangpermpoon, T. (2008) 'Integrated approaches to improve students writing skills for English major students', *ABAC Journal,* vol. 28, no. 2, pp. 1-9.
Yu, Z. (2019) 'Gender Differences in Cognitive Loads, Attitudes, and Academic Achievements in Mobile English Learning', *International journal of distance education technologies*, vol. 17, no. 4, pp. 21-35. https://dx.doi.org/10.4018/IJDET.2019100102
Zerzánová, D., Čechová, I. and Beránková, J. (2017) 'Blended Learning as Efficient Method of Language Acquisition', *DisCo 2017: Open Education as a Way to a Knowledge Society*. Prague: Centre for Higher Education Studies, pp. 217-228. Available: http://disconference.eu/wp-content/uploads/2017/01/DisCo-2017-Open-education-as-a-way-to-a-knowledge-society_-12th-conference-reader.pdf [30 Apr 2020].

AN APPROACH FOR EVALUATING WORKERS IN ACADEMIC INSTITUTIONS BY LOGIC AGGREGATION

[1]Miroslav Hudec, [1]Jana Hančlová, [2]✉Lucie Chytilová

[1]Faculty of Economics, VSB - Technical University of Ostrava, Czech Republic
[2]Faculty of Economics, VSB - Technical University of Ostrava, Czech Republic, lucie.chytilova@vsb.cz

Abstract

This paper proposes a new evaluation methodology for individual academic staff at the VSB-Technical University of Ostrava (VSB-TUO). The new wage regulation divides academic staff into lecturers, academicians and researchers. The regulation specifies their activities and proposes tariffs of remuneration within intervals. This article determines their specific tariff levels based on the employees' performance. The new methodology adopted logical aggregation functions for the defined categories of employees. Aggregations are carried out in such a way that they meet the required conditions set by the wage regulation. The examples are explained for categories of lecturers and academicians. The proposed innovative methodological approach is a supporting tool for decision making and assignment of personal components to the wages. This model can be further adapted to the particularities of diverse departments and their internal rules.

Keywords

Academic staff wage evaluation, logic aggregation function, motivation of workers, education

Introduction

Managing human resources in educational processes at universities requires assessing their performance, self-education, but also ensuring their financial reward and maintaining the competitiveness of educational institutions. Vnouckova et al. (2016) deals with the evaluation of human resources by students in private Czech university by questionnaire survey. The conclusions of the paper show that there is a dependence between the effort of teachers, student understanding and teacher's willingness to give students an opportunity to express an opinion. Yıldızlı (2019) examines teachers' goal orientations for teaching and their attitudes towards their job through measures of self-efficacy and burnout in more detail. The conclusions of the structural modeling study show that a positive predictor of attitudes in teaching is the focus on self-liberalization and the effectiveness of student education. The link between the strategic development of human capital and the achievement of competitive advantages in the academic environment is examined in his article Hamadin and Atan (2019) through a questionnaire survey of structural equation modeling (SEM) techniques. The results show that strategic human resources management has a positive impact on the development of human capital at universities as well as on the sustainability of the university´s competitiveness.

Universities are currently interested in evaluating their staff based not only on the quantitative but also the qualitative aspects of performance. The factors that influence the quality of educational processes by teachers, especially professors, are analyzed by Flegl and Rosas (2019). An important factor is the assignment of teachers to the right courses. Gadusova, et al (2016) devoted themselves to the evaluation of teacher's competences as well as with career positions. The authors tried to construct a model in which they link three dimensions: competences related to learner, competences related to the educational process and competences related to professional self-development of teachers at Slovak universities. The research results unequivocally confirm that

it is necessary to evaluate teachers at universities not only in terms of the amount of performance but also the quality of performance. On the other hand, it is also necessary to look for motivation of teachers for quality assurance of teaching. Wang, S.Y. and Wang, Y. (2000) investigated the system of employment costs in colleges and universities in China. The study shows that teachers' motivation is influenced by the mismatch between current wages and expectations, but also whether the distribution system is fair or not. A fair motivation of worker through wages is a demanding task due to diverse aspects which influence work activities as well as a variety of tasks posed on workers. This observation especially holds for workers at universities and research institutions.

This paper is devoted to a completely new methodology for evaluating worker performance and fair remuneration of workers in academia. Generally, workers in such institutions are usually divided into the following three main categories: lecturers (L - focused on the pedagogic work), researchers (focused on science and research) and academic workers (AW - partially devoted to teaching and partially to science and research). The traditional evaluation via matrix dimensioned by degrees and age groups is not a good motivation, because we cannot accept that age and attainments always positively correlate.

Thus, instead of age groups we should consider several levels of categories, let say AW1 to AW4 for academic workers and L1 to L2 for lecturers. A simpler solution is assigning a crisp value of salary to each group. But, when wage should be an assigned value from an interval, e.g., $[a_{L2D}, b_{L2D}]$ for category L2 and Ph.D. degree, we should develop an explainable logical aggregation of elementary achievements to adequately evaluate each worker, where the left border is a base wage rate, whereas the value inside the interval (including the right border) is a bonus.

The key tasks in evaluation are measuring achievements in elementary requirements and recognizing the most suitable aggregation functions to fit with the needs (Dujmović, 2018). Apparently, this observation should hold for measuring the quality of work required for calculating wages. But, in the academic environment it is not an easy task. The main goal is to create transparent and fair evaluation for assigning wages and for benchmarking workers.

The rest of this contribution is organized as follows. Section Material and Methods includes brief explanation of suitable logic aggregation functions. These functions are applied in the next section and explained for staff categories in the proposed remuneration model of the VSB-TUO on an example. Next, discussion and concluding remarks are provided.

Materials and Methods

VSB-TUO has so far used age of employees, which has been a criterion of experience, and qualifications, for the determination of wage. This combination cannot distinguish workers with the same qualifications and age, but with different performances. The paper deals with a novel approach to the evaluation of wages based on the qualification and performances. In this evaluation, different types of logical aggregation functions are used in each step.

The main goal of aggregation is to find a value which in a best way represent all relevant elementary requirements. Aggregation is any function which meets the following properties:

$$A(1,1,...,1) = 1 \tag{1a}$$

$$A(0,0,\ldots,0) = 0 \tag{1b}$$

$$x_i \le y_i, i = 1,\ldots,n \Rightarrow A(x_1,\ldots,x_n) \le A(y_1,\ldots,y_n) \tag{1c}$$

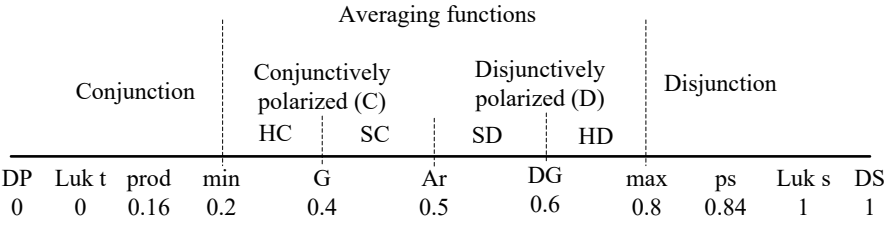
where, x_i and y_i are satisfaction degrees of elementary requirements. The main classification of aggregation functions is due to Dubois and Prade (2004): conjunctive $0 \le A(\boldsymbol{x}) \le \min(\boldsymbol{x})$, i.e., the property of full simultaneity; averaging $\min(\boldsymbol{x}) \le A(\boldsymbol{x}) \le \max(\boldsymbol{x})$, disjunctive $\max(\boldsymbol{x}) \le A(\boldsymbol{x}) \le 1$, i.e., the property of full substitutability, and mixed ones, i.e., functions which combine afore mentioned three cases, where x is a vector of degrees of satisfied requirements or predicates, $\mathbf{x}^T = (x_1, \ldots, x_n)$. In our work, we are focused on aggregation functions which cover the observable properties of human reasoning in evaluation. It means that these logical aggregation functions are a subset of the all aggregation functions satisfying (1a – 1c). For this work, a more suitable classification is due Dujmović (2018), who considers arithmetic mean

$$A_{Ar}(\mathbf{x}) = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{2}$$

as a neutral logic aggregation function due to its full compensation, i.e., its position in the middle between the drastic conjunction and drastic disjunction (see Figure 1). Thus, all functions between arithmetic mean and *MIN* are conjunctively polarized functions, whereas functions having solution lower than or equal to minimum are hyper-conjunctive. The dual observation holds for the disjunctive part. The *MIN* function,

$$A_M(\mathbf{x}) = \min(x_1, x_2, \ldots, x_n) \tag{3}$$

supports mandatory requirements where the worst elementary requirement limits the solution without the compensation. The other conjunctive functions support mandatory requirements and compensation, but the solution is lower than by the *MIN*. Thus, hyper-conjunctive and hyper-disjunctive functions including *MIN* and *MAX* are not suitable for our work.



Legend:
HC- hard partial conjunction, SC – soft partial conjunction, SD – soft partial disjunction, HD – hard partial disjunction, DP – drastic product, DS – drastic sum, Luk t – Łukasiewicz t-norm, prod – product t-norm, min – *MIN* function, G – geometric mean, Ar – arithmetic mean, DG – dual geometric mean, max – *MAX* function, ps – probabilistic sum t-conorm, Luk s – Łukasiewicz t-conorm, for $x = 0.8$ and $y = 0.2$.

Figure 1: Aggregation functions adapted from Dujmović (2018)

The conjunctively polarized class of functions (C) we divide into the hard-partial conjunction (HC) and soft-partial conjunction (SC). The former supports the absorbing element 0, but have the compensatory property. A representative function from this class is geometric mean

$$A_G(\mathbf{x}) = \sqrt[n]{\prod_{i=1}^{n} x_i} \tag{4}$$

The SC class does not support mandatory requirements (i.e., does not have absorbing element 0). A representative aggregator of class SC is dual to quadratic mean (see, (7))

$$A_{\bar{Q}}(\mathbf{x}) = 1 - \sqrt{\frac{1}{n}\sum_{i=1}^{n}(1-x_i)^2} \tag{5}$$

Due to duality property (arithmetic mean is a self-dual function) the same observations hold for the partial disjunctive part of aggregation (Dujmović, 2018). The function which belongs to the hard-partial disjunction (HD) class is a dual function to logical geometric mean (4), i.e.,

$$A_{\bar{G}}(\mathbf{x}) = 1 - \sqrt[n]{\prod_{i=1}^{n}(1-x_i)} \tag{6}$$

Finally, a function belonging to the soft-partial disjunction (SD) class is logical quadratic mean

$$A_{Q}(\mathbf{x}) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}x_i^2} \tag{7}$$

The next category required for our work are asymmetric aggregations capable to aggregate mandatory and optional requirements (asymmetric conjunction, AC), and dual aggregation of sufficient and optional requirements (asymmetric disjunction, DC) (Bosc and Pivert, 2012). The former is known as AND IF POSSIBLE operator, where if the mandatory requirement (x_1) is non-satisfied the solution is 0. But, a non-satisfied optional requirement (x_2) decreases the solution without reaching value 0 when for mandatory requirement holds $x_1 > 0$. Mathematically, this logical aggregation is expressed as

$$AC(x_1, x_2) = \min\left(x_1, Av(x_1, x_2)\right) \tag{8}$$

where for *Av* Hudec and Mesiar (2020) suggested the whole range of averaging functions in the sense of Dubois and Prade (2004). For DC we get operator *OR ELSE*, expressed as

$$DC(x_1, x_2) = \max\left(x_1, Av(x_1, x_2)\right) \tag{9}$$

In the next part, we adopt the afore examined aggregations for evaluating wages at universities.

Results of The Evaluation of Workers' Wages

Generally, workers at universities and related institutions are divided into these categories: lecturers (focused on the pedagogic work), researchers (focused on science and research) and academic workers (partially devoted to teaching and partially to science and research). In this work, we proposed aggregations for lecturers and academic workers, while aggregations for research can be developed in a similar manner as for lecturers.

Our task is to find the most suitable functions for calculating fair wages considering elementary requirements and their aggregations as well as intervals for each category. To our best knowledge, complex calculations of logical aggregate functions in the process of designing wages of workers in universities is an original approach that has not yet been published in scientific literature. However, it might be considered as a tacit knowledge of head workers when assigning bonus to the base wage rate. A transparent structure of

aggregating requirements could avoid any misunderstanding and feeling of under-estimating achievements.

The key contribution of this paper is the design of methodology, which is practically explained for categories of lectures and academic workers. The below proposed approach should not be considered as a universal solution, but to illustrate richness of logic aggregation functions and their flexibility to adapt to particular requirements in diverse departments and elicit further discussion and improvements.

Lecturers

At our university, this category of workers is divided into four sub-groups regarding degrees and achievements at work shown in Table 1, where a is a lowest amount of month income (a base wage rate) and b is the highest amount of month income (base rate plus maximal bonus).

Aggregation functions map $[0,1]^n \to [0,1]$, whereas salaries intervals are real numbers greater than 0. It is not a problem, because we can straightforwardly transform any closed interval $[a, b]$ into the unit interval.

Work assignment	Master degree (M)	PhD degree (PhD)
Lecturer 1 (L1)	$[a_{L1M}, b_{L1M}]$	$[a_{L1D}, b_{L1D}]$
Lecturer 2 (L2)	$[a_{L2M}, b_{L2M}]$	$[a_{L2D}, b_{L2D}]$

Table 1: A matrix of wages dimensioned by degrees and attainments at work for lecturers' categories

The pedagogical work duty, in our example for *L2* consists of atomic tasks: lectures (T1), seminars (T2), work in laboratory (T3), preparing study materials (T4), writing textbooks (T5), internship (T6), and participation in educational projects (T7). Tasks T1 - T3 should be substitutable satisfied and should support compensative effect, i.e., a lower laboratory work load is compensated by a higher activity on lectures and seminars. In addition, lecturer should not participate in all tasks. Thus, this part of lecturer work duties is aggregated by a function from the SD class. In our illustrative example, we adopted the quadratic mean (7) to aggregate this direct teaching work load *Tt*. Tasks T4 - T7 should be simultaneously satisfied with a compensative effect, where elementary tasks are not mandatory and therefore are aggregated by the function from the SC class, in our case by function dual to quadratic mean (5). This is the aggregation of teaching support work *Ts*. Further, a lecturer should mandatory participate in both parts: *Tt* and *Ts* and therefore these two compound requirements are aggregated into the pedagogical activity T_p by a function belonging to class HC, in our case geometric mean (4).

Obviously, the position of lecturer requires devotion to the pedagogical activities. But, lecturers might also publish research articles (T8). Thus, we have sufficient requirement (pedagogical work) and optional one (research). Hence, the lack of research results should not cause decreasing salary, whereas some results in research might increase bonus, but cannot alternate pedagogical work. This requirement is formalized as an asymmetric disjunction (9) by a function from the HC class for *Av*, e.g., geometric mean as

$$DC(x_p, x_r) = max\left(x_p, \sqrt{x_p x_r}\right), \tag{10}$$

where x_p is a degree of satisfaction pedagogical duties T_p and x_r is a degree of satisfaction research activities T_r. A weaker result in pedagogical work is partially compensated by research. But, when worker do not meet the minimum of pedagogical activities, scientific work cannot compensate it. Contrary, in the case of, *Av* modeled by arithmetic mean (2) a non-satisfied pedagogical work is partially compensated by research, which is not the case for this category of workers. The

aggregation structure is shown in Table 2, whereas an illustrative example is shown in Table 3 for seven hypothetical workers w1, w2,…, w7 for the L2 category having PhD degree with allowable salary assumed in the [29 101, 35 500] interval of Czech crowns.

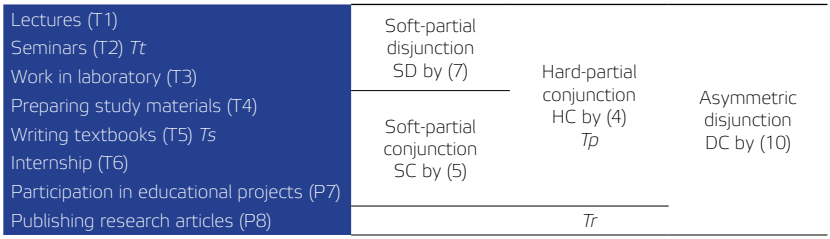


Table 2: The aggregation structure for calculating salaries of L2 category

	Aggregation by AD by by (10)												
	HC by (4)												$a_{L2\,D}$=29101
	SD by (7)				SC by (5)								$b_{L2\,D}$=33500
Worker	*T1*	*T2*	*T3*	*Tt*	*T4*	*T5*	*T6*	*T7*	*Ts*	*Tp*	*T8*	Solution	**salary for PhD**
w1	0.1	0.20	0.30	0.22	0.40	0.00	0.00	0.10	0.11	0.15	0.00	0.15	**29 869.91**
w2	1	0.20	0.90	0.79	0.50	1.00	0.50	0.50	0.57	0.67	1.00	0.82	**32 530.27**
w3	0.3	0.50	0.60	0.48	0.00	0.25	0.25	0.60	0.24	0.34	0.00	0.34	**30 709.78**
w4	1	0.50	0.80	0.80	1.00	1.00	1.00	0.30	0.65	0.72	1.00	0.85	**32 831.02**
w5	0.7	0.00	0.30	0.44	0.00	1.00	1.00	1.00	0.50	0.47	0.00	0.47	**29 101.00**
w6	0.8	1.00	1.00	0.94	1.00	0.00	1.00	0.30	0.39	0.60	0.00	0.60	**31 771.48**
w7	0	1.00	1.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	**29 101.00**

Table 3: Evaluation of lecturers of the L2 category

The lowest salary should correlate with the minimal expected work load. On the other hand, aggregation functions work on the unit interval. So, value 0, or the lower bound of the salary range might indicate minimal, but still acceptable work load, or also working significantly under the minimal load. In the latter, worker should be moved to position L1. Anyway, from Table 3 head of department recognizes, whether value 0 appears only for few tasks, or for majority of them. Table 3 also reveals that worker w7 might be shifted to the position of academic worker, due to relatively low pedagogical activities, but a good publication record.

Academic workers

This category of workers is divided into the twelve sub-categories according to the attainments and degrees. Let us focus on the most demanding position, *AW4*. It consists of two main mandatory parts: teaching and research. Each of them has its own sub-requirements or tasks, which are more demanding than for the lower AW positions. These two main parts should be aggregated by a conjunctively polarized aggregation which supports absorbing element 0 (both activities should be present) and compensation effect: a lower teaching work load is compensated by a higher research work load and vice versa. Hence, we adopted for HC logical geometric mean (4). The aggregation structure is shown in Table 4 where the suitable classes and functions are indicated. Moreover, department heads can choose the other functions and distributions of elementary tasks to meet particularities in their respective departments.

Following teaching trends (P1) Research focused on teaching (P2) Leading scientific workers and PhD students (P3) Innovations in teaching (P4)	HC by (4)	HC by (4)
Guarantee of courses and programs (P5) Committee member for final exams (P6) Lectures, seminars, teaching PhD students (P7)	HC by (4)	
Expertise (P8) Reviewing papers (P9) Papers in top-tiered journals (P10)	SC by (5)	
National projects (P11) International projects (P12)	SD by (7)	

Table 4: The aggregation structure for calculating salaries of AW4 category

Discussion

The number of requirements, computing their intensities for workers as well as the aggregation needs might change in the future and among departments, but the main framework should remain the same. We have chosen the representative functions from each category of logical aggregation, but particular evaluation tasks might need other SD and HD functions, for instance. This is a matter of examining and adopting the right functions for particular goals.

The main issue in this proposal is transformation from [0,1] interval into the salary range. More precisely, workers which meet minimal requirements for the given position should be filtered from the workers which failed, or are released from some duties for a given period. This is a matter of scaling and further adjustment, and therefore it is a topic for the future research.

In the case of workers who failed to meet the minimal requirements on the higher level, e.g., on WP3 (zeros in mandatory elementary tasks), they should be moved to the lower sub-category. In the case of worker who failed to meet minimal requirements on the lowest level it is on the institution, whether worker should get a change to improve or should be released.

Our intent was to propose aggregation model for evaluation of workers achievements, which might be compared with other models. On our best knowledge, complex models for covering mandatory, sufficient and optional requirements supported by compensation among requirements by aggregation functions have not been complexly evaluated. Therefore, our work can be basis for other researches and practitioners to compare their internal models, or future models with the proposed ones.

Conclusion

The tailored motivation of workers is not an easy task. It especially holds for workers at universities where various tasks should be realized and moreover tasks can be mandatory, sufficient and optional. In addition, workers are divided into lecturers, research workers and academic workers, which are further divided into several sub-categories by achieved degrees and attainment of work activities. This work has proposed a flexible aggregation of intensities of satisfaction elementary tasks by the logic aggregation functions ranging from conjunctive to disjunctive functions to meet particularities of each workers group. This solution can be adjusted to particularities of diverse departments and their internal rules.

Acknowledgement

This article was supported by the European Social Fund within the project CZ.1.07/2.3.00/20.0296.

References

Bosc, P. and Pivert, O. 'On four noncommutative fuzzy connectives and their axiomatization', *Fuzzy Sets and Systems*, vol. 202, pp. 42-60. http://dx.doi.org/10.1016/j.fss.2011.11.005

Dubois, D. and Prade, H. (2004) 'On the use of aggregation operations in information fusion processes', *Fuzzy Sets and Systems*, vol. 142, pp. 143-161. http://dx.doi.org/10.1016/j.fss.2003.10.038

Dujmović, J. (2018) *Soft Computing Evaluation Logic: The LSP Decision Method and its Applications*, Hoboken: Wiley-IEEE Computer Society.

Flegl, M. and Rosas, LAA. (2019) 'Do professor's age and gender matter or do students give higher value to professors' experience?', *Quality Assurance in Education*, vol. 27, no. 4, pp. 511-532. http://dx.doi.org/10.1108/QAE-12-2018-0127

Gadusova, Z., Hockickova, B., Lomnicky, I., Predanocyova, L. and Zilova, R. (2016) 'Evaluation of teachers' competences', In *INTED2016: 10th Conference Proceedings, Internal Technology, Education and Development Conference*, Valencia, Spain, pp. 6957-6965.

Hamadin, H.H. and Atan, T. (2019) 'The Impact of Strategic Human Resource Management Practices on Competitive Advantage Sustainability: The Mediation of Human Capital Development and Employee Commitment', *Sustainability,* vol. 11, no. 20, 5782.

Hudec, M. and Mesiar, R. (2020) 'The axiomatization of asymmetric disjunction and conjunction', Information Fusion, vol. 53, pp. 165-173. http://dx.doi.org/10.1016/j.inffus.2019.06.018

Vnouckova, L., Urbancova, H., Smolova, H. and Smejkalova, J. (2016) 'Students' evaluation of education quality in human resource management area: Case of private Czech university', *Journal on Efficiency and Responsibility in Education and Science*, vol. 9, no. 2, pp. 45-51. http://dx.doi.org/10.7160/eriesj.2016.090203

Wang, S.Y. and Wang, Y. (2000) 'The analysis of college and university employment costs in China – A case study of a major Chinese university', *Seminar on Changing Patterns in University Management,* Paris, France, pp. 127-142.

Yıldızlı, H. (2019) 'Structural relationships among teachers' goal orientations for teaching, self-efficacy, burnout, and attitudes towards teaching', *Journal on Efficiency and Responsibility in Education and Science*, vol. 12, no. 4, pp. 111-125. http://dx.doi.org/10.7160/eriesj.2019.120402

MENTAL LOAD: THE NEED FOR SOCIAL SUPPORT AND STRESS AVOIDANCE AT UNIVERSITY STUDENTS

[1]✉Hana Chýlová, [2]Kristýna Krejčová, [3]Pavel Michálek, [3]Luděk Kolman

[1]Department of Psychology, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, chylova@pef.czu.cz

[2] Department of Psychology, Faculty of Arts, Charles University, Czech Republic

[3]Department of Psychology, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

According to numerous evidence, mental load at work has undoubtedly a considerable impact on human performance, quality of life and overall health. The present study will address the issue of the subjective mental load reported by university students and how it could be affected by other relevant variables, especially its relationship with the need for social support and active stress avoidance. The authors conducted their research at a convenient sample of 103 full-time Master students of the Faculty of Economics and Management of the Czech University of Life Sciences in Prague. The data were gathered by two standardized psychological questionnaires on subjective mental load and stress coping strategies. The results show that expected relationship, in some way, could be found especially between the subjective mental load and the need for social support. The outcomes should help to outline the targeted way for psychological counselling centres at universities and provide better help to students in distress.

Keywords

Avoiding, coping, mental load, social support, work stress

Introduction

The number of tasks associated with the need to adapt to a new university environment, to new colleagues and teachers, and especially to a dramatically different and demanding way of studying, lead frequently to the increase of distress and discomfort at students. According to numerous evidence from work psychologists as well as from educational psychologists, perceived mental load at work has undoubtedly a considerable impact on human performance, quality of life and overall health (Griffin and Clarke, 2011; Waqas et al., 2015; AbuAlRub, 2004). Psychological research has revealed disturbing rates of stress, anxiety, and depression among university students (Regehr, Glancy and Pitts, 2013). The high level of stress together with the low capacity to cope with it effectively were the outcomes of the study at the Faculty of Economics and Management at the Czech University of Life Sciences as well (Chýlová and Natovová, 2013).

Australian researchers (Cotton, Dollard and de Jonge, 2002) surveyed university students' psychosocial work characteristics, stress, and performance. Their results showed high levels of psychological distress and low levels of satisfaction, both linked to high demands combined with low control, where satisfaction mediated the impact of the work environment on performance. Positive emotions enhance not only academic achievement, but they also promote social resources such as lasting social relationships (Aron et al., 2000). On the negative side, Grøtan, Sund, and Bjerkeset (2019) found out the bi-directional relationship between mental health and academic achievement: mental health problems may lead to low academic self-efficacy and poor study progress, but they can also be a consequence of low academic self-efficacy and poor study progress.

Stress is usually understood as a disbalance between the demands of the environment and the inner capacities for an adequate response of an individual, fortunately, the individual is protected by the means of the defence mechanisms as well as by social support (Kramer, 2010). Waqas et al. (2015) revealed an association between ego defence mechanisms and academic performance - moderate levels of anxiety and low levels of depression were associated with higher academic performance.
Also, Štikar, Riegel, and Hoskovec (2003) consider social support to be one of the most prominent protective factors against the workload. The workload is stated as an achievement of the work under the given, mental and physical conditions of the work itself, the psychic load is commonly connected to emotional stress. The signs of workload can be psychical, physical as well as behavioural – moodiness, tiredness, low productivity, higher error rate, cognitive disorders, attention deficits, etc. Such manifestations have a considerable negative impact on academic performance and quality of life of students the same way as they affect the common workers.
Social support is undoubtedly one of the most powerful protective and stress coping strategies for all the respondents, even though not always is the connection straightforward. Felsten and Wilcox (1992) studied the influences of stress and situation-specific mastery beliefs and satisfaction with social support on well-being and academic performance. The results proved a relationship between satisfaction with social support to anxiety through interaction with mastery and consequently to better academic performance, however, satisfaction with support did not appear to act as a stress-buffer to moderate effects of high stress.
An extensive body of research has identified the central role of coping strategies in individuals' differential vulnerability to stressors (Holahan et al., 2005). There exist some preferences at stress coping strategies, namely the need for social support according to the personality traits of individuals. Amirkhan et al. (1995) studied the influence of personality on the use of social support and other coping strategies in samples of undergraduate students and revealed a connection between extraversion and social support seeking at students. Responses to workplace demands result in different activities to deal with the stress – it ranges from positive activities such as the strengthening of the social network support, eating healthy food and exercising as well as negative activities as smoking, alcohol and drug abuse (Faye and Bell, 2016). AbuAlRub (2004) described an enhanced level of reported job performance and decreased level of job stress in hospital nurses' in connection with the enhanced level of social support from co-workers.
Even though avoidance is typically understood as negative stress coping technique (Holahan et al., 2005), some findings strongly suggest that avoidance coping operates as a mediator in the stressor - symptom relationship. The potential mediational role of avoidance coping was assessed by Snow (2003), who concluded the strong relationship between work stressors and avoidance, whereas on the other hand there was found a negative relationship between work stressors and social support perceived by workers.
As the work psychology field is seriously concerned with the amount of workload at workers and consecutive work stress, researchers aim at a deeper insight into the understanding of related factors and especially the protective mechanisms. Židková (2002) comments on the dispersed and conceptually unclear methods of assessment of the workload, which led to the design of the unified methodological procedure of assessing the mental load of a work, where she introduces Meister questionnaire on mental load, which is going to be described later.
The present study aims to explore and analyse the relationship between perceived mental load at university students, as an important stress-inducing factor on one hand and the need for social support as well as the avoidance of the stress as the coping mechanisms on the other hand. To achieve this goal two standardised psychological questionnaires will be used - Meister questionnaire on mental load (Židková, 2002) and SVF 78 on stress coping strategies (Janke and Erdmannová, 2003).
Authors expect to reveal a significant relationship between the higher level of the work-related

mental load and the need for social support and active stress avoidance as a coping technique at the surveyed group of students.
The hypotheses on the relationship between variables will be tested, with the use of inductive statistics method to ascertain the plausibility of the hypothesised concept:

- $H1_0$: There is no relationship between subjective mental load and the need for social support at students;
- $H2_0$: There is no relationship between subjective mental load and active stress avoidance at students.

The present paper is divided into several sections. It offers a brief description of the current state of the art in the Introduction, above. Following section, Materials and methods, will describe a group of respondents, methods for data collection and used statistical analysis. Section Results is dedicated to the most important findings arisen from the statistical analysis of the data. Next, the section Discussion compares results with other similar researches together with the applicability of the outcomes. The Conclusion of the paper summarizes the most important findings together as well as provides for the service of the outcomes in an academic environment.

Materials and Methods

Participants

The survey was conducted on a convenient sample of 103 students of Master programmes at the Faculty of Economics and Management at the Czech University of Life Sciences, during the years 2018-2019.
The sample consisted of 103 respondents, 21 (21.63%) males, and 82 (84.46 %) females. The mean age was 23.41 years (standard deviation of 1.22).
All the students cooperated voluntarily, with no financial reward for it.

Method

The data were gathered with the use of two standardised psychological questionnaires:
Czech version of Meister questionnaire for the assessment of the mental load at work was used. The psychometric qualities of this questionnaire were repeatedly evaluated,and the critical value of the excessive psychic load has been stated rather precisely (Židková, 2002). This questionnaire consists of 10 items (focusing for example on time pressure, low joy from work, tiredness), which can be assessed on a 5-point Likert style scale. The outcomes could be evaluated in a form of three separate factors (Overload, Monotony, Unspecified factor), or all the items together resulting in one overall score of the mental load, which can be compared to the critical value (presented in Table 1) - the latter was the way used by the authors of this study.
Next to the above-described questionnaire, the Czech version of the Stressverarbeitungsfragebogen - Stress Coping Style Questionnaire SVF78 (Janke and Erdmann, 2003) was administered. This version of the questionnaire consists of 78 items on stress coping strategies, each assertion (e.g., “When I have been upset by anybody, disturbed by anything, or somehow thrown off the balance,… I tell myself, that this is not my fault”) is evaluated on a 5-point Likert type scale. The results are grouped into 13 scales, 7 on Positive strategies, 2 Neutrals, 4 on Negative strategies. According to Balcar, Trnka and Kuška (2011), the internal consistency of scales in the Czech standardisation is satisfying –(0.77,0.94 Cronbach alpha).

Statistical analysis

First of all, the descriptive statistics of the group of respondents and scales in focus were computed, mainly the measures of central tendency and measures of variability and dispersion.

Consequently, the normal distribution hypothesis was tested with the use of general Kolmogorov-Smirnov normality test. Concerning its results, nonparametric Spearman's rank correlation method will be used to ascertain the hypothesis of the relationship between the variables, deVaus (2014) recommends it also for its robustness.
The data were processed with the use of software IBM SPSS Statistics, version 25, all the results are to be found in the respective section.

Results

The descriptive statistics of the participants (described in the respective paragraph) and the scales (displayed in Table1) were run.

Factor	N	Mean	Std. Deviation	Critical/mean value *
Mental load	103	28.36	5.91	29
Social support	103	15.84	5.09	12.89
Avoiding	103	15.61	4.13	11.97

** critical resp. mean value of the population sample (Židková, 2002; Janke and Erdmann, 2003)*

Table 1: Results – descriptive statistics of the scales, 2019 (source: own calculation)

The normal distribution hypothesis was tested with the use of the Kolmogorov-Smirnov test, results of the test can be seen in Table 2. According to the results of the tests, we conclude that most of the data does not come from a normal distribution, and therefore the nonparametric test will be used to measure the degree of association between the two variables.

	Kolmogorov-Smirnov[a] test		
	Statistic	df	Sig.
Mental load	0.09	103	0.05
Social support	0.11	103	0.00
Avoiding	0.01	103	0.02

[a]Lilliefors Significance Correction

Table 2: Tests of normality, 2019 (source: own calculation)

Spearman's rank correlation was employed to test the following null hypotheses:

- *$H1_0$: There is no relationship between subjective mental load and the need for social support at students;*
- *$H2_0$: There is no relationship between subjective mental load and active stress avoidance at students.*

			Mental load	Social Support	Avoiding
Spearman's rho	Mental load	Correlation coefficient	1.00	0.210*	0.033
		Sig. (2-tailed)	.	0.033	0.738
	Social support	Correlation coefficient	0.210*	1.000	0.271**
		Sig. (2-tailed)	0.033	.	0.006
	Avoiding	Correlation coefficient	0.033	0.271**	1.00
		Sig. (2-tailed)	0.738	0.006	.

**-sig at 0.05; ** - sig. at 0.01*

Table 3: Correlations of mental load and stress coping strategies, 2019 (source: own calculation)

As can be seen in Table 3, two associations between variables can be found, they are statistically significant, either at 0.05 or at 0.01 significance level alpha.
To answer the hypothesis of a relationship between subjective mental load and the need for social support at students in our sample, we can reject $H1_0$ (rho = 0.210), the correlation is significant at

the 0.05 significance level alpha. Hence the importance of others for the students when in stress caused by mental load could be declared as confirmed.
The second hypothesis $H2_0$ cannot be rejected, the relationship between subjective mental load and active stress avoidance at students is weaker than we originally expected (rho = 0.033). Students typically choose other strategies to cope with the higher levels of a mental load than to avoid them.
However, we can see also the correlation between avoiding stress situation and the need for social support at students (rho = 0.271), which is statistically significant even at the 0.01 significance level alpha. It seems, that students who choose to ask for help in a stressful situation also actively try to avoid these situations.

Discussion

Subjective evaluation of mental load through Meister questionnaire is quite unequivocally used as a reliable measuring method for measuring mental load at work (Židková, 2011). We have used it to measure perceived mental load in the academic environment, as we believe, that full-time students experience the same levels as stress connected with the mental load as workers do.
From the results, it could be concluded, that students with higher levels of perceived mental load at their academic environment tend to seek social support from others. Similarly, Leiter and Straight (2016) concluded that social environment plays a vital role in coping with work stress and building work engagement.
The need for social support is strongly correlated with stress coping strategy called avoiding stressful situations, however, there is no important relationship between the use of avoidance strategy and the level of perceived mental load. This may be understood as the tendency to use these coping strategies no matter how high the perceived mental load is and how stressed these students are, but this explanation would deserve more in-depth conducted study on its own.
That connection deserves further exploration in additional research to answer the question, why students under higher levels of mental load perceived upon them seek help from others, while not avoiding these situations; on the other hand, those who typically choose to ask for help under any kind of stressful situation also actively try to avoid stress-inducing situations. We may speculate, that not all the students, who seek social support perceive the level of a mental load as high for them, they just feel this way better than on their own. The need for social support is reflected in outcomes of Aron et al. (2000), who found out that positive emotions enhance academic achievement and promote lasting social relationships. Also Cotton, Dollard and de Jonge (2002) stress the importance of students' satisfaction through their environment on the improvement of academic achievement. It seems, that no matter how stressful and demanding academic environment is, it has its specific benefits as well.
According to Balcar, Trnka and Kuška (2011), avoiding of stress situations and the need of social support are coping strategies that could be in certain circumstances not only seen as purely neutral ones but could act as a component of various factors together with other strategies which are considered to have their valence - the need of social support could be a component of a factor called *Breakdown of psychological defence*; while avoiding could be found in a factor called *Active problem confrontation* (at some situations). These two stress coping strategies would, therefore, be of the two opposing valences, however, in our research, these two strategies have a positive mutual correlation. We could suppose that this disparity is caused by specifics of the academic environment, where commonly neutral strategies took their course. This finding deserves further research in more environmentally valid settings.

Conclusion

This study was focused on the relationship between the perceived mental load of students and its consequences in stress coping strategies the need for social support and active avoidance of stress. The most important findings are the mutual correlation between mental load and the need for social support together with the correlation between avoidance of stress situation and the need for social support. However, there has not been proved any important relationship between avoiding stress situation and perceived mental load, which was originally expected. The missing particle at the connection between stress avoidance and the level of mental load could serve as a starting point of future work on mental load in the academic environment settings.

Strong need for social support when facing high levels of mental load signalises the way the focused interventions could lead. Regehr, Glancy and Pitts (2013) recommend programmes on cognitive, behavioural, and mindfulness interventions for reducing stress widely available to all the students. Some allocated area provided by the university for sharing of mutual experience with mental load at the university and connected stress could serve similarly plus offer the opportunity of socializing in life settings (in contrast to the on-line social network).

The outcomes of this study should serve to provide for the students more focused and customized help via psychological counselling as well as through raising the awareness of mutual experience in a common academic environment, how it could be affected to enhance the students' satisfaction and consequently also the academic achievement.

References

AbuAlRub, R.F. (2004) 'Job Stress, Job Performance, and Social Support Among Hospital Nurses', *Journal of Nursing Scholarship*, vol. 36, pp. 73-78. https://doi.org/10.1111/j.1547-5069.2004.04016.x

Amirkhan, J.H., Risinger, R.T. and Swickert, R.J. (1995) 'Extraversion: A "Hidden" Personality Factor in Coping?', *Journal of Personality*, vol. 63, pp. 189–212. https://doi.org/10.1111/j.1467-6494.1995.tb00807.x

Aron, A., Norman, C.C., Aron, E.N., McKenna, C. and Heyman, R.E. (2000) 'Couples' shared participation in novel and arousing activities and experienced relationship quality', *Journal of Personality and Social Psychology,* vol. 78, no. 2, pp. 273–284. https://doi.org/10.1037/0022-3514.78.2.273

Balcar, K., Trnka, R. and Kuška, M. (2011) 'How Many Ways to Deal with Stress? Stress coping factors in the SVF 78', *Activitas Nervosa Superior*, vol. 53, no. 1-2, pp. 27–34. https://doi.org/10.1007/BF03379931

Chýlová, H. and Natovová, L. (2013) 'Stress, Self-efficacy and Well-Being of the University Students - Part I: Gender Differences', *Journal on Efficiency and Responsibility in Education and Science*, vol. 6, no. 3, pp. 190-202. http://dx.doi.org/10.7160/eriesj.2013.060306

Cotton, S.J., Dollard, M.F. and de Jonge, J. (2002) 'Stress and Student Job Design: Satisfaction, Well-Being, and Performance in University Students', *International Journal of Stress Management*, vol. 9, no. 3, pp. 147–162. https://doi.org/10.1023/A:1015515714410

De Vaus, D. (2014) *Surveys in Social Research (6th ed.).* Abingdon, UK: Routledge.

Faye, K.C. and Bell, M.P. (2016) 'Gender and Work Stress: Unique Stressors, Unique Responses', In C.L. Cooper, J.C. Quick and M.J. Schabracq (eds.) *International Handbook of Work and Health Psychology,* pp. 123-146. Chichester: Wiley Blackwell.

Felsten, G. and Wilcox, K. (1992) 'Influences of stress and situation-specific mastery beliefs and satisfaction with social support on well-being and academic performance', *Psychological Reports,* vol. 70, no. 1, pp. 291–303. https://doi.org/10.2466/PR0.70.1.291-303

Griffin, M.A. and Clarke, S. (2011) 'Stress and well-being at work', In S. Zedeck *APA Handbook of Industrial and Organizational Psychology*, pp. 359-397. Washington: APA.

Grøtan, K., Sund, E.R. and Bjerkeset, O. (2019) 'Mental Health, Academic Self-Efficacy and Study Progress Among College Students - The SHoT Study, Norway', *Frontiers in Psychology*, vol. 10, no. 45, pp. 1 – 11. https://doi.org/10.3389/fpsyg.2019.00045
Holahan, C.J., Moos, R.H., Holahan, C. K., Brennan, P.L. and Schutte, K.K. (2005) 'Stress generation, avoidance coping, and depressive symptoms: a 10-year model', *Journal of consulting and clinical psychology*, vol. 73, no. 4, pp. 658–666. https://doi.org/10.1037/0022-006X.73.4.658
Janke, W. and Erdmann, G. (2003) *Strategie zvládání stresu — SVF 78*, Praha: Testcentrum.
Kramer, U. (2010) 'Coping and defence mechanisms: What's the difference? – Second act.', *Psychology and Psychotherapy: Theory, Research and Practice*, vol. 83, pp. 207-221. https://doi.org/10.1348/147608309X475989
Leiter, M.P. and Straight, N. (2016) 'The Social Context of Work Life: Implications for Burnout and Work Engagement', In C.L. Cooper, J.C. Quick and M.J. Schabracq (eds.) *International Handbook of Work and Health Psychology*, pp. 25-47. Chichester: Wiley Blackwell.
Regehr, Ch., Glancy, D. and Pitts, A. (2013) 'Interventions to reduce stress in university students: A review and meta-analysis', *Journal of Affective Disorders,* vol. 148, no. 1, pp. 1-11. https://doi.org/10.1016/j.jad.2012.11.026
Snow, D., Swan, S. C., Raghavan, C., Connell, C.M. and Klein, I. (2003) 'The relationship of work stressors, coping and social support to psychological symptoms among female secretarial employees', *Work and Stress*, vol. 17, no. 3, pp. 241-263. https://doi.org/10.1080/02678370310001625630
Štikar, J., Riegel, K. and Hoskovec, J. (2003) 'Činnostní charakteristiky metod', In J. Štikar, M. Rymeš, K. Riegel, and J. Hoskovec (eds.) *Psychologie ve světě práce,* (pp. 245-279), Praha: Karolinum.
Waqas, A., Rehman, A., Malik, A., Muhammad, U., Khan, S. and Mahmood, N. (2015). 'Association of Ego Defence Mechanisms with Academic Performance, Anxiety and Depression in Medical Students: A Mixed Methods Study', *Cureus*, vol. 7*,* no. 9, e337. https://doi.org/10.7759/cureus.337
Židková, Z. (2002) 'Využití dotazníků k hodnocení psychické zátěže při práci', *České pracovní lékařství*, vol. 3, no. 2, pp. 69-73. https://zdenka-zidkova-psvz.webnode.cz/_files/200000014-5ab3e5ca72/vyuzdotaz.pdf

COMPARISON OF SOFTWARE TOOLS FOR SOLVING DEA MODELS

Josef Jablonský

University of Economics, Prague, Czech Republic, jablon@vse.cz

Abstract

Data envelopment analysis (DEA) models belong among the most often applied modelling tools for efficiency and performance evaluation of the set of homogeneous decision-making units (DMUs). DEA models are based on solving several linear programming (LP) problems. In typical problems, the number of LP problems that have to be solved is rather high, and it is impossible to deal with DEA models without any specialized software tool. The paper aims at discussion and comparison of available software tools for solving DEA models with respect (not only) to their using in the teaching of operations research courses. Except for this primary goal, the paper introduces an original software tool for solving this class of models. It is designed on MS Excel platform with co-operation with LINGO modelling language and uses fast LINGO internal solver for solving particular LP problems. Discussion about experiences with using this application in teaching process concludes the paper.

Keywords

Data envelopment analysis, efficiency, LINGO, modelling languages, MS Excel

Introduction

Data envelopment analysis (DEA) models are the most often applied modelling tools for relative efficiency and performance evaluation of the set of decision-making units (DMUs). They have been introduced by Charnes, Cooper and Rhodes (1978) and since this pioneering paper was published, many extensions of their traditional model have been proposed. The number of articles dealing with DEA theory and applications exceeded 10000 according to the study (Emrouznejad and Yang, 2018). The real number of articles and various studies is much higher.

Due to the importance of DEA models in theory and practice, they belong to topics that are covered by standard operations research courses. DEA models assess the relative efficiency of the DMUs, i.e. the unit under evaluation is compared with the other units of the set. In order to obtain the result for each unit of the set, it is necessary to solve n DEA models where n is the number of DMUs to be evaluated. Even the models that must be solved are linear programs, and they are rather simple their number is usually high (several tens at least) in real applications. That is why the interested users cannot use educational or commercial optimization packages, but specialized DEA software tools are the must.

The aim of this paper is to inform about both commercial and non-commercial software tools for solving DEA models and discuss their suitability for using in teaching. Except for this aim, we introduce an original package for solving DEA models that uses MS Excel interface and LINGO modelling system for model formulation and solving. The paper is organized as follows. The next section contains the formulation of traditional DEA models and a survey of several commercial and non-commercial tools for DEA models. Section *Results* describes in detail DEA Excel/LINGO solver and illustrates its using on an example. The last section of the paper (*Discussion and Conclusions*) discusses the advantages and disadvantages of the presented packages mainly concerning their suitability in teaching and education of students. This part is based on the author's real experience with operations research and DEA courses.

Materials and Methods

The most commonly used DEA models in application studies are Charnes, Cooper and Rhodes (1978) model very often denoted as CCR model and Banker, Charnes and Cooper (1984) model that is often known as BCC model. They both evaluate the efficiency of transformation of m inputs into r outputs and return as a result the efficiency measure (score) that reaches the value 1 for efficient units and lower or higher than 1 (depending on the model applied) for the inefficient ones. Another significant output of the model is the information on the improvement the inputs and/or outputs in order to reach maximum efficiency (efficient frontier) – these values are usually called target values. CCR and BCC models can be formulated in their input- or output-oriented modifications.

Let us suppose a set of n DMUs evaluated by m inputs and r outputs with input and output values x_{ij}, $j = 1,\ldots,m$, $i = 1,\ldots,n$ and y_{ik}, $k = 1,\ldots,r$, $i = 1,\ldots,n$, respectively. Input-oriented CCR (BCC) model for evaluation of the q-th DMU is formulated as follows:

Minimize
$$\theta_q - \varepsilon\left(\sum_{j=1}^{m} s_j^- + \sum_{k=1}^{r} s_k^+\right)$$

subject to

$$\begin{aligned}
&\sum_{i=1}^{n} x_{ij}\lambda_i + s_j^- = \theta_q x_{qj},\ j = 1,\ldots,m,\\
&\sum_{i=1}^{n} y_{ik}\lambda_i - s_k^+ = y_{qk},\quad k = 1,\ldots,r,\\
&\left(\sum_{i=1}^{n} \lambda_i = 1,\ \text{for BCC model}\right)\\
&\lambda_i \geq 0, \qquad\qquad i = 1,\ldots,n,
\end{aligned} \tag{1}$$

where λ_i, $i = 1,\ldots,n$ are the weights of DMUs, s_j^-, $j = 1,\ldots,m$, and s_k^+, $k = 1,\ldots,r$ are slack and surplus variables, θ_q is the efficiency score of the q-th DMU, and ε is an infinitesimal constant The unit q is efficient if $\theta_q = 1$ and all slack and surplus variables are 0. Model (1) is not complex to solve even for a higher number of DMUs. This linear program has only $(n+m+k+1)$ variables and $(m+k)$ constraints ($(m+k+1)$ constraints for BCC model). Problem with efficiency assessment using DEA models consists in the necessity to repeat solving model (1) for all units of the set. Except for a very small rather illustrative examples, it is impossible to perform all calculations without any DEA software tool. Below is a short survey of available DEA packages with their main advantages and disadvantages.

Frontier Analyst (www.banxia.com) is probably the first specialized commercial DEA solver. It was developed by Banxia Software, Inc. (UK) in the '90s of the last century. It is oriented mainly to the commercial sphere. Using this software for educational use is limited due to the rather low number of supported DEA models. Below are listed its pros and cons for using in teaching:

+ user's interface, variety of graphical outputs, academic licenses available;

– the high price of commercial and also academic licenses, a very limited number of supported models.

DEA Solver Pro (www.saitech-inc.com) is the software product that comes (minimal version) with the textbook (Cooper, Seiford and Tome, 2007), i.e. it contains a high number of DEA models rather. In our opinion, the main pros and cons of this software are as follows:

+ relatively high number of DEA models;

– price of both commercial and academic licenses is high (1600/800 USD), there is no user's guide (except the book).

DEAFrontier Excel Add-In (www.deafrontier.net) is the solver that was developed by J. Zhu. Its trial version is included in (Zhu, 2014) or it is downloadable on the product's web pages. This solver covers all models included in the mentioned book. This software uses internal Excel solver, which limits the number of DMUs that can be analyzed. In order to solve the problems with a higher number of units, a premium version of Excel solver must be purchased. Its pros and cons are below:

+ high number of DEA models, all students are familiar with the user's interface (Excel), excellent support on the web pages;

– the price of single academic licenses is not low (700 USD), and there are not available any lab licenses; the fixed format of input data; the capacity of the DEA solver (the number of DMUs) is limited by the capacity of Excel solver; no graphical output of results.

Performance Improvement Management DEA Software (www.deasoftware.co.uk) is probably the best option among professional software tools for teaching purposes of DEA models. It was initially developed at the University of Warwick (UK). It is a standalone application with a high number of supported models and can be extended by other modules.

+ high number of DEA models; user's comfort; various available licenses including academic network license (approx. 900 GPB for 1000 DMUs); graphical outputs of results; Excel interface (import of data/export of results);

– the solver is not free; it is not possible to extend the solver by other models by the user.

MaxDEA Software (www.maxdea.cn) is announced as the software with the highest number of supported models at all. It is delivered in three versions – Basic, Pro and Ultra. The first one contains a limited number of models, but it is free for an unlimited number of DMUs. This option may be probably desirable for both research and teaching.

+ free Basic version with unlimited capacity of data; the high number of models for Pro and Ultra versions; very fast solver;

– missing graphical outputs; the user's comfort is on a lower level.

Except for the above mentioned professional DEA software tools, there exist several other tools. Below is their list – due to the limited space for this article they are listed without any detailed comments:

- *DEAOS – Data Envelopment Analysis Online Software* (www.deaos.com) allows online analysis of DMUs using traditional DEA models. Unfortunately, the pricing policy is not very friendly.
- DEA Solver Online (www.dea.fernuni-hagen.de) is a simple application that supports several basic DEA models, and after registration, it is free to use.
- *EMS – Efficiency Measurement System* (www.holger-scheel.de/ems) is an old (more than 20 years) non-commercial solver that still can be used but is not user-friendly, and the number of models is limited.
- *A Data Envelopment Analysis (Computer) Program – DEAP* (https://economics.uq.edu.au/cepa/software) was developed by T. Coelli from the University of Queensland. It is a free application that supports traditional CCR and BCC models, including Malmquist index for dynamic efficiency assessment.
- DEA Excel Solver (webhosting.vse.cz/jablon) is an MS Excel add-in application that supports the most commonly used DEA models and uses in-built Excel solver. More information about this application can be found in (Jablonský, 2014).

Results

Our original DEA solver mentioned in the last paragraph of the previous section used internal MS Excel linear solver for solving linear programs (1). This approach is possible but has several disadvantages:

- MS Excel Solver in the standard version is limited to approx. 250 variables, i.e. it is not possible to solve DEA models with more than 200-250 DMUs. Moreover, the properties of this solver are incomparable to other professional linear and integer solvers.
- It is not easy to modify the models included in the DEA package and to extend the system by other DEA models.

Due to these limitations, we decided to create a new DEA application that will be on a higher level and more flexible. This application uses *LINGO* modelling language and *LINGO* solver for building the models and their solving. More information about *LINGO* system can be found in (Schrage, 2015). There are available many high-quality modelling systems like *LINGO* on the software market. *IBM ILOG CPLEX Optimization Studio*, *MPL for Windows*, *FICO Xpress Optimization Suite*, *GAMS*, *AMPL*, and *AIMMS* belong to the typical representants of this group of software packages. Some of them are much powerful than *LINGO*, but *LINGO* is a compact system easy to use, especially for students. Main characteristics of our new original DEA/LINGO/Excel solver can be summarized by the following:

1. Models written in *LINGO* language are very similar to their formal mathematical notation. They can be easily modified even by non-experienced users. This property allows to create an application that is self-learning, i.e. can be extended by users by other models. For illustrative purposes, below is model (1) written in the *LINGO* modelling language.

```
MODEL:
SETS:
    INPUT/@OLE('data.xlsx','INP')/:SMIN;
    OUTPUT/@OLE('data.xlsx','OUT')/:SPLUS;
    DMU/@OLE('data.xlsx','DMU')/:LAMBDA, EFF;
    MATX(DMU, INPUT): X;
    MATY(DMU, OUTPUT): Y;
ENDSETS
DATA:
    X, Y = @OLE('data.xlsx');
    EPS = 10E=8;
ENDDATA
MIN = EFF;
EFF = THETA - EPS*(@SUM(INPUT: SMIN) + @SUM(OUTPUT: SPLUS);
@FOR(INPUT(J): @SUM(DMU(I): LAMBDA(I)*X(I,J)) + SMIN(J) =
THETA*X(Q,J));
@FOR(OUTPUT(K): @SUM(DMU(I): LAMBDA(I)*Y(I,K)) - SPLUS(K) =
Y(Q,K));
CALC:
    @FOR(DMU(P): Q = P;
    @SOLVE();
    ESCORE(P) = EFF; );
ENDCALC
DATA:
    @OLE('data.xlsx') = ESCORE;
ENDDATA
END
```

This notation does not need almost any comments. The data for the analysis (the number of DMUs, inputs and outputs, and matrices X and Y) are read from the file data.xlsx. The model itself (starting by MIN = EFF) is clear; it is identical to model (1). Section CALC: performs calculations for all DMUs of the set, and the last section DATA: exports the obtained efficiency scores back to the Excel file. It is straightforward to modify this CCR input-oriented model to BCC model. What is only necessary to do is to add a new row to the model part of the notation: @SUM(DMU: LAMBDA) = 1.

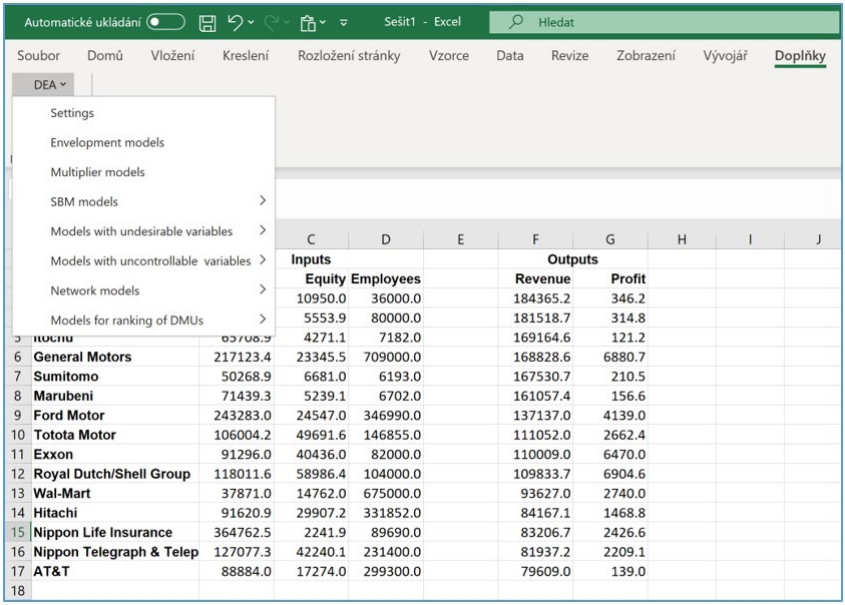
2. There have been formulated many DEA models in the past – a survey of the most important among them can be found in textbooks (Zhu, 2014), (Cooper, Seiford and Tone, 2007) or in (Dlouhý, Jablonský and Zýková, 2018) in Czech. It is easy to write these models in *LINGO* language and then connect them with MS Excel environment using VBA procedures.
3. The application is designed for non-experienced users. They need not know anything about *LINGO* or DEA mathematical models. It is an MS Excel add-in application, and everything is controlled by pull-down menu from the main MS Excel menu bar. The user must prepare the data set in a free format – two matrices of inputs (X) and outputs (Y) are required in most cases only. Results of the analysis are automatically returned to the Excel sheet that it is created for each applied model. It allows a simple comparison of results obtained by various DEA models. The current version of the system contains the following menu items (see Figure 1):
   - Envelopment models (constant/variable/non-increasing/non-decreasing returns to scale, input-/output-oriented). All these models return efficiency scores, slack and surplus variables, target values for inputs and outputs, and optionally weights of the DMUs.
   - Multiplier models with the same assumptions as in the previous case. This group of models offers to decision-maker efficiency scores and weights of inputs and outputs.
   - Slack based measure (SBM) models. Under this group of models, there are three sub-groups: simple additive model, weighted additive model and Tone's SBM model. Especially, the last one belongs to the most used DEA models in practice. All models return efficiency scores and other information as envelopment models.
   - Ranking models. As known, efficient units by any traditional DEA model have the same maximum efficiency scores and cannot be ranked according to these values. Our application contains Andersen and Petersen model under the assumption of various returns to scale and input and output orientation, Tone's overall, input and output super-efficiency model, and SBMG model proposed in (Jablonský, 2012).
   - Models with non-discretionary variables deal with problems where some of the inputs and outputs are continuous non-discretionary variables. This group of models is just a modification of envelopments models with various assumptions, and they return the same information (see above).
   - Network models allow solving two-stage serial processes using three traditional models – Kao and Hwang model (input- and output-oriented) and Chen's model.

A detailed formulation of all models included in the application can be found in (Dlouhý, Jablonský and Zýková, 2018).

4. The users with administrative rights can extend the application by their own models but this option requires a more experienced user.

The application is very easy to use. After installing the add-in, the user can see a new pull-down menu with the main commands that correspond the main group of models as presented above and setting option that allows switching between language versions and several other settings. The data set must be prepared by the user in two ranges (one for inputs, one for outputs) – see Figure 1. After choosing the model, its results are displayed in newly created sheet for a possible

future handling. The output information depends on the DEA model selected and, as this paper is not a user's guide, cannot be presented here in detail.



		C	D	E	F	G	H	I	J
		Inputs			Outputs				
		Equity	Employees		Revenue	Profit			
		10950.0	36000.0		184365.2	346.2			
		5553.9	80000.0		181518.7	314.8			
		4271.1	7182.0		169164.6	121.2			
6	General Motors	217123.4	23345.5	709000.0	168828.6	6880.7			
7	Sumitomo	50268.9	6681.0	6193.0	167530.7	210.5			
8	Marubeni	71439.3	5239.1	6702.0	161057.4	156.6			
9	Ford Motor	243283.0	24547.0	346990.0	137137.0	4139.0			
10	Totota Motor	106004.2	49691.6	146855.0	111052.0	2662.4			
11	Exxon	91296.0	40436.0	82000.0	110009.0	6470.0			
12	Royal Dutch/Shell Group	118011.6	58986.4	104000.0	109833.7	6904.6			
13	Wal-Mart	37871.0	14762.0	675000.0	93627.0	2740.0			
14	Hitachi	91620.9	29907.2	331852.0	84167.1	1468.8			
15	Nippon Life Insurance	364762.5	2241.9	89690.0	83206.7	2426.6			
16	Nippon Telegraph & Telep	127077.3	42240.1	231400.0	81937.2	2209.1			
17	AT&T	88884.0	17274.0	299300.0	79609.0	139.0			
18									

Figure 1: Main menu of the application and a test data set

Discussion and Conclusion

The presented DEA/LINGO/Excel solver is based on using *LINGO* modelling language. Of course, in order to use this application, the users have to install the *LINGO* system. In general, it is not free, but one can download and install a trial version that is limited by 200 continuous variables and has no time restrictions. Then, it is possible to handle problems up to nearly 200 DMUs. For commercial or research use, solving problems with a higher number of DMUs can be requested. In this case, one of the four size versions of *LINGO* can be purchased. The cheapest one (500 USD) allows solving problem up to 2000 variables, and when connected with our DEA system problems up to nearly 2000 DMUs can be analyzed. For educational purposes, there are available even cheaper options – per 25 USD the student may have a license for 500 variables. Upon request, lab licenses of this version are available, and the pricing policy is reasonable and acceptable. The comparison with the prices of specialized DEA commercial products goes for our application.

The advantage of our DEA solver is that it is designed in MS Excel environment, and all students and our users are familiar with it. The results can be processed using MS Excel tools, e.g. graphical outputs similarly to specialized DEA products can also be created. The application may be used for educational purposes but has high enough capacity for solving research or other professional (commercial) problems. The system is in its testing and verifying phase. The accuracy and correctness of the outputs of all models was tested by the author and several students on many numerical examples. The application will be shortly available for downloading on the author's web pages.

Acknowledgement

The research is supported by the Grant Agency of the Czech Republic, project no. 19-08985S – Models for efficiency and performance evaluation in non-homogeneous economic environment.

References

Charnes, A., Cooper, W.W. and Rhodes, E. (1978) 'Measuring the efficiency of decision making units', *European Journal of Operational Research*, vol. 2, no. 6, pp. 429–444. https://dx.doi.org/10.1016/0377-2217(78)90138-8

Banker, R., Charnes, A. and Cooper, W.W. (1984) 'Some models for estimating technical and scale inefficiencies in data envelopment analysis', *Management Science*, vol. 30, no. 9, pp. 1078–1092. http://dx.doi.org/10.1287/mnsc.30.9.1078

Cooper, W.W., Seiford, L.M. and Tone, K. (2007) *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*, 2nd edition. Berlin: Springer.

Dlouhý, M., Jablonský, J. and Zýková, P. (2018) *Data Envelopment Analysis* (in Czech). Praha: Professional Publishing.

Emrouznejad A. and G. Yang (2018) 'A survey and analysis of the first 40 years of scholarly literature in DEA: 1978–2016', *Socio-Economic Planning Sciences*, vol. 61, no. 1, pp. 1-5. https://dx.doi. org/10.1016/j.seps.2017.01.008

Jablonský, J. (2014) 'MS Excel based software support tools for decision problems with multiple criteria', In: *17th International Conference Enterprise and Competitive Environment 2014. Book Series: Procedia Economics and Finance*, vol. 12, pp. 251-258. https://doi.org/ 10.1016/S2212-5671(14)00342-6

Jablonský, J. (2012) 'Multicriteria approaches for ranking of efficient units in DEA models', *Central European Journal of Operational Research*, vol. 20, no. 3, pp. 439-454. https://doi.org/10.1007/s10100-011-0223-6

Schrage, L. (2015) *Optimization Modelling with LINGO*, 6th edition, Chicago: Lindo Systems.

Zhu, J. (2014) *Quantitative Models for Efficiency Evaluation and Benchmarking*. Berlin: Springer.

TYPES AND FUNCTIONS OF REPORTING VERBS IN LITERATURE REVIEWS OF STUDENTS' THESES

[1]✉Martina Jarkovská, [2]Lenka Kučírková

[1]Department of Languages, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, jarkovska@pef.czu.cz

[2]Department of Languages, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

The paper investigates the use of reporting verbs (RVs) in Master's theses written in English by Czech students of Economics and Management field of study. Adopting one of the most elaborate frameworks of RVs to date (Hyland, 1999, 2002), the research performed on the second language learners' writing has concentrated on the types of RVs as one of the citation practices and their communicative functions in the academic discourse. The data were drawn from the corpus of 439,356 words, consisting of Literature Reviews, where other authors' research is summarized and commented on. The findings revealed that the majority of the RVs conveyed a neutral attitude towards the reported message and neutrally summarised outcomes of previous research. The study has pedagogical implications for academic writing in PhD courses at institutions of non-philological tertiary education and hopes to contribute to the existing body of research on the citation.

Keywords

Academic writing, integral citation, L2 learning, reporting structure, verb form

Introduction

Reporting the work of others is one of the identifying features of academic writing. Reports, or citations, are the meta-linguistic representation of an idea from another source (Thomas and Hawes, 1994). Their importance in academic discourse lies in providing an appropriate context of persuasion, demonstrating how the current work builds on and reworks past utterances to establish inter-textual links to the wider discipline (Hyland, 2002). Swales (1990) makes a distinction between an integral and non-integral citation. The former contains the name of the reported researcher in the grammar of the reporting sentence and thus places an emphasis on the messenger. The latter refers to the researcher only in parenthesis or by the use of superscript numbers, emphasizing the reported message (Lee, Hitchcock and Casal, 2018).

One of the most explicit ways of attributing content to another source is the use of reporting verbs (RVs) which represent a significant rhetorical choice (Hyland, 2002) allowing writers not only to report the source material but also to indicate their position or stance towards a quoted material (Ramoroka, 2014). Although RVs are not the only means of citation, by employing RVs writers can fluently synthesize reported material rather than list or summarize it while at the same time expressing their attitude towards it. The usage and appropriate choices of RVs in academic discourse undoubtedly present a higher-level mastery of academic writing. As Nguyen and Pramoolsook (2016) demonstrate, RVs help writers appropriately integrate other people's works and ideas into their writing and present their study persuasively.

Despite a high number of studies on RVs in academic discourse focusing on research articles (RAs) (e.g. Thomas and Hawes, 1994; Bloch, 2010; Mansourizadeh and Ahmad, 2011; Agbaglo,

2017) or university writing (Ramoroka, 2014; Jomaa and Bidin, 2016), the number of studies concentrating particularly on Master's theses is relatively low (e.g. Samraj, 2013; Manan and Noor, 2015). Yet Master's theses very often represent students' first major academic and scientific writing before entering the world of research and science as PhD candidates and/or novice researchers. It is particularly the Literature Review section of a thesis where citations are mostly found (Soler-Monreal and Gil-Salom, 2011), presenting historical background, discussing theories and concepts, showing related research and clarifying terminology and concepts parallel with the context of the research (Ridley, 2008). As Bloch (2010) points out, for second language (L2) learners it is often difficult to choose the RVs that can both meet the syntactic requirements of the reporting sentence and at the same time express their attitudes toward the reported claims.
This article examines the use of RVs found in citations of reported work by L2 learners, students of Economics and Management at the Czech University of Life Sciences Prague (CULS Prague). The objective was to find out how frequently certain RVs categories and their evaluative functions occurred in English texts of the students and based on these results to provide us with better insight into the performance of students when writing their theses in English. In the following section we describe the creation of the corpus and method of RVs categorization. Next, we present the results of our research. Finally, we discuss the results with findings of other studies focused on RVs.

Materials and Methods

The research was performed on 82 Master's theses written in English by Czech students of the English programme Economics and Management at the Faculty of Economics and Management of CULS Prague. The created corpus contained 82 Literature Review sections from Master's theses that met the following criteria: 1) the theses were available online - to meet this criterion only the theses no older than January 2017 could be considered, 2) were successfully defended between January 2017 and June 2019 - at the time of performing this research no newer theses were available, and 3) were written by Czech students as English L2 learners. Using descriptive statistics, we analysed the created corpus. The corpus consisting of 82 texts contained 439,356 words in total. The length of individual texts varied from 3,899 to 6,401 words, amounting to 5,358 words per text on average. The texts in the corpus were carefully read and searched for the occurrences of citations containing RVs.
The types of citations under analysis are illustrated in examples (1-3). Only such reporting structures were analysed where the name of the agent was specified either in the subject position - see example (1), or as a "by-adjunct" in the sentence structure - see example (2), or as a generalized or meta-linguistic expression used in place of the agent - see example (3). In the examples (1-3) both the RV and the agent are italicised:

1. "*Daniela Pauknerová et al.* also *state* that the manager should be able to influence the evaluation of workers." (MTLR11RV3);
2. "The third reason *suggested by Kirkpatrick* (2006) is to find out whether the program was effective and brings improvements and also how can the future programs be changed." (MT23RV2);
3. "*The study confirmed* a weak relationship between work satisfaction and the subjective feeling of nurses." (MTLR4RV6)

Each reporting structure was allocated a code - e.g. MTLR1RV1 - where MTLR1 stood for the Master's thesis Literature Review randomly coded from 1 to 82 and RV1 for the order of the RV found in that particular section.
Altogether 837 occurrences of RVs were extracted from the corpus. First, the frequencies of individual

RVs occurrences were counted. Frequencies are used to indicate how often a phenomenon occurs and are based on counting the number of occurrences (Seliger and Shohamy, 1990).

The present study employs Hyland's (1999, 2002) framework of categorizing RVs according to their evaluation of the process which the RVs describe or represent in the discourse. Thus, within the framework, RVs are divided into three process categories: Research Acts, Cognitive Acts and Discourse Acts RVs. In each process category the RVs are further classified as follows:

Research Acts verbs refer to the research activity or experimental procedure. They occur in the statement of Findings (e.g. *observe*, *discover*, *notice*, *show*) or Procedures (e.g. *analyse*, *calculate*, *explore*) (Hyland, 2002). Within the Findings subcategory of RVs, writers can acknowledge their acceptance of the author's reported results with factive verbs (e.g. *demonstrate*, *establish*, *show*, *solve*), such as *confirmed* in (3), or they can portray the author's judgment as false or incorrect, adopting a counter-factive stance (e.g. *fail*, *misunderstand*, *ignore*). Or they can comment on research findings non-factively (e.g. *find*, *identify*, *observe*, *obtain*), "with no clear attitudinal signal as to their reliability" (Hyland, 2002:7).

Cognitive Acts verbs portray the cited work in terms of mental processes, the writer having either a positive attitude to the reported material (e.g. *agree*, *hold*, *know*, *think*, *understand*), a tentative view (*believe*, *doubt*, *suppose*, *suspect*), a critical stance (*disagree*, *dispute*, *not think*) or a natural attitude towards the proposition (e.g. *picture*, *conceive*, *reflect*). Discourse Acts verbs are verbal expressions of both the research and cognitive activities, evaluating the cited material. Hyland (2002) further divides those verbs that express Doubt into tentative (e.g. *hypothesize*, *indicate*, *postulate*), such as *suggested* in (2), or directly critical verbs (e.g. *exaggerate*, *not account*, *not make point*). Assurance verbs, on the other hand, introduce the reported material more positively. They are further sub-divided into non-factive verbs neutrally informing the reader about the author's position (e.g. *describe*, *discuss*, *report*, *define*, *summarize*), such as *state* in (1), and factive verbs supporting the writer's position towards that of the author cited (e.g. *argue*, *affirm*, *explain*, *note*, *point out*, *claim*). The last sub-category of Discourse Acts verbs are Counters, which express reservations or objections towards the reported message. The objections are attributed by the writer to the original author of the cited message (e.g. *deny*, *challenge*, *question*, *refute*, *rule out*).

Results

In the corpus, RVs occurred in all three process categories, however rather disproportionally. As shown in Table 1, of all 837 occurrences of RVs Discourse Acts verbs were the most highly represented (68.5%), followed by a significantly lower occurrence of Research Acts verbs (20.8%) and even lower occurrence of Cognitive Acts verbs (10.7%). In total, the mean occurrence of RVs was 10.21 per 5,358 words, i.e. the mean number of words per text, with the marginal minimal occurrence at 0 (2 texts) and the marginal maximum occurrence at 26 (1 text). Discourse Acts verbs averaged out to 6.99 occurrences per text, Research Acts verbs to 2.12 occurrences per text and Cognition Acts to 1.10 occurrences per text.

RVs	Occurrences in the corpus	Mean occurrence per text
Discourse	573 (68.5%)	6.99
Research	174 (20.8%)	2.12
Cognition	90 (10.7%)	1.10
Total	**837 (100%)**	**10.21**

Table 1: Frequencies of RVs in the corpus and their mean frequency per text

As is further demonstrated in Table 2, within the most highly represented category of RVs, Discourse Acts, it was the Assurance verbs that were by far the most frequent (95.3%). The non-factive verbs (56.6%), neutrally informing the reader of the author's position towards the cited material were used more frequently than the factive verbs (38.7%), employed by the writers to

bolster their views and introduce the cited material in more positive or conclusive terms. The non-factive Assurance verbs were thus the most frequent subcategory not only within the Assurance verbs but also within the overall occurrences of the RVs used.

The Doubt category verbs (4.7%) appeared in 27 occurrences only, which can be attributed to the 27 occurrences of the only tentative Doubt verb *suggest* (4.7%) found in the corpus (Table 3). The Doubt category verbs which are directly critical (0%) were not used at all. Similarly, the final category of Discourse Acts verbs, Counters (0%), referring to the author's reservations or objections to the correctness of the reported message, had no representatives in the corpus.

As regards Research Acts, Procedures verbs (62.1%) were more frequent than Findings verbs (37.9%), thanks to the 51 occurrences of *add* (Table 3). Both the factive (20.7%) and non-factive Findings verbs (17.2%) contained a variety of verbs usually found in three or six occurrences only. The frequency of the factive verbs (20.7%) was slightly higher than that of the non-factive verbs (17.2%) thanks to *confirm* which had 9 occurrences, unlike the other verbs in the Research Acts category recorded in 3 or 6 occurrences only.

Category/Sub-Category	Frequency	Percentage
Research Acts	**174**	**20.8%**
Findings	*66*	*37.9%*
Factive	36	20.7%
Non-factive	30	17.2%
Counter-factive	0	0%
Procedures	*108*	*62.1%*
Cognitive Acts	**90**	**10.7%**
Positive	63	70%
Critical	0	0%
Tentative	6	6.7%
Neutral	21	23.3%
Discourse Acts	**573**	**68.5%**
Doubt	*27*	*4.7%*
Tentative	27	4.7%
Critical	0	0%
Assurance	*546*	*95.3%*
Factive	222	38.7%
Non-factive	324	56.6%
Counters	*0*	*0%*
Total	**837**	**100%**

Table 2: Frequencies of RVs in different evaluative functions in the discourse

Of the least represented Cognitive Acts verbs it was the positive Cognitive Acts verbs (70%) that occurred in abundance, mainly thanks to the 33 occurrences of *agree* representing the author as having a positive attitude to the reported material (Table 3). They were followed by the neutral verbs (23.3%) representing the author as having a neutral attitude toward proposition and tentative verbs (6.7%) represented by *believe* in 6 occurrences. Cognitive verbs presenting the author as taking a critical stance (0%) toward the cited message were not found.

Table 3 displays the most commonly used RVs with the frequency of occurrences ≥ 15. The non-factive Discourse Acts verbs *state* and *point out* informing the readers neutrally of the authors' position were found in 75 and 69 occurrences each, amounting thus to 13.1% and 12% of all Discourse Acts verbs. The verb *claim* (11%) supporting the reported information was the most frequent factive Assurance verb found in 63 occurrences. Other most frequently used Discourse

Acts verbs were non-factive Assurance verbs *define* found in 57 occurrences (10%), *describe* in 54 occurrences (9.4%) and *mention* in 48 occurrences (8.4%).
The lowest frequency ≥ 15 is ascribed to *suggest*, tentatively expressing doubt about the reported claims which occurred 27 times (4.7%) and was the only RV in the Doubt subcategory of Discourse Acts Verbs (Table 2). The remaining 60 occurrences can be attributed to various Assurance Discourse Acts verbs found in frequencies ≤ 15 and amounting to 31.4% of all Discourse Acts verbs found.
Besides *add*, recorded in 51 occurrences and thus amounting to 29.3% of all Research Acts, other verbs reporting either on the statement of findings or researchers' procedures occurred in rather an abundant variety (70.7%), however each in the frequency ≤ 15. A slightly higher frequency of factive Findings verbs over non-factive Findings verbs (Table 2) is attributed to *confirm*, which occurred 9 times, as opposed to other Findings verbs which, similarly to other procedures verbs of Research Acts category, were recorded in 3 or 6 occurrences only.

Category / RV	Frequency	Percentage
Discourse Acts	**573**	**68.5%**
state	*75*	*13.1%*
point out	*69*	*12%*
claim	*63*	*11%*
define	*57*	*10%*
describe	*54*	*9.4%*
mention	*48*	*8.4%*
suggest	*27*	*4.7%*
RVs ≤ 15	180	31.4%
Research Acts	**174**	**20.8%**
add	*51*	*29.3%*
RVs ≤ 15	123	70.7%
Cognition Acts	**90**	**10.7%**
agree	*33*	*36.7%*
RVs ≤ 15	57	63.3%
Total	**837**	**100%**

Table 3: Most common RVs with occurrences ≥ 15

Among the Cognitive Acts verbs, the most frequent was *agree* in 33 occurrences (36.7%), representing authors as having a positive attitude (Table 3). The other 30 occurrences of positive Cognitive verbs (Table 2) comprised verbs that occurred three or six times only, thus contributing to the remaining 57 occurrences (63.3%) of the Cognitive Acts verbs that occurred ≤ 15 times. Verbs portraying the author as holding a neutral attitude towards the cited claim were recorded in 21 occurrences (Table 2) with 3 or 6 occurrences per each verb. The only tentative Cognitive verb found in the corpus was *believe* in 6 occurrences, illustrating the author as having a tentative view toward the reported matter.

Discussion

This study explored the types of RVs and their frequencies as they were used by L2 learners - the Czech students of Economics and Management - in the Literature Review sections of their Master's theses written in English. From the corpus of 439,356 words in total, 837 occurrences of RVs were extracted. To classify the RVs, Hyland's model of RVs categorization was applied (Hyland, 1999, 2002).
The results of the present study suggest a predominant use of non-factive Assurance Discourse Acts verbs which merely acknowledge reported communication rather than express a more pronounced or even critical stance. The findings are consistent with those of Ramoroka (2014), whose investigation

of RVs in university students' papers confirms a high frequency of non-factive Assurance verbs. This may be caused by the fact that novice writers tend to attribute the reported content to the source rather than provide support for their arguments and justify their claims. The comparison of citations in novice and expert RAs by Mansourizadeh and Ahmad (2011) also confirms the claim. The strong reliance on reporting structures attributing the knowledge to outside experts in novice writing is also supported by the findings of Liardét and Black (2019), who, in line with the findings of the present study, also mention *state* as one of the most highly recorded citation structures.

Similarly, Lee, Hitchcock and Casal (2018) conclude that the undergraduate L2 learners are inclined to show deference to the perceived authority of published sources. Undergraduate students may also have problems with evaluation because they are not at the appropriate intellectual level to do so. As Ansas and Sukyadi (2019) also confirm, they find it even more difficult to relate the sources to their own ideas and develop their argument based on the sources. On the other hand, the lack of critical RVs in the corpus (0% of Counters in Discourse Acts and 0% of counter-factive verbs in Research Acts) may not be surprising or significant, as studies (Agbaglo, 2017; Hyland and Jiang, 2017) confirm a predominant use of Discourse verbs even in RAs written by professional writers. In this light, the fact that student-writers take neutral rather than critical stance towards cited material might not be of considerable significance, especially if this stance is most frequent in social science and humanities texts (Agbaglo, 2017; Hyland and Jiang, 2017) among which the academic texts in the field of Economics and Management definitely belong.

Despite these findings, we believe that it is still important to emphasize the existence of different types of RVs and make student-writers aware of the variety they have at their disposal when synthesizing other authors' findings and taking a stance towards a cited message. We agree with Nguyen and Pramoolsook (2016) who suggest that a clear focus on the lexical grammatical aspects of citation in terms of accurate structures and appropriately used RVs should be introduced into the academic writing classroom. As Jomaa and Bidin (2019) suggest, involving the information on citation and different types of RVs in textbooks of academic writing together with authentic materials from students' and experts' writings would be beneficial for novice writers. We believe in line with Jomaa and Bidin (2019) that combining the understanding of students' academic practices with the understanding of academic texts in context is essential for the implication of the findings into the context of academic writing courses at undergraduate or postgraduate levels.

Conclusion

The paper investigated the use of RVs in L2 learners' writing. It did so on the corpus of Literature Reviews of Master's theses written in English by Czech students of Economics and Management. The results showed that students had not been always aware of how to use different categories of RVs and their evaluative functions. The findings reported high use of discourse verbs in passing the information cited (e.g. *state*, *point out*), communicating generalized interpretations or conclusions. Much less frequent were verbs signifying different evaluative roles. Although the use of discourse verbs seems to be predominant even in professional writings, the promotion of various RVs' types carrying a more pronounced stance in citations is still of great significance in L2 learners' academic writing courses. As a practical benefit of this study, the findings might help adjust syllabi of academic English courses at institutions where English is a non-native language, enhancing students' understanding of the elements of academic writing, and the use of RVs in citation structures in particular. Performing broader experimental research might contribute to evidence on the effectiveness of such knowledge in academic writing at a tertiary level of education.

References

Agbaglo, E. (2017) 'The Types and the Frequencies of Reporting Verbs in Research Articles Written by Lecturers in a Ghanaian University', *Journal of Literature, Language and Linguistics*, vol. 34, pp. 51-57.

Ansas, V.N. and Sukyadi, D. (2019) 'Source-based writing among undergraduate students: Students' perspective and challenges', *Indonesian Journal of Education*, vol. 11, no. 2, pp. 152-157. https://doi.org/10.17509/ije.v11i2.14757
Bloch, J. (2010) 'A concordance-based study of the use of reporting verbs as rhetorical devices in academic papers', *Journal of Writing Research*, vol. 2, no. 2, pp. 219-244. http://dx.doi.org/10.17239/jowr-2010.02.02.7
Hyland, K. (1999) 'Academic attribution: Citation and the construction of disciplinary knowledge', *Applied Linguistics*, vol. 20, no. 3, pp. 341-367. http://dx.doi.org/10.1093/applin/20.3.341
Hyland, K. (2002) 'Activity and evaluation: reporting practices in academic writing', In J. Flowerdew (Ed), *Academic discourse*, London: Longman, pp. 115-130.
Hyland, K. and Jiang, F. K. (2017) 'Is academic writing becoming more informal?', *English for Specific Purposes*, vol. 45, pp. 40-51. http://dx.doi.org/10.1016/j.esp.2016.09.001
Jomaa, N.J. and Bidin, S.J. (2016) 'Roles of the cited author in citations of the literature review by EFL postgraduates', *International Journal of Applied Linguistics and English Literature*, vol. 5, no. 7, pp. 213-225. https://doi.org/10.7575/aiac.ijalel.v.5n.7p.213
Jomaa, N.J. and Bidin, S. . (2019) 'Variations in the Citation Use and Perceptions in Writing the Literature Review by EFL Postgraduates', *Eurasian Journal of Applied Linguistics*, vol. 5, no. 3, pp. 441-460. http://dx.doi.org/10.32601/ejal.651398
Lee, J.L., Hitchcock, C. and Casal, J.E. (2018) 'Citation practices of L2 university students in first-year writing: Form, function, and stance', *Journal of English for Academic Purposes*, vol. 33, pp. 1-11. http://dx.doi.org/10.1016/j.jeap.2018.01.001
Liardét, C. and Black, S. (2019) '"So and so" says, states and argues: A corpus-assisted engagement analysis of RVs', *Journal of Second Language Writing*, vol. 44, pp. 37-50. http://dx.doi.org/10.1016/j.jslw.2019.02.001
Manan, N.A. and Noor, N.M. (2015) 'The use of integral citations in master's degree theses', *International Journal of Education and Research*, vol. 5, no. 7, pp. 233-246. https://www.ijern.com/journal/2015/July-2015/21.pdf
Mansourizadeh, K. and Ahmad, U.K. (2011) 'Citation practices among non-native expert and novice scientific writers', *Journal of English for Academic Purposes*, vol. 10, pp. 152-161. http://dx.doi.org/10.1016/j.jeap.2011.03.004
Nguyen, T.T.L. and Pramoolsook, I. (2016) 'Citations in literature review chapters of TESOL master's theses by Vietnamese postgraduates', *GEMA Online Journal of Language Studies*, vol. 16, no. 2, pp. 17-32. https://doi.org/10.17576/gema-2016-1602-02
Ramoroka, B.T. (2014) 'Integration of sources in academic writing: a corpus-based study of citation practices in essay writing in two departments at the University of Botswana', *Reading & Writing*, vol. 5, no. 1, pp. 1-7. http://dx.doi.org/10.4102/rw.v5i1.41
Ridley, D. (2008) *Multiple Purposes of Literature Review*. Sage Publications Inc.
Samraj, B. (2013) 'Form and function of citations in discussion sections of Master's theses and RAs', *Journal of English for Academic Purposes*, vol. 12, pp. 299-310. http://dx.doi.org/10.1016/j.jeap.2013.09.001
Seliger, H.W. and Shohamy, E. (1990) *Second Language Research Methods,* 2nd edition, Oxford University Press.
Soler-Monreal, C. and Gil-Salom, L. (2011) 'A cross-language study on citation practice in Ph.D. theses', *International Journal of English Studies*, vol. 11, no. 2, pp. 53-75. http://dx.doi.org/10.6018/ijes.11.2.149641
Swales, J. M. (1990) *Genre Analysis: English in academic and research settings*. Cambridge: CUP.
Thomas S. and Hawes, T. (1994) 'Reporting verbs in medical journal articles', *English for Specific Purposes*, vol. 13, no. 2, pp. 129-148.

CORPORATE SOCIAL RESPONSIBILITY AS THE SOURCE OF TEACHERS' JOB SATISFACTION

Petra Jarkovská

Department of Management, Faculty of Economics, University of South Bohemia in České Budějovice, Czech Republic, pjarkovska@hotmail.com

Abstract

Teachers' work performance is frequently the only way how to differentiate among otherwise almost identical outputs of different universities. Thus, teachers' motivation plays a significant role in stipulating university teaching staff work performance, where job satisfaction often plays a mediating role between teachers' needs and their ultimate work behaviour, including work performance. Unfortunately, scholarly literature gives little room to Corporate Social Responsibility (CSR) functioning as a motivation factor in relation to employees. Therefore, the purpose of this paper is to fill in this gap and to examine the link between CSR and job satisfaction (JS) of university teaching staff using regression analysis. Drawing upon Carroll's (2015, 2016) four-dimensional concept of CSR, the results of this paper indicate a significant positive causal relationship between the economic, ethical and philanthropic dimension of CSR and JS. However, a significant positive causal relationship between the legal CSR dimension and JS was not confirmed.

Keywords

Corporate Social Responsibility, job satisfaction, motivation, regression analysis, university teaching

Introduction

Corporate Social Responsibility (CSR) can be understood as all decisions of an organization that goes beyond its economic and technical interests (Carroll, 2015). The most commonly used and cited concept of CSR (e.g. Bauman and Skitka, 2012; Farooq, Farooq and Jasimuddin, 2014; Kim, Song and Lee, 2016; Kim et al, 2017; Zhang and Lim, 2019) is the model defined for the first time in 1979 by Carroll (2015, 2016) who proposed a four-level CSR model that includes the economic, legal, ethical and discretionary (later referred to as philanthropic) level (dimension) of social responsibility. According to CSR theory, an organization must satisfy the needs and desires of different groups of people (stakeholders) who would otherwise stop supporting or could not support the organization. Organizational stakeholders typically include customers, employees, investors, suppliers, and the community. The list of stakeholders may vary for each organization, but it is widely accepted that employees belong to the organization's key stakeholders. Their interest may be a legal claim, such as a fulfilment of contractual terms (legal dimension of CSR) or at other times, a moral claim, such as employees' ability to express their own opinions (ethical dimension of CSR) (Carroll 2015, 2016). Such understanding of CSR is undoubtedly in line with motivational theories; many scholars confirm the important role of individual CSR components or activities as motivation factors in meeting employees' needs and improving the quality of their working lives, which eventually leads to bettering employee work performance (e.g. Cycyota, Ferrante and Schroeder, 2016; Kim et al, 2017; Graves, Sarkis and Gold, 2019; John et al, 2019). Seemingly, according to the Self Categorization Theory (SCT), employees seek to integrate and become workers of such organizations that share compatible values; enabling them to satisfy their psychological desires and meaningfully fulfil their existence (John et al, 2019). Likewise, Social

Identity Theory (SIT) argues that if people have positive feelings for a group, they tend to identify themselves with a social status of this particular group, and a membership in that group affects their self-esteem and pride (Fu, Li and Duan, 2014).
Based on the synergy of the above-described knowledge from the SCT, SIT and motivational theories (e.g. Deci and Ryan, 2000), we can conclude that organization's involvement in CSR activities can therefore significantly strengthen employer-employee relationship and lead to Job Satisfaction (JS), Work Performance (WP) and employees' Organizational Commitment (OC), which in turn leads to voluntary employee Retention (R). Therefore, we can define a causal relationship between CSR (as a motivation factor) and employee behaviour (JS, WP, OC, R), where JS not only explains employee's interest in individual aspects of CSR (e.g. Bauman and Skitka, 2012; Youn, Lee and Lee, 2018; Graves, Sarkis and Gold, 2019) but also functions as a mediator between CSR (as a motivation factor) and other employee´s behaviour desired by organization (WP, OC, R).

- CSR → JS
- CSR → WP
- CSR → OC
- CSR → R
- CSR → JS → WP
- CSR → JS → OC
- CSR → JS → OC → R

Thus, the purpose of this paper is to identify those CSR dimensions (economic, legal, ethical, and philanthropic) which play a significant role in university teaching staff job satisfaction, as "university teaching" is a job inherently meaningful, based on expanding novel knowledge and moral principles, yet according to many authors (e. g. Caprara et al, 2006; Smetáčková, 2019), it is one of the most stressful occupations. Additionally, this paper fills the gap in academic literature, as the majority of CSR scholars are focusing exclusively on other groups of stakeholders but employees (Youn, Lee and Lee, 2018). In higher education (a subsector of the service industry), teachers' performance is often the only way how to differentiate among almost identical organizational outputs. Using the right CSR components or activities might be one of the ways how to attract and retain highly skilled employees who strive for excellence and represent a competitive advantage (Fejfarová and Fejfar, 2018; Kvasničková Stanislavská, Kvasnička and Pániková, 2018; Flégl, Jiménez-Bandala and Rosas, 2019).
Hence this paper proposes the following hypotheses (H):

H1: The perceived economic dimension of CSR by university teachers has a positive direct influence on their job satisfaction.
H2: The perceived legal dimension of CSR by university teachers has a positive direct influence on their job satisfaction.
H3: The perceived ethical dimension of CSR by university teachers has a positive direct influence on their job satisfaction.
H4: The perceived philanthropic dimension of CSR by university teachers has a positive direct influence on their job satisfaction.

To fulfil the set objectives, the paper is structured as follows: after a brief description of the relationship between CSR as a motivation factor and JS, the used research methods are specified. The next section summarizes the research findings, which are further interpreted and discussed.

Materials and Methods

To analyse the relationship between perceived CSR by university teachers and their JS, the four-dimension/factor (altogether 19 items) concept of CSR by Carroll (2015, 2016) and JS concept (altogether 11 items) based on Bauman and Skitka (2012) were used. Both concepts/constructs were adjusted for this research and included 30 items converted into questions/statements like e.g. "The institution, which I work for, has a remuneration system based on performance" (CSR, economic dimension) or "Employer-employee contractual obligations are always honoured by the institution I work for" (CSR, legal dimension) and for the JS construct, e.g. "I am satisfied with my immediate supervisor" or "I am satisfied with my promotion opportunities". Respondents were requested to answer these questions/statements by choosing an adequate level of their agreement on the 7-point Likert scale, ranging from strong disagreement (1 point) to strong agreement (point 7). Apart from questions on CSR and JS, respondents were asked to answer 6 questions on demographics, using the best fitting option from given alternatives. Since this study was carried out as pilot research, the questionnaire was selected as the best option for collecting the data. It was administered to randomly selected university teachers in the Czech Republic using their university email addresses. The list of universities (26 public universities, 2 state universities, and 33 private universities) was retrieved from the official web pages of Ministry of Education, Youth and Sport (2019). Altogether 600 questionnaires were distributed during the months of October and November 2019. The response rate was 22%. Thus, the final sample consisted of 134 respondents (N = 134), which was considered satisfactory for the purpose of the pilot research. For the analysis, the IBM SPSS Statistics software was used. First, descriptive statistics were employed to investigate the demographic characteristics of the respondents. Second, Cronbach´s alpha was used to investigate factors of internal consistency reliability. Third, factor analysis was applied to factor/dimension reductions. Fourth, regression analysis was used to identify relations between variables and to test hypotheses.

Results

Demographic characteristics of respondents

The sample consisted of 134 respondents in total, with males representing 32% (N=43) and females representing 68% (N=91). Based on the age, the respondents were segmented into the following 5 subgroups: 1. less than 35 years old - 8% (N=10), 2. between 35 and 45 years old - 25% (N=34), 3. between 45 and 55 years old - 30% (N=40), 4. between 55 and 65 years old - 17% (N=23) and 5. 65 and above - 20% (N=27). Out of the total (N=134), 45 respondents (34%) were single, 73 respondents were married (54%) and 16 respondents were divorced (12%). No respondent marked "widow/widower" as a marital status option. 81 respondents had one or more children (60%), while 53 respondents, which is 40% out of the total, had no children. 65 respondents (49%) were financially dependent on their income from university teaching at a questioned institution (university), while the majority of respondents - 69 (51%) were not dependent on their current earnings from university teaching job (at questioned university). Lastly, all respondents were sub-grouped into 4 categories based on the type of household they lived in as follows: 1. One-member household - 40 respondents (30%), 2. One adult-member with one or more children - 3 respondents (2%), 3. More than one adult- member with no children - 55 respondents (41%) and 4. More than one adult-member with one or more children - 36 respondents (27%).

Reliability test

The factor analysis investigated the reliability of 5 factors (4 independent variables, 1 dependent variable), which is to say the economic dimension of CSR (independent variable), legal dimension

of CSR (independent variable), ethical dimension of CSR (independent variable), philanthropic dimension of CSR (independent variable), and job satisfaction (dependent variable). Cronbach´s alpha was used to investigate the internal consistency among the items of each variable. Cronbach´s alpha for the economic dimension of CSR after excluding 2 items equalled 0.758 (5 items). Cronbach´s alpha for the legal dimension of CSR equalled 0.925 (2 items). Cronbach´s alpha for the ethical dimension of CSR after excluding 2 items equalled 0.853 (3 items). Cronbach´s alpha for the philanthropic dimension of CSR after excluding 3 items equalled 0.674 (2 items). And lastly, Cronbach´s alpha for job satisfaction after excluding 2 items equalled 0.831 (9 items). In social scientific research, Cronbach´s alpha coefficient of 0.600 and higher is accepted as satisfactory (Kim et al, 2015), therefore Cronbach´s alpha for the philanthropic dimension ($\alpha = 0.674$, 2 items) justifies the interpretation of the scores for the two aggregated items together and is satisfactory. All other remaining Cronbach´s alpha coefficients are well above the minimum requirement, and are thus also satisfactory.

Hypotheses test

The effect of the perceived economic dimension of CSR by university teachers on their job satisfaction:

The effect of the independent variable (economic dimension of CSR) upon the dependent variable (JS) has R^2 of.324 with F of 63.142 (p <.05) to be significant. The perceived economic dimension of CSR by university teachers has a significantly positive influence on their job satisfaction with β=. 569 (p <.05) (Table 1).

Thus, H1 "Perceived economic dimension of CSR by university teachers has a positive direct influence on their job satisfaction" has been confirmed ($p < 0.01$).

N=134	Regression analysis for dependent variable: JS R=.56883189 R2=.32356972 Modified R2=.31844525 F (1.132) =63.142 *p*<.00000 Standard error of estimate: 6.4477					
	β	Standard error of *β*	*b*	Standard error of *b*	*t* (132)	*p*-value
Constant			31.48629	2.628129	11.98050	0.000000
Economic	0.568832	0.071585	0.85812	0.107992	7.94620	0.000000

Table 1: Regression analysis for the economic dimension of CSR and JS (author's work)

The effect of the perceived legal dimension of CSR by university teachers on their job satisfaction:

The effect of the independent variable (legal dimension of CSR) upon dependent variable (job satisfaction) has R^2 of .008 with F of 1.06 (p <.31) to be insignificant. The perceived legal dimension of CSR by university teachers has an insignificant influence on their job satisfaction with β =.089 (p <.31) (Table 2).

Thus, H2 "The perceived legal dimension of CSR by university teachers has a positive direct influence on their job satisfaction" has been rejected ($p < 0.31$).

N=134	Regression analysis for dependent variable: JS R=.08919573 R2=.00795588 Modified R2=.00044039 F (1.132) =1.0586 *p*<.30542 Standard error of estimate: 7.8083					
	β	Standard error of *β*	*b*	Standard error of *b*	*t* (132)	*p*-value
Constant			39.04215	3.705779	10.53548	0.000000
Legal	0.089196	0.086692	0.25177	0.244699	1.02888	0.305417

Table 2: Regression analysis for the legal dimension of CSR and JS (author's work)

The effect of the perceived ethical dimension of CSR by university teachers on their job satisfaction: The effect of the independent variable (ethical dimension of CSR) upon dependent

variable (job satisfaction) has R^2 of.450 with F of 107.96 (p <.05) to be significant. The perceived ethical dimension of CSR by university teachers has a significantly positive influence on their job satisfaction with β =.671 (p <.05) (Table 3).
Thus, H3 "The perceived ethical dimension of CSR by university teachers has a positive direct influence on their job satisfaction" has been confirmed (p < 0.01).

N=134	Regression analysis for dependent variable: JS R=.67074596 R2=.44990015 Modified R2=.44573272 F (1.132) =107.96 *p*<.000000 Standard error of estimate: 5.8145					
	β	Standard error of *β*	*b*	Standard error of *b*	*t* (132)	*p*-value
Constant			34.76538	1.723500	20.17138	0.000000
Ethical	0.670746	0.064556	1.25092	0.120394	10.39021	0.000000

Table 3: Regression analysis for the ethical dimension of CSR and JS (author's work)

The effect of perceived philanthropic dimension of CSR by university teachers on their job satisfaction: The effect of the independent variable (philanthropic dimension of CSR) upon dependent variable (job satisfaction) has R^2 of.859 with F of 12.409 (p <.05) to be significant. The perceived philanthropic dimension of CSR by university teachers has a significantly positive influence on their job satisfaction with β =.293 (p <.05) (Table 4).
Thus, H4 "The perceived philanthropic dimension of CSR by university teachers has a positive direct influence on their job satisfaction" has been confirmed (p < 0.01).

N=134	Regression analysis for dependent variable: JS R=.29313849 R2=.08593017 Modified R2=.07900540 F (1.132) =12.409 *p*<.00059 Standard error of estimate: 7.4952					
	β	Standard error of *β*	*b*	Standard error of *b*	*t* (132)	*p*-value
Constant			39.04215	3.705779	10.53548	0.000000
Philanthropic	0.293138	0.083215	1.14671	0.325523	3.52266	0.000587

Table 4: Regression analysis for the philanthropic dimension of CSR and JS (author's work)

Discussion

45% of teachers' job satisfaction was explained by the ethical dimension of CSR. This result is in line with current research findings on CSR and employees (e.g. Kim et al, 2017; John et al, 2019). In general, employees like to be treated with fairness and dignity (e.g. transparent performance evaluation or the implementation of antidiscrimination policies), have the opportunity to express themselves freely and take part in open discussions (e.g. presenting employees with adequate information or two-way symmetrical communication). Additionally, teaching by its nature exposes teachers to high moral adoration and, in case of failure, to saver ethical scrutiny. Likewise, the economic CSR dimension scored high (32%). Similar results are confirmed by the majority of scholars (e.g. Kim, Song and Lee, 2016; Kim et al, 2017). Therefore, such practices as a remuneration system based on performance, competitive wages, employees' security or promotion opportunities need to be considered when adopting human resources management policies. Surprisingly, despite having a significant positive influence on job satisfaction, the philanthropic dimension scored low (9%) in comparison with the findings of other service sector management scholars (e.g. Cycyota, Ferrante and Schroeder, 2016; Graves, Sarkis and Gold, 2019). This could be probably explained by sufficient teachers' contribution to "improving" society or community within their job profile scope, as teaching calls for teachers' active participation in students' development and ethical building up. Seemingly it could be reasoned by teachers having no urge to justify their work performance or outcomes, as the education sector

dos not contribute to negative externalities production, and thus is not viewed negatively by the public. In contradiction to contemporary academic research on CSR and employees (e.g. Kim et al, 2017; John et al, 2019), the findings of this paper claim that the legal dimension of CSR has no significant positive influence on job satisfaction. Although contrary to other research findings, the present results on the legal CSR dimension are in line with motivational theories. For example, according to Herzberg's Two-factor motivation theory, practices like e.g. institution's compliance with employment-related laws and regulations (safety procedures, health, and social insurance contribution) function as hygienic factors when present, thus not contributing to increasing employees' job satisfaction but when missing, contributing to employees' dissatisfaction.
According to motivation theories (e.g. Deci and Ryan, 2000), different groups of employees are motivated by different motivation factors. This paper does not confirm this statement as the results for 6 subgroups of respondents do not show any deviation from the results of 134 respondents in total, which is in line with other academic research findings on CSR and employees (e.g. Kim et al, 2017; John et al, 2019).

Conclusion

This paper discussed the purpose of individual CSR dimensions as motivation factors in stipulating university teachers' job satisfaction. The results indicate that the employees' perceptions of ethical, economic, and philanthropic dimensions of CSR are positively related to their JS, and thus suggest that adding these CSR dimensions practices into human resources programmes is likely to overly improve employees' desirable behaviour or attitudes, such as WP, OC, and voluntary R. It is also vital to highlight that, from the CSR theory perspective, the causal relationship between CSR and job satisfaction is mutually influential, and hence positively affects all relations between organization and its stakeholders, which is in line with the holistic concept of organizations.

References

Bauman, Ch.W. and Skitka, L.J. (2012) 'Corporate social responsibility as a source of employee satisfaction', *Research in organizational Behavior*, vol. 32, pp. 63-86. https://doi.org/10.1016/j.riob.2012.11.002

Caprara, V., Barbaranelli, C., Steca, P. and Malone, P.S. (2006) 'Teachers' self-efficacy beliefs as determinants of job satisfaction and students' academic achievement: A study at the school level', *Journal of School Psychology*, vol. 44, no. 6., pp. 473-490. https://doi.org/10.1016/jsp.2006.09.001

Carroll, A.B. (2015) 'Corporate social responsibility: The centrepiece of competing and complementary frameworks', *Organizational Dynamics*, vol. 44, pp. 87-96. https://doi.org/10.1016/j.orgdyn.2015.02.002

Carroll, A.B. (2016) 'Carroll's pyramid of CSR: taking another look', *Int. J. Corp. Soc. Responsibility,* vol. 1, no.1, 3. https://doi.org/10.1186/s40991-016-0004-6

Cycyota, C.S., Ferrante, C.J. and Schroeder, J.M. (2016) 'Corporate social responsibility and employee volunteerism: What do the best companies do?', *Business Horizons*, vol. 59, pp. 321-329. http://dx.doi.org/10.1016/j.bushor.2016.01.004

Deci, E.L. and Ryan, R.M. (2000) 'The "what" and "why" of goal pursuits: human needs and the self-determination of behavior', *Psychological. Inquiry*, vol. 11, pp. 227-268. https://doi.org/10.1207/S15327965PLI1104_01

Farooq, M., Farooq, O. and Jasimuddin, S.M. (2014) 'Employee's response to corporate social responsibility: exploring the role of employees collectivist orientation', *European Management Journal*, vol. 32, pp. 916-927. https://doi.org/10.1016/j.emj.2014.03.002

Fejfarová, M. and Fejfar, J. (2018) 'Employee training and development: Organizational aspect', *Proceedings of 15th International Conference on Efficiency and Responsibility in Education (ERIE 2018)*, Prague: pp. 45-51.
Flégl, M., Jiménez-Bandala, C.A. and Rosas, L.A.A. (2019) 'Can we measure professors' productivity over longer period? An introductory analysis', In *Proceedings from the 16th International Conference on Efficiency and Responsibility in Education (ERIE 2019)*, Prague, Czech University of Life Sciences, June 2019, pp. 50-56.
Fu, H., Li, Y. and Duan, Y. (2014) 'Does employee-perceived reputation contribute to citizenship behavior? The mediating role of organizational commitment', *International Journal of Contemporary Hospitality Management*, vol. 26, no. 4, pp. 593-609. https://doi.org/10.1108/IJQSS-12-2017-0117
Graves, L.M., Sarkis, J. and Gold, N. (2019) 'Employee pro-environmental behaviour in Russia: The roles of top management commitment, managerial leadership, and employee motives', *Resource, Conservation and Recycling*, vol. 140, pp. 54-64. https://doi.org/10.1108/IJM-07-2019-0347
John, A., Qadeer, F., Shahzadi, G. and Jia, F. (2019) 'Getting paid to be good: How and when employees respond to corporate social responsibility?', *Journal of Cleaner production*, vol. 215, pp. 784-795. https://doi.org/10.1016/j.jclepro.2019.01.074
Kim, JJ., Eom, T. K., Kim, S.W. and Youn, M.K. (2015) 'Effects of ethical management on job satisfaction and turnover in the South Korean service industry', *International Journal of Industrial Distribution and Business*, vol. 6, no. 1, pp. 17-26. https://doi.org/10.13106/ijidb.2015.vol6.no1.17
Kim, J., Song, H.J. and Lee, Ch.K. (2016) 'Effects of corporate social responsibility and internal marketing on organizational commitment and turnover intentions', *International Journal of hospitality Management*, vol. 55, pp. 25-32. https://doi.org/10.1016/j.ijhm.2016.02.007
Kim, H.L., Rhou, Y., Uysal, M. and Kwon, N. (2017) 'An examination of the links between corporate social responsibility (CSR) and its internal consequences', *International Journal of Hospitality Management*, vol. 61, pp. 26-34. https://doi.org/10.1016/j.ijhm.2016.10.011
Kvasničková Stanislavská, L., Kvasnička, R. and Pániková, V. (2019) 'The social responsibility of universities in the Czech Republic: Comparison of the situation in 2011 and 2018', In *Proceedings from the 16th International Conference on Efficiency and Responsibility in Education (ERIE 2019)*, Prague, Czech University of Life Sciences, pp. 154-160.
Ministry of Education, Youth and Sport (2019) *Přehled vyskokých* škol *v ČR* [Overview of schools of higher education in the CZ], MEYS, [Online], Available: http://www.msmt.cz/vzdelavani/vysoke-skolstvi/prehled-vysokych-skol-v-cr-3 [20 Sep 2019].
Smetáčková, I. (2019) 'Gender gap in burnout syndrome among Czech teachers', In *Proceedings from the 16th International Conference on Efficiency and Responsibility in Education (ERIE 2019)*, Prague, Czech University of Life Sciences, pp. 258-266.
Youn, H., Lee, K. and Lee, S. (2018) 'Effects of corporate social responsibility on employees in the casino industry', *Tourism Management*, vol. 68, pp. 328-335. https://doi.org/10.1016/j.tourman.2018.03.018
Zhang, Q.O.B.L. and Lim, B.T.H. (2019) 'Drivers, motivations, and barriers to the implementation of corporate social responsibility practices by construction enterprises: A review', *Journal of Cleaner Production*, vol. 210, pp. 563-584. https://doi.org/10.1016/j.jclepro.2018.11.050

THEORETICAL ACCOUNTING COURSES STUDENTS´ SUCCESS RATE AT FEM CULS PRAGUE APPRAISAL

[1]✉Jakub Ječmínek, [2]Ivana Kuchařová, [2]Daniela Pfeiferová

[1]Department of Trade and Accounting, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, jecminek.k@gmail.com

[2]Department of Trade and Accounting, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

This paper focuses on the exams success rate of students of different grades, disciplines and forms of study in accounting subjects at FEM CULS Prague in the period 2014/2015-2018/2019. A partial objective is to determine an optimal number of places needed for the exam terms announced in a semester for students of accounting courses. The data were drawn from the FEM CULS information system. The results have shown that there is a statistically significant difference in the success rate of the examinations among students of different grades, disciplines and forms of study who passed the exam on the first, second or third attempt. The number of places required for the exams terms was determined based on the exams results in the previous periods. The results show that the need of the exams places for examination period reaches 1.85 multiple of number of students enrolled for the given subjects.

Keywords

Accounting, appraisal, exam, student, university

Introduction

Changes in accounting and tax laws increase the demands for learning accounting and its application in practice. Graduates should be able to use the accounting and tax contexts and be skilled in decision-making. Johnson (2014) study the impact of the university education on accountants' career and identify the graduates with a difference between the skills gained from university studies of accounting and the skills applied in practice. According to Lodha, Sheikh and Soral (2019), the ability of accountants to effectively and continuously face new challenges and adapt their services to changing conditions and situations is directly connected with the reliability and quality of their university education.

Prince (2004) indicates that choices of teaching style, dominated by the activities focused on students (self-study), may be effective in some subjects while not in the others. According to Concannon, Flynn and Campbell (2005), students of accounting at the beginning of 21st century preferred traditional methods and ways of learning at universities (lectures and tutorials) over the possibility to study the materials independently online. However, many students belonging to Millennials (born from 1982 to 2005) have a strongly negative opinion of classic lectures and of using PowerPoint. They believe that presenting online video lectures and other materials would be effective only for students in the learning process (Phillips and Trainor, 2014). On the other hand, seminars are still of great importance in providing a meaningful personal contact in case they support interesting interactions among students and students and teachers (Arvanitakis, 2014).

In the research by Taplin, Kerr and Brown (2017), the students state that only one quarter of the sources available for education should be transformed into online materials and require

personal teacher's approach. According to Hutaibat (2019), one of the possibilities how to make the accounting lessons attractive at universities is to create an interactive project in an advanced accounting course.

For teaching accounting subjects at the Faculty of Economics and Management (FEM), Czech University of Life Sciences Prague (CULS), a personal interaction is used, and students have at disposal printed as well as online resources. The analysis of the students' requirements at the IFRS Accounting subject (at FEM CULS) shows that students express a desire for the lessons to be more practical (Stárová et al., 2018). The forms of education may influence the students' success in the accounting subjects. The exams results evaluation of the accounting subjects at FEM CULS within 2014-2017 reveals the results deteriorate (Kuchařová, Pfeiferová and Prášilová, 2018). This research includes suggestions for improving the students' knowledge in accounting. Some other authors at FEM CULS also deal with exams results of students in different subjects. Kukalová et al. (2019) or Ječmínek et al. (2018) report appraisal of the exams results in tax subjects. Rydval and Brožová (2017) present impacts of self-test improvements in Applied Mathematics for Informatics in the session 2015/2016 at Czech University of Life Sciences Prague. Kučera, Svatošová and Pelikán (2015) assessed the relation between the entrance exams results in Mathematics and the exams results of two subjects taught during the first year of the bachelor study.

The evaluation of the exams success rate of students is one of the goals of this research. The study verifies whether there is a statistically significant difference in the exams results in the accounting subjects among students of different disciplines and of different forms of study. The main objective is to determine the total number of places to be available to students in the given subjects in the exam period. With regard to interconnections of the accounting and tax subjects, our results are compared to the results of a similar study concerning subjects focused on taxes.

Materials and Methods

The first part of the article is focused on the evaluation of success rate among students in the Accounting Theory exams for disciplines Economics and Management, Business and Administration, further in the Accounting exams for discipline Informatics, and in the Essentials of Accounting exams for disciplines Public Administration and Rural Development, in both, the full-time and combined, form of study. These subjects have the same content and are taught using the same teaching methods. The method of students' knowledge testing at final examination is also the same. From the reasons given, the exams results are comparable. The data are drawn from the FEM CULS Prague information system for academic years 2014/2015–2018/2019 ($T=5$). Five disciplines ($I=5$) are available for each period ($I=5$), 25 observations in total (panel data). The complete data file is included in the Table 1.

Following the methodology of Ječmínek et al. (2018) and Kukalová et al. (2019), we perform a similar analysis using different dataset. The same methodology is used mainly for comparison reasons.

Year	Subject Code	Number of students	First		Second		Third		Failed	
			abs	rel. (%)	abs	rel. (%)	abs	rel. (%)	abs	rel. (%)
2014/2015	EUE21E	418	249	59.57	57	13.64	39	9.33	73	17.46
2015/2016	EUE21E	312	263	84.29	24	7.69	6	1.92	19	6.09
2016/2017	EUE21E	305	188	61.64	55	18.03	18	5.90	44	14.43
2017/2018	EUE21E	290	109	37.59	36	12.41	21	7.24	124	42.76
2018/2019	EUE21E	287	108	37.63	40	13.94	22	7.67	117	40.77
2014/2015	EUE33E	249	110	44.18	34	13.65	18	7.23	87	34.94
2015/2016	EUE33E	218	84	38.53	31	14.22	11	5.05	92	42.20
2016/2017	EUE33E	247	96	38.87	37	14.98	20	8.10	94	38.06
2017/2018	EUE33E	214	65	30.37	26	12.15	14	6.54	109	50.93
2018/2019	EUE33E	223	76	34.08	29	13.00	10	4.48	108	48.43
2014/2015	EUE34E	28	13	46.43	3	10.71	1	3.57	11	39.29
2015/2016	EUE34E	35	13	37.14	5	14.29	3	8.57	14	40.00
2016/2017	EUE34E	18	1	5.56	2	11.11	4	22.22	11	61.11
2017/2018	EUE34E	18	6	33.33	2	11.11	3	16.67	7	38.89
2018/2019	EUE34E	23	8	34.78	6	26.09	2	8.70	7	30.43
2014/2015	EUEJ1E	40	14	35.00	7	17.50	1	2.50	18	45.00
2015/2016	EUEJ1E	49	12	24.49	7	14.29	0	0.00	30	61.22
2016/2017	EUEJ1E	28	10	35.71	6	21.43	3	10.71	9	32.14
2017/2018	EUEJ1E	25	7	28.00	8	32.00	2	8.00	8	32.00
2018/2019	EUEJ1E	47	20	42.55	5	10.64	0	0.00	22	46.81
2014/2015	EUEH1E	51	20	39.22	4	7.84	0	0.00	27	52.94
2015/2016	EUEH1E	46	21	45.65	7	15.22	0	0.00	18	39.13
2016/2017	EUEH1E	43	17	39.53	7	16.28	6	13.95	13	30.23
2017/2018	EUEH1E	32	16	50.00	7	21.88	0	0.00	9	28.13
2018/2019	EUEH1E	30	13	43.33	3	10.00	0	0.00	14	46.67

Table 1: Number and success rate of students in the exams (source: CULS)

Preliminary tests

In order to use parametric ANOVA as Ječmínek et al. (2018), standard assumptions such as normal distribution and homogeneity of variances must be met. To make sure the data follow normal distribution, we used Shapiro-Wilk's test, which is believed to have stronger power than Kolmogorov-Smirnov test for instance. If the data are independently distributed according to normal distribution and Levene's test also verifies homogeneity of variances, then we use standard parametric ANOVA. However, if the assumptions are violated then we proceed to Kruskal-Wallis one-way ANOVA.

One-way Analysis of Variance (ANOVA)

One of the research goals is to verify the hypothesis that there is no statistically significant difference in the success rate of the examinations among students of different courses. The analysis results are mainly essential for:

- preparation of the studying support materials (lecture notes, presentations and others),
- adapting the education to needs of students with a different history of education,
- planning the exam terms,
- choice of a structure and setting self-tests, credit tests and exams tests,
- choice of minimum borders for grading the credit tests and examination tests.

Four statistical hypotheses have been set to achieve the above-mentioned goal:

- $H_0$1: There is no statistically significant difference in the exams success rate among students of different grades, disciplines and forms of study who passed the exam on the first attempt.
- $H_0$2: There is no statistically significant difference in the exams success rate among students of different grades, disciplines and forms of study who passed the exam on the second attempt.
- $H_0$3: There is no statistically significant difference in the exams success rate among students of different grades, disciplines and forms of study who passed the exam on the third attempt.
- $H_0$4: There is no statistically significant difference in the exams success rate among students of different grades, disciplines and forms of study who failed the exam.

Model for number of places for the exam terms

For planning and announcing the places for exam terms is essential to take into account not only the capacities of the educators, but also the history of students' success. A linear regression model was chosen to calculate the appropriate number of the examination places. Based on the historical success rate, the model allows to estimate the students' success rate in the given subjects. On the basis of panel data, four models of simple linear regression have been constructed and defined as:

$$y_1 = \beta_1 x_1 + \mu\,, \tag{1}$$

$$y_2 = \beta_2 x_1 + \mu\,, \tag{2}$$

$$y_3 = \beta_3 x_1 + \mu\,, \tag{3}$$

$$y_4 = \beta_4 x_1 + \mu\,, \tag{4}$$

where y_1 represents the number of the students who passed the exam on the first attempt, y_2 represents the number of the students who passed on the second attempt, y_3 is the number of the students who passed the exam on the third attempt, y_4 represents the number of the students who failed the exam, x_1 is the total number of the students who had the subject enrolled, and μ is a random element of the model. Via a common method of the smallest variances, the model is estimated and lately verified. Based on the estimated coefficients β, the number of places required for the exam terms can be estimated according to the following relation:

$$z_1 = \beta_1 x + 2\beta_2 x + 3\beta_3 x + 3\beta_4 x\,. \tag{5}$$

Results

The data were first tested for normality using Shapiro-Wilk's test. The results of normality testing are summarized in the Table 2. All four null hypotheses are rejected at 5% significance level and thus we conclude that our data are not normally distributed.

	W	*p*-value
first	0.74436	<0.001
second	0.80917	<0.001
third	0.79942	<0.001
failed	0.7804	<0.001

Table 2: Shapiro-Wilk's test of normality (source: own calculation, R statistics)

Since all parametric tests assume normal distribution, we proceed to non-parametric analysis of variance based on Kruskal-Wallis test (Table 3).

	chi-squared	*df*	*p*-value
first	20.656	4	<0.001
second	19.865	4	<0.001
third	18.932	4	<0.001
failed	17.434	4	<0.002

Table 3: Kruskal-Wallis one-way ANOVA (source: own calculation, R statistics)

Defined statistical hypotheses ($H_0$1–$H_0$4) were tested using Kruskal-Wallis test. For testing the statistical hypotheses, a *p*-value was used which is presented together with the other results in the Table 3. With regard to the fact that all *p*-values are lower than 0.05, we reject all four null hypotheses at 5% significance level, and thus there are statistically significant differences in success rate of exams among students of different grades, disciplines and forms of study.

Model results of number of places for exam terms

Model parameters of number of places for the exam terms of the accounting subjects have been estimated via a common method of the smallest variances. Linear regression results are summarized in Table 4.

	coeff	std.error	*t* value	*p*-value	*F*-statistic (*p*-value)
first	0.506	0.0333942	15.16	<0.001	<0.001
second	0.134	0.0055981	23.89	<0.001	<0.001
third	0.066	0.0049795	13.24	<0.001	<0.001
failed	0.294	0.0306170	9.603	<0.001	<0.001

Table 4: Results of linear regression (source: own calculation)

From the results (Table 4), it is apparent that 50.6% of students will successfully pass the exam on the first attempt, 13.4% of students will pass on the second attempt, 6.6% of students will pass on the third attempt and 29.4% of students will fail the exam. All parameters are statistically significant at 1% significance level. The fact that all models are statistically significant at 5% significance level speaks for a suitably applied model.

The model was applied to success rate simulation for the summer semester in the academic year 2019/2020. 593 students were enrolled in the accounting subjects in the summer semester. According to the estimated parameters (Table 4) and the methodology defined in equation (5), we can simulate future success rate, based on the historical data, resulting in determination of a required number of the places for the exam terms. From the total number of 593 students, 300 students will pass the exam on the first attempt, 80 students will pass on the second attempt, 39 students will pass on the third attempt and 174 students will fail the exam. If comparable success rate is considered with the previous five years, the required number of places for the exam period is 1 099, according to the model. The number of places required for the exam terms in the summer semester reaches 1.85 multiple of the number of the students who have enrolled in the accounting subjects in both, full-time and combined, forms of study.

Discussion

Successful completion of the accounting subjects is necessary for successful completion of studies in different disciplines at FEM CULS Prague. The performed analyses results show that there is a statistically significant difference in the success rate among students of different disciplines and forms of study in the exams of accounting subjects. Kuchařová, Pfeiferová and Prášilová (2018) deal with analysis of success

rate of students in accounting subjects on the basis of systematic preparation during semester. Results of their statistical analyses do not show the same results in the subject Essentials of Accounting. Better results show students of Public Administration and Rural Development discipline though in the course of preparation, they have rather worse results.

Knowledge of accounting is logically and systematically connected with contents of education in the subjects Tax System and Tax System and Administration for given fields of study. Success rate of students of different disciplines in the subjects dealing with taxes were evaluated by Ječmínek et al. (2018). Their results show that there is no statistically significant difference in exam success rate among students of full-time and combined forms of study. The students shall apply the knowledge of tax and accounting principles in the follow-up study of the Local Finance and Municipality Management subject. Appraisal of the exam success rate of students within this subject was also performed. On account of the analysis, it was found that there was no statistically significant difference in the exams success rate in this subject among students who studied in full-time or combined form of study. The results presented for the subjects Tax System and Tax System and Administration (Ječmínek et al., 2018), and Local Finance and Municipality Management (Kukalová et al., 2019), do not correspond to the results of the current research for the accounting subjects since there was found a statistically significant difference in success rate in the exams among students of different disciplines and forms of study. This fact can be explained, for example, by a lower number of practical seminars within the combined form of study.

On the basis of constructed model, the number of places on exam terms for students of analysed accounting subjects was set to 1.85 multiple of number of the students enrolled in these subjects. This number does not correspond to the multiple of number of places set for the tax subjects; here the number of places on the exam terms was set to 1.42 multiple of number of students (Ječmínek et al., 2018). The results of the model for the subject Local Finance and Municipality Management show that it needs to be opened 623 places in total on the exam terms. That is 1.58 multiple of the students who were enrolled in this subject in full-time and combined form of study.

Conclusion

One of the research objectives was to verify whether there is a statistically significant difference in examination results in the subjects dealing with theoretical essentials of accounting in different fields of study at FEM CULS Prague. Data were taken from the FEM CULS University Information System for the academic years 2014/2015–2018/2019. Basic input information used for the statistical analysis contains: the total number of the students in the subjects Accounting, Accounting Theory and Essentials of Accounting in the given academic year, the number of students who passed the exam on the first, on the second and on the third attempt, and also the number of the students who failed the exam. The results of this output are important also for setting an optimal number of places required for the exam terms of the mentioned subjects. The analyses results showed there is a statistically significant difference in exams success rate among students in the accounting subjects (Accounting, Accounting Theory and Essentials of Accounting) of different disciplines and forms of study. Null hypotheses $H_0 1$, $H_0 2$, $H_0 3$ and $H_0 4$ are rejected at 5% significance level.

The main output was to determine a number of places needed to be opened on the exam terms in the accounting subjects Accounting, Accounting Theory, and Essentials of Accounting) for the summer semester in the academic year 2019/2020. In the summer semester, 593 students were enrolled in the accounting subjects. Through the models based on the panel data, the estimates of success rate of students who passed the exam on the first, second or third attempt, or who failed the exam, were created. On the basis of the estimated parameters and defined methodology, the authors determined the future success rate of students and the consequent number of places needed for the exam period. According to the used model, the number of places needed for the future exam period was set to value 1 099. Thus, the number of places reaches 1.85 multiple of the students who are enrolled in the

accounting subjects in full-time as well as in combined form of study. Interval of reliability for the determined places in the course of exams is 99%.

A secondary output of the data analysis is finding that 29.4% of the students in the accounting exams will fail. A future research shall be aimed at estimation of the failure rate causes. The presented results are part of the wider research aimed at success rate of students in the exams of accounting and tax subjects. Further research is aimed at subjects in the field of finance since finance overlaps in some aspects with accounting and taxes.

References

Arvanitakis, J. (2014) 'Massification and the large lecture: From panic to excitement', *Higher Education*, vol. 67, no. 6, pp. 735-745. https://doi.org/10.1007/s10734-013-9676-y

Concannon, F., Flynn, A., and Campbell, M. (2005) 'What campus-based students think about the quality and benefits of e-learning', *British Journal of Educational Technology*, vol. 36, no. 5, pp. 501-512. https://doi.org/10.1111/j.1467-8535.2005.00482.x

Hutaibat, K. (2019) 'Incorporating practical sustainability and managerial and financial reporting in accounting education', *Journal of International Education in Business*, vol. 12, no. 2, pp. 181-197. https://doi.org/10.1108/JIEB-10-2018-0047

Ječmínek, J., Kukalová, G., Moravec, L. and Bína Filipová, D. (2018) 'Tax Courses Exams Results at FEM CULS Prague Evaluation', *Proceedings of the 15th International Conference on Efficiency and Responsibility in Education (ERIE 2018)*, Prague, pp. 132-139.

Johnson, R. (2014) 'Accounting practitioners reflect on faculty impact: Bridging the gap between theory and practice', *American Journal of Business Education*, vol. 7, no. 2, pp. 109-114. https://doi.org/10.19030/ajbe.v7i2.8469

Kučera, P., Svatošová, L. and Pelikán, M. (2015) 'University Study Results as Related to the Admission Exam Results', *Proceedings of the 12th International Conference on Efficiency and Responsibility in Education*, Prague, pp. 318-324.

Kuchařová, I., Pfeiferová, D. and Prášilová, M. (2018) 'Results Analysis of the Exam in Accounting Theory', *Proceedings of the 15th International Conference on Efficiency and Responsibility in Education (ERIE 2018)*, Prague, pp. 171-179.

Kukalová, G., Ječmínek, J., Moravec, L. and Bína Filipová, D. (2019) 'Municipal Finance Education Results at FEM CULS Prague Appraisal', *Proceedings of the 16th International Conference on Efficiency and Responsibility in Education (ERIE 2019)*, Prague, pp. 146-153.

Lodha, S., Sheikh, A. A. and Soral, G. (2019) 'The Perceived Gap between Academicians and PG Students about Accounting Education System in India: A Case Study', *Pacific Business Review International*, vol. 11, no. 11, pp. 22-36.

Phillips, C.R. and Trainor, J.E. (2014) 'Millennial students and the flipped classroom', *Journal of Business & Educational Leadership*, vol. 5, no. 1, pp. 102-112.

Prince, M. (2004) 'Does active learning work? A review of the research', *Journal of Engineering Education*, vol. 93, no. 3, pp. 223-231. https://doi.org/10.1002/j.2168-9830.2004.tb00809.x

Rydval, J. and Brožová, H. (2017) 'Analysis of Self-Test Improvement for Increasing the Quality of Education Process' *Proceedings of the 14th International Conference on Efficiency and Responsibility in Education (ERIE 2017)*, Prague, pp. 347-354.

Stárová, M., Navrátilová, M., Lörinczová, E. and Beranová, M. (2018) 'Teaching of International Accounting Standards IFRS at the University Level', *Proceedings of the 15th International Conference on Efficiency and Responsibility in Education (ERIE 2018)*, Prague, pp. 366-372.

Taplin, R., Kerr, R. and Brown, A. (2017) 'Monetary valuations of university course delivery: the case for face-to-face learning activities in accounting education', *Accounting Education*, vol. 26, no. 2, pp. 144-165. https://doi.org/10.1080/09639284.2016.1274913

ENTRANCE EXAMINATIONS MOCK

Jindřich Klůfa

Department of Mathematics, University of Economics, Prague, Czech Republic, klufa@vse.cz

Abstract

From 2019, students can be admitted to Faculty of Informatics and Statistics at University of Economics in Prague on the basis of excellent results in entrance examinations mock (i.e. entrance examinations that take place before the regular entrance examinations under the same rules). University study results of these students in mathematics will be compared with other students which were accepted to study by different way. For this comparison we shall use some methods of mathematical statistics. Results of this paper can be used for improvement of the admission process at the Faculty of Informatics and Statistics at University of Economics in coming years.

Keywords

Course Mathematics for informatics, entrance exams mock, methods of mathematical statistics, University of Economics, Prague

Introduction

The admission process at the Faculty of Informatics and Statistics at University of Economics in the 2019/2020 academic year was changed. Applicants can be accepted to study of this faculty also on the basis of excellent results in entrance examinations mock (denoted EEM). All ways of acceptance students at the Faculty of Informatics and Statistics are as follows:

- On the base of tests in mathematics and English, which are used at University of Economics in Prague (VSE tests)
- On the base of excellent results in entrance examinations mock (EEM)
- On the base of the national comparative exams - the tests of general academic prerequisites (SCIO tests)
- On the base of excellent results in mathematics and English at grammar school (GrSch)
- Without entrance examinations (Other).

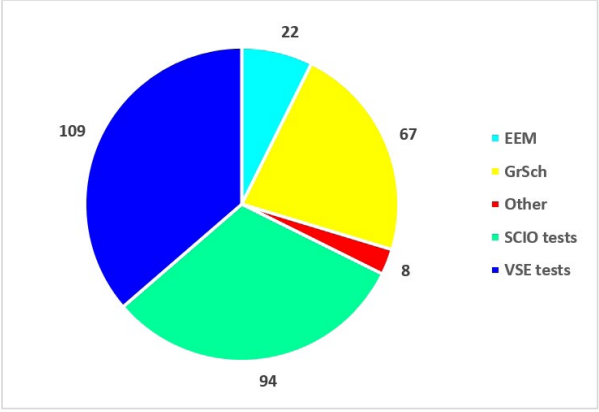


Figure 1: Number of students admitted - course Mathematics for informatics, winter semester of the 2019/2020 academic year (own construction)

Exams in mathematics include mid-term test, final test and oral examination. These tests are standard tests, the multiple choice question tests (see e.g. Klůfa (2015b), Klůfa (2016)) are not used. The number of points in the mid-term test can be in interval [0,20], the number of points in the final test can be in interval [0,40] (Otavová and Sýkorová, 2014) and the number of points in the oral examination can be in interval [0,40], i.e. total number of points in mathematics can be in interval [0, 100]. The result of examinations is in Table 1.

Grade		Points
Excellent	= 1	90 - 100
Very good	= 2	75 - 89
Good	= 3	60 - 74
Failed, eligible for retake	= 4+	50 - 59
Failed	= 4	0 - 49

Table 1: Grade (own construction)

The relations between the study results in mathematics and the ways of acceptance applicants are analysed in present paper. Similar problem is studied in Kubanová and Linda (2012), Linda and Kubanová (2013) at University Pardubice, Poláčková and Svatošová (2013), Kučera, Svatošová and Pelikán (2015) at Czech University of Life Sciences, Otavová and Sýkorová (2017) at University of Economics. The aim of this paper is to study dependence of the results of examinations in mathematics at university on the ways of acceptance students. Analogous problems are studied in Sulphey et al. (2018), Svatošová and Pelikán (2017), Kaspříková (2012), Flégl et al. (2014), Klůfa (2015c), Bartoška, Brožová, Šubrt and Rydval (2013), Hrubý (2016), Kaspříková (2013), Murshid (2013), Ječmínek, Kukalová, Moravec and Filipová (2018), Klůfa (2015a), Zvára and Anděl (2001), Ağazade et al. (2014). Results of this paper can be used for improvement of the admission process at the Faculty of Informatics and Statistics at University of Economics in coming years.

Material and Methods

The analysed data are the results in mathematics of 300 students in winter semester of the 2019/2020 academic year in the course Mathematics for informatics (ident 4MM106). These data are sorted according to ways of acceptance in contingency table – see Table 2.
For study dependence of the results of examinations on the ways of acceptance students we shall use χ^2 test of independence in contingency table. Statistic χ^2 is (see e.g. Anděl (1978))

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{s}\frac{(n_{ij} - n_{ij}^o)^2}{n_{ij}^o}, \tag{1}$$

where r is number of rows, s is the number of columns in contingency table and n_{ij}^o is the expected frequency in case of independence. When

$$\chi^2 > \chi_\alpha^2((r-1)(s-1)), \tag{2}$$

where $\chi_\alpha^2((r-1)(s-1))$ is critical value of χ^2 distribution, hypothesis of independence is rejected at significance level, which is asymptotically equal to α.
The power (intensity) of dependence we can find using Cramer coefficient of contingency

$$C = \sqrt{\frac{\chi^2}{n(m-1)}} \tag{3}$$

where $n = 300$ and $m = \min(r,s)$. Values of Cramer coefficient of contingency are in interval [0,1], in case of independence is C=0.

For comparison of the ways of acceptance students we shall use ANOVA and Scheffé's method. We shall verify the validity of the null hypothesis: mean number of points in final test in mathematics is the same for all ways of acceptance students. When (the test statistic F see e.g. Rao (1973))

$$F > F_\alpha(s-1, n-s)$$

where $F_\alpha(s-1, n-s)$ is critical value of Fischer-Snedecor distribution with $(s-1)$ and $(n-s)$ degrees of freedom (n=300, s=5 (number of ways of acceptance students)), hypothesis is rejected at significance level α.

Results and Discussion

Results of the examinations in mathematics are in Table 2 (for example 22 students accepted on the base of excellent results in mathematics and English at grammar school obtained grade "excellent" = 1, i.e. 22 is frequency n_{31} in 3rd row and 1st column of the contingency table).

Ways of acceptance students	Grade				Sum
	1	2	3	4 and 4+	
VSE tests	13	18	39	39	109
SCIO tests	13	23	24	34	94
GrSch	22	24	14	7	67
EEM	3	7	7	5	22
Other	4	2	1	1	8
Sum	55	74	85	86	300

Table 2: Distribution of the grades in course 4MM106 - contingency table (own construction)

Now we shall test null hypothesis:

Ho: the results of exams (grades) is not dependent on the ways of acceptance students.

For the decision on the validity of the hypothesis we shall use χ^2 test of independence in contingency table. In the first step we calculate according to (1) value of statistic χ^2 We have

$$\chi^2 = 39.6$$

Critical value of χ^2 distribution for 12 degrees of freedom and significance level $\alpha = 0.01$ is $\chi^2_{0.01}(12) = 26.2$. Since

$$\chi^2 = 39.6 > 26.2,$$

null hypothesis H_o is rejected at approximately 1% significance level. We can say that the results of exams (grades) depend on the ways of acceptance students. This dependence is weak (Cramer coefficient of contingency is C = 0.21).

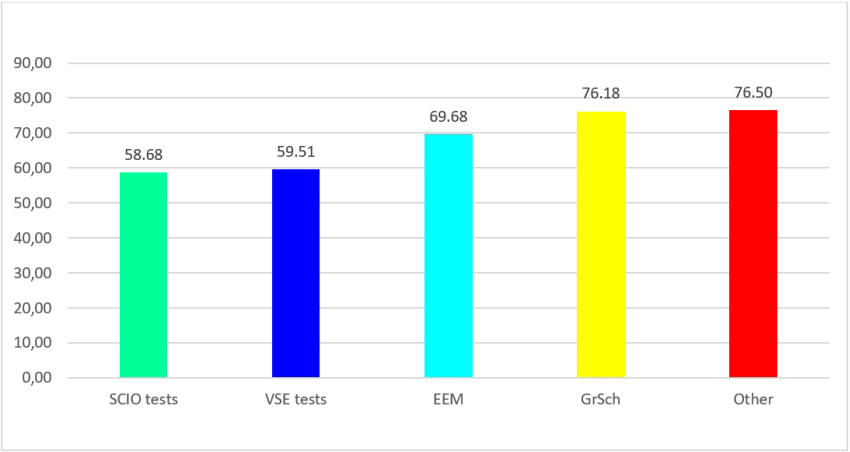


Figure 2: Average number of total points in math in course 4MM106, winter semester of the 2019/2020 academic year (own construction)

Ways of acceptance	Frequency n_i	Average number of points	Variance
SCIO tests	94	58.6808511	734.6927477
VSE tests	109	59.5137615	586.9743459
EEM	22	69.6818182	182.7034632
GrSch	67	76.1791045	404.6037992
Other	8	76.5000000	468.5714286

Table 3: Basic descriptive statistics for total number of points in math (own calculation)

For a detailed analysis we shall further study the total number of points in mathematics. From Figure 2 it seems that the results in math of students which were accepted to study on the basis of excellent results in entrance examinations mock (EEM) are better than students who were admitted to study on the basis of SCIO tests and VSE tests. For objective decision we shall test null hypothesis

H_o: mean number of total points in math is the same for all ways of acceptance students

To verify the validity of the hypothesis we use ANOVA. Results of ANOVA we got with MS Excel (e.g. Marek (2013)) – see Tab. 4.

Source of variability	Sum of squares	Degrees of freedom	Fraction	*F*	*p* value	*F* crit
Ways of acceptance	16742.7083	4	4185.67708	7.459059	0.0000098	2.402248
Residual	165540.2784	295	61.153486			
Sum	182282.9867	299				

Table 4: Results of ANOVA (own calculation)

Since

$$F = 7.459 > 2.402$$

null hypothesis is rejected at 5% significance level (also is rejected at 0.001% significance level – see P value). The differences between average number of total points in math in Table 3 are statistically significant. There are significant differences between ways of acceptance students to study Faculty of Informatics and Statistics.

Finally we shall study which pairs of averages differ significantly. We use Scheffé's method – see e.g. Anděl (1978). Pairs of averages differ significantly if absolute value of difference in averages exceeds critical value (see Tab. 3 and Tab. 4)

$$\sqrt{\left(\frac{1}{n_i}+\frac{1}{n_j}\right)\cdot 4\cdot 61.153486\cdot 2.402248}$$

Ways of acceptance	VSE	EEM	GrSch	Other
SCIO	0.83	11.00*	17.50*	17.82*
VSE		10.17*	16.67*	16.99*
EEM			6.50*	6.82
GrSch				0.32

** Significant difference for α=0.05*

Table 5: Absolute value of the differences between average number of total points in mathematics (own calculation)

From Table 5 it is seen that a significant difference at 5% significant level is not only between VSE and SCIO, GrSch and Other, EEM and Other. All other pairs of averages are significantly different.

Remark. The analysis of variance assume that variances are equal across groups, i.e. differences between variances in last column of Table 3 are not statistical significant. The Bartlett's test can be used to verify that assumption. In our case Bartlett's statistic B (see e.g. Anděl (1978)) is B=16.2. Critical value of χ^2 distribution for 4 degrees of freedom and significance level 0.01 is 13.3. Since B>13.3, the assumption of ANOVA is not met. Therefore, instead of ANOVA and Scheffé's method, we also used the corresponding nonparametric Kruskal-Wallis test and Nemenyi's test. The results of these tests confirmed the previous conclusions (only Nemenyi's test did not confirm a statistically significant difference between EEM and GrSch).

Analogous problem as was studied in this article is analysed in some scientific papers. In Kubanová and Linda (2012) we can find relation between university study results and SCIO tests at University Pardubice. The authors of this paper recommend using their own admissions procedure instead of SCIO tests. This conclusion is consistent with the results of this paper – see Figure 2. Relation between university study results and admission exam results at Czech University of Life Science is also studied in Kučera, Svatošová and Pelikán (2015). Using the regression and correlation analysis, the dependence of the university study results on admission process is shown. The same problem at the Faculty of Medicine of Juntendo University was analysed in He et al. (2015). From obtained results follows: There were significant correlations between the English test scores for the entrance examination and academic performance in many subjects. On the other hand, there were non-significant correlations between the mathematics test scores for the entrance examination and academic performance in many other subjects. The aim of these papers is a little different. Data from four faculties were used in Otavová and Sýkorová (2017) for comparison ways of acceptance students at University of Economics. Obtained results are similar as in present paper but without entrance exams mock (EEM).

Conclusion

From chi-square test of independence in contingency table follows that the results of exams in mathematics at university depend on the ways of acceptance students. From detailed analysis we can say that the results in math of students which were accepted to study on the basis of excellent results in entrance examinations mock (EEM) are better than the results in math of students which were admitted to study on the basis of SCIO tests and VSE tests – see Figure 2. Best results of

exams in mathematics at university have students which were accepted to study on the basis of excellent results in mathematics and English at grammar school (GrSch) and other way. It seems reasonable to accept students at University of Economics on the basis of excellent results in entrance examinations mock.

Acknowledgement

The paper was processed with contribution of long term support of scientific work on Faculty of Informatics and Statistics, University of Economics, Prague (IP 400040).

References

Ağazade, A.S., Caner, H., Hasipoğlu, H.N. and Civelek, A.H. (2014) 'Turkish University Entrance Test and Academic Achievement in Undergraduate Programs: A Criterion-related Validity Study', *Procedia -Social and Behavioral Sciences,* vol. 116, pp. 4582 – 4590. https://doi.org/10.1016/j.sbspro.2014.01.990

Anděl, J. (1978) *Matematická statistika.* Praha: SNTL/ALFA.

Bartoška, J., Brožová, H., Šubrt, T. and Rydval, J. (2013) 'Incorporating practitioners' expectations to project management teaching', *Proceedings of the 10th International Conference on Efficiency and Responsibility in Education (ERIE 2013)*, Prague, pp. 16–23.

Flégl, M. et al. (2014) 'Comparison of Research Engagement of PhD Students at Various Study Programs at CULS Prague: An Introductory Study', *Journal on Efficiency and Responsibility in Education and Science*, vol. 7, no. 3-4, pp. 66-73, https://doi.org/10.7160/eriesj.2014.070304

He, S., Kempe, K., Tomiki, Y., Nishizuka, M., Suzuki, T., Dambara, T. and Okada, T. (2015) 'Correlations between Entrance Examination Scores and Academic Performance Following Admission', *Juntendo Medical Journal,* pp. 1-7. https://doi.org/10.14789/jmj.61.142

Hrubý, M. (2016) 'Feedback improvement of question objects', *International Journal of Continuing Engineering Education and Lifelong Learning,* vol. 26, no. 2, pp. 183–195. https://doi.org/10.1504/IJCEELL.2016.076010

Ječmínek, J., Kukalová, G., Moravec, L and Filipová. D.B. (2018) 'Tax courses exams results at FEM CULS Prague evaluation', *Proceedings of the 15th International Conference on Efficiency and Responsibility in Education (ERIE 2018)*, Prague, pp. 132–139.

Kaspříková, N. (2012) 'Data analysis of students' performance', *Proceedings of the 9th International Conference on Efficiency and Responsibility in Education (ERIE 2012),* Prague, pp. 213–218.

Kaspříková, N. (2013) 'Evaluation of the tests within the latent variable models framework', *Proceedings of the 10th International Conference on Efficiency and Responsibility in Education (ERIE 2013)*, Prague, pp. 264–269.

Klůfa, J. (2015a) 'Dependence of the Results of Entrance Examinations on Test Variants', *Procedia - Social and Behavioural Sciences*, vol. 174, pp. 3565–3571. http://dx.doi.org/10.1016/j.sbspro.2015.01.1073

Klůfa, J. (2015b) 'Analysis of entrance examinations', *Proceedings of the 12th International Conference on Efficiency and Responsibility in Education (ERIE 2015)*, Prague, pp. 250–256.

Klůfa, J. (2015c) 'Comparison of the ways of acceptance students at university', *Journal on Efficiency and Responsibility in Education and Science,* vol. 8, no. 3, pp.72-76. http://dx.doi.org/10.7160/eriesj.2015.080204

Klůfa, J. (2016) 'Analysis of the differences between results of test variants', *Proceedings of the 13th International Conference on Efficiency and Responsibility in Education, (ERIE 2016)*, Prague, pp. 279–285.

Kubanová, J. and Linda, B. (2012) 'Relation between results of the learning potential tests and study results', *Journal on Efficiency and Responsibility in Education and Science,* vol. 5, no 3, pp.125-134. http://dx.doi.org/10.7160/eriesj.2012.050302
Kučera, P., Svatošová, L. and Pelikán, M. (2015) 'University study results as related to the admission exam results', *Proceedings of the 12th International Conference on Efficiency and Responsibility in Education (ERIE 2015)*, Prague, pp. 318–324.
Linda, B. and Kubanová, J. (2013) 'Relation between results of the entrance examination test in mathematics and examination in mathematics at the university', *Proceedings of the 10th International Conference on Efficiency and Responsibility in Education (ERIE 2013)*, Prague, pp. 370–373.
Marek, L. (2013) *Statistika v příkladech,* Prague: Professional Publishing.
Murshid, K.R. (2013), 'The predictive value of individual admission criteria on academic performance in a Saudi medical college', *Journal of Taibah University Medical Sciences*, vol. 8, no. 1, pp. 18 – 23. https://doi.org/10.1016/j.jtumed.2013.01.005
Otavová, M. and Sýkorová, I. (2014) 'Analysis of Scores from Mid-Term and Final Test by a Contingency Table', *Proceedings of the 11th International Conference on Efficiency and Responsibility in Education (ERIE 2014)*, Prague, pp. 527–533.
Otavová, M. and Sýkorová, I. (2017) 'The differences in results among students admitted in different ways', *Proceedings of the 14th International Conference on Efficiency and Responsibility in Education (EIRE 2017)*, Prague, pp. 295–302.
Poláčková, J. and Svatošová, L. (2013) 'Analysis of success in university study as connected to admission exam results', *Proceedings of the 10th International Conference on Efficiency and Responsibility in Education (ERIE 2013)*, Prague, pp. 503–509.
Rao, C.R. (1973) *Linear Statistical Inference and Its Applications,* New York: John Wiley
Sulphey, M.M, AlKahtani, N.S. and Abdul Malik Syed, A.M. (2018) 'Relationship between admission grades and academic achievement', *Entrepreneurship and Sustainability Issues,* vol. 5, no. 3, pp. 648-658. http://doi.org/10.9770/jesi.2018.5.3(17)
Svatošová, L. and Pelikán, M. (2017) 'Success of study regarding the admission procedure outcomes: case of the FEM CULS Prague', *Proceedings of the 14th International Conference on Efficiency and Responsibility in Education (ERIE 2017)*, Prague, pp. 408–416.
Zvára, K. and Anděl, J. (2001) 'Souvislost výsledku přijímacího řízení s úspěšností studia na MFF', *Pokroky matematiky, fyziky a astronomie*, vol. 46, no. 6, pp. 304-312.

INCREASING STUDENT READING COMPREHENSION USING EYE-TRACKING DATA ANALYSIS

[1]✉Michal Kohútek, [2]Milan Turčáni

[1] Faculty of Natural Sciences, Constantine the Philosopher University in Nitra, Slovakia, michal.kohutek@ukf.sk

[2] Faculty of Natural Sciences, Constantine the Philosopher University in Nitra, Slovakia

Abstract

An improvement of existing e-learning courses, both in terms of structure and content, is not a trivial task to achieve. In order to step in the right direction, we've decided to utilise the insight found in current research and continuous analysis of the way students internalize the knowledge provided through e-courses. To identify the shortcomings of current e-courses, authors have used Eye-Tracking to pinpoint areas, where students have difficulty understanding text and internalizing the knowledge contained therein. Utilising the Eye-Tracking data, it is possible to create heat-maps to visualise the gaze of the students, to identify and modify problematic parts of the course lectures and subsequently adjust them according to the acquired data and current didactic, pedagogical and psychological theories. The impact of these innovations on the effectiveness of e-learning courses will be verified by testing the newly-gained knowledge and monitoring activity of students participating in the established research groups.

Keywords

Constructivism, e-courses, e-learning, Eye-Tracking, Heat-maps, LMS Moodle

Introduction

Using e-learning courses not only in distance, but also in combined (blended) form of learning is a well-established area of research. The implementation and integration of some e-learning system is nowadays a trivial matter in all, but the least developed areas of the world. Due to this low bar to entry, its effective usage is not a question of technology, but rather didactics. E-learning is based on a number of thought streams and ideologies. Looking at the structure of e-learning systems and the tools they provide to the users, the inspiration of B.F. Skinner is an obvious one. Skinner's theory is based on the behaviourist laws of learning, especially Thorndike's laws of practice and effect. The essence of its characteristics can be distilled into these 5 principles:

- principle of small steps,
- principle of active response,
- principle of immediate consolidation,
- principle of subjective pace,
- principle of performance evaluation.

All of these principles are largely fulfilled by e-learning or m-learning, modified branch with a focus on on-the-go learning. It is a logical evolution of classical e-learning, taking advantage in technical advances and widespread use of mobile devices, which allows students to learn in various environments and even while commuting, without being chained to a classroom, or even a fixed desk. E-learning and M-learning do differ not only in their technical implementations, but also in the way their user interface and course material are construed. In e-learning one can assume, the student is comfortably sitting at the desk, in front of a large screen and using computer mouse for navigation and interaction with the course. For this reason, the e-courses can be more

complex, consist of a combination of graphics and text and take longer to complete. Conversely, in case of M-learning such assertions are invalid and the course creators must take into account that the lecture will be consumed on the go, using a device with constrained screen real-estate and thus must be shorter, simpler to understand and the course matter must be confined to a more defined context (Pauline Chitra and Antoney Raj, 2018).

The ideological basis of e-learning is also perceptible in theory of constructivism. It is an approach to learning that is based on the idea, that cognitive processes of learning are the result of a so-called "mental construction". Students create, or rather build up knowledge by linking new information with the knowledge they already possess. The process of learning is influenced and based on the context in which new insights are acquired, as well as the attitudes and opinions the student holds. If what students think they know is inconsistent with new observations, students will refine their knowledge to incorporate new information into a meaningful overall picture. Therefore, students are constantly active during the education process, applying new experiences, taking note of relevant details and assessing the consistency of old and new observations, consolidating and adjusting their views accordingly (Gupta, 2017).

The research we have decided to carry out is an attempt to address one of the key issues of improving the structure and content of existing e-learning courses. The principles and methods necessary to answer this question are being explored by psychologists, didactic researchers and online marketers. As the continuous improvement of the e-course structure and content is a complex process taking several steps, the related literature can also be divided into several categories. The first category from which we drew knowledge is didactics, in which the work of Erich Petlák, especially his teaching principles, proved to be a valuable source of information. Petlák (2005) posits that the teaching principles are the most general or basic requirements that determine its character in accordance with the aims of the learning process and its basic principles. Those principles are that the educational process should be appropriate and systemic. Among these principles, Petlák includes principles of illustration and proportionality, which are exceptionally applicable to learning using the e-learning technology. E-courses can contain lectures, where phenomena can be illustrated and explained to the student using multimedia and the courses themselves have the potential to be dynamically adapted to be appropriate to the student's bio-psychological abilities. When creating teaching materials, Petlák advices that important parts be visually highlighted, students to be continually tested and educators should apply different methods of differentiated teaching (Petlák, 2005).

For the insight into educational psychology we have reached for the work of Richard Mayer. Mayer has published a number of articled dealing with various aspect of multimedia use in teaching and has presented a number of widely accepted hypotheses and views. The basic premise of a large fraction of his work is that students achieve a deeper understanding of the subject matter when they receive information from a combination of words and pictures, than they would achieve from verbal interpretation alone. This is widely referred to as the "Cognitive Theory of Multimedia Learning". Under the term multimedia, Mayer understands a way of transferring information by combining verbal (spoken or printed) and visual (images, animations, illustrations, photos and video) information flows. This general definition includes a variety of cases, such as multimedia encyclopaedia, online textbooks, educational computer games, etc. (Colvin Clark and Mayer, 2016; Mayer, 2014, 2017).

Apart from the textual content and the usage of multimedia, proper typographical properties of the text also play a large part in text comprehension. The influence of properties such as font, line spacing, word spacing, etc. was researched by Kuzu Demir and Ceylan (2010). In their paper, they define font as a word encompassing all the properties of a text, such as a character of a font, its style and size. They assert, that serif-type fonts are better readable than sans-serif and discourage

from combining the use of sans-serif and serif fonts in texts of the same category. Proper word, letter and line spacing are also an important factor for readability. If the spaces between the words are too large, reader may have a problem in linking the related words. Conversely, if the spaces are too small, the readability suffers due to the words visually blending together. Following these theoretical considerations and establishing the general conditions for the preparation of the appropriate teaching text used in the e-course, we have decided to select the appropriate technology for exploring the stated research goal.

The main aim of the paper is to describe the methodology of the suggested procedure utilising Eye-Tracking technology in order to identify and localize areas of text that are harder for students to understand and learn from. The issue students' lack of reading comprehension is best studied when we look directly at the reading process itself and the cognitive functions that enable it. As we describe in the next chapter, Materials and Methods, Eye-Tracking is a viable method of studying reading process. In this chapter we also describe our apparatus and the experiment we've designed for use in our further research. The chapter Results and Discussion illustrates the finalized method we will continue using during our research and the various implementation details that may affect the collected data and visualisations fit for different purposes and research goals. In the last chapter, Discussion, we review our method and compare it with others in literature.

Materials and Methods

Eye-Tracking is a very useful tool in examining how students access learning materials. Tsianos et al. (2009) have used it in a study to separate learners into two categories – verbalisers and visualisers. They have used metrics such as fixation lengths and concentrations to create a map of transitions where the difference between the subjects belonging to either groups were visible to the naked eye. Verbaliser fixations are concentrated mainly on the text of the lesson, while visualisers' gaze often jump around from text to illustrations and back. Such transition maps can be very helpful in personalisation of e-learning courses based on the category a given student belong to.

Magdin and Turčáni (2015) have also looked into dividing students into categories according to their learning strategies. They have used the categorisation by Felder and Silverman to divide students into groups of active and reflective learners. Among other things, they have shown that correctly classifying students is a non-trivial task, as students' learning strategies may change over the course of the e-course.

Methods of capturing eye movement are a well described topic. The very first devices required a direct physical contact with the subject's eyes, making it nearly impossible to use this method in a versatile manner. Current Eye-Tracking devices are implemented in a non-invasive way, based on the mathematical algorithms to determine the position of the subject's pupil in real-time video feed. This has allowed Eye-Tracking to become one of the widely-adopted technologies, allowing to monitor the attention of the user, to examine the movements of his eyes while reading text or focusing on an object. Modern implementations (whether placed above the computer screen or mounted on the user's head) allow users to perform monitored activities without disturbing their concentration or significantly restricting their movement. Some progress has also been made in the field of emotion recognition through observation of movement patterns and changes in pupil sizes. This offers some advantages in simplifying emotion recognition as opposed to the „sensory wristband" approach described by Francisti and Balogh (2019)

The movement of subject's gaze in time can be mapped and subsequently visualised by generating heat-maps, in which the gaze concentration is represented on a blue-red colour gradient. By compositing a given heat-map over the mapped region of interest we can gain a graphical representation, helping the course creators to understand how students consume the provided study materials.

Currently there several categories of Eye-Tracking devices on the market, divided based on the price of the solution and the implementation. Ehinger et al. (2019) have compared multiple parameters of Eye-Tracking devices Pupil Labs and significantly more expensive EyeLink 1000. In terms of calibration, both devices were comparable, however Pupil Labs device was faster to lose calibration. The precision of the gaze capture, EyeLink 1000 proved to be much superior, especially in tasks in which micro-saccades were being measured. Pupil Labs is also inadequate in detecting blinking of the eye. Considering the significant price difference, however, Pupil Labs device is far from being disqualified from the usage in our experiments, though it is necessary to take larger tolerances into account when interpreting the results. A great advantage of Pupil Labs is the included software that provides many useful features. One of the key functions used in the design of our experiment is the creation of monitored zones by delimiting those using black and white tracking markers (Figure 1) generated by running a program included in the Pupil Labs software package and the subsequent semi-automated creation of heat-maps from the collected data. Pupil Capture can recognize 64 different markers, using a combination of at least four different markers to automate the creation of separate zones.
Complete source code of the included software is freely available online, licensed under GNU GPL.

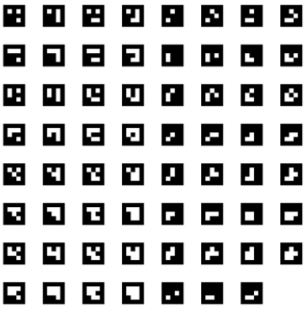


Figure 1: Tracking markers

license and with very well maintained documentation website. Inter-process communication is provided by ZeroMQ framework, which allows a simple creation of additional programs, which can, for example, aggregate data generated by the Pupil Capture software, control the headset using pre-defined commands, etc. This extensibility has allowed us to collect a large amount of data, such as the changes of pupil size, detected blinking, movements of eyes relative to the head of the user, etc.
The problem we deal with in our research is the observed trend of superficial reading of learning material by students. However, it is necessary to determine whether their lack of mastery of the subject matter is due to their lack of interest, superficial approach, or lack of understanding of the text provided in form of e-courses. In such a case, it is necessary to modify the e-course texts so that the modified lessons contain only syntactically correct sentences, with a simple structure and adequate density of new information. For the purpose of our experiment, we decided to select the related subjects Logic Systems and Computer Architecture, given the specific characteristics of the subjects.

Results and Discussion

In our pilot research, we have chosen an excerpt from the Computer Architecture e-course and requested a group of 25 first-year undergraduate students who were willing to undertake an

experiment researching reading comprehension. These students were tasked to read through the selected chapter from the existing course, which was minimally altered to allow for effective Eye-Tracking. The chapter has been divided into four parts so that each part would fit on the screen in its entirety. We've marked these parts with unique combinations of tracking markers. The average time spent on reading the chapter was 5-10 minutes, staying within the calibration limit of the Pupil headset.

Each participant was instructed to avoid significant movements of his or her head, which could result in loss of tracking. Then we've asked them to put on the headset and we've adjusted the positions of Eye-Tracking cameras. After that we have calibrated the device using a set of targets appearing on the screen. During the recording session, the student was left to read the chapter alone and without any significant distractions. Not all sessions were successful, however we were able to generate heat-maps from 20 out of 25 Eye-Tracking recordings. After generating the first heat-map, we have concluded, that the default setting of the heat-map generating plug-in creates representations with very low granularity and is more suited for research in usability of user interfaces rather than the process of reading a text (Figure 2).

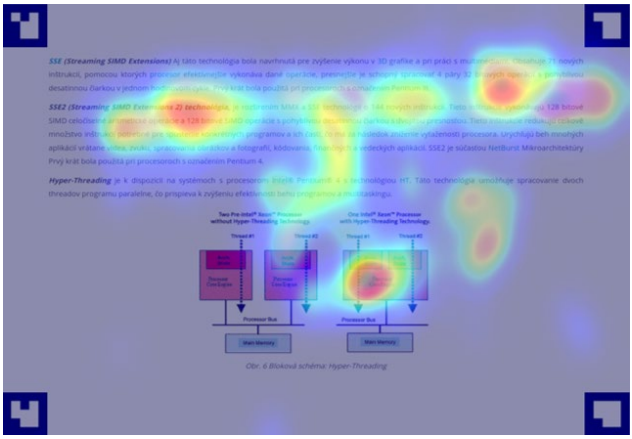


Figure 2: Heat-map with insufficient granularity

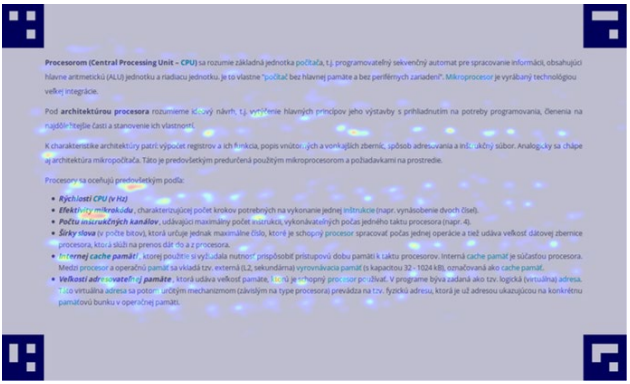


Figure 3: Composite heat-map with fine granularity

By fine-tuning the parameters of the heat-map generator we were able to create a visualisation which allows us to identify gaze fixations on words and even syllables. We have merged these heatmaps using GIMP graphics editor into a composite heat-map and filtered out one-off fixations with minimal intensity represented by blue and green colour (Figure 3). By this process we've gained a composite map with clusters of distinct fixation points around specific words and phrases. Such representation can tell us which areas of text or words required the student's greatest concentration.

We then distinguished the words surrounded by clusters of fixations from the rest of the text by saturating the colour to create a so-called "word cloud" (Figure 4). Based on the dialogue with the students, we can then distinguish which words or phrases the students fixated on because they did not yet know them or came to them inadequately explained. In the event that words that do not fall into the above categories are included in the visualization, they can be removed very easily based on questionnaires and interviews with students.

Using the experience and insight gained from this pilot experiment, we are designing and conducting a follow-up experiment planned for this semester, modifying a part of the Computer Architecture course as recommended in the works mentioned in this article. By random selection from the students of the Department of Informatics, we will create two groups – an experimental and a control group. While the experimental group will go through the course using materials continuously modified to meet the principles of effective e-learning courses, the control group will complete the course using existing e-courses. Both groups will be evaluated on an ongoing basis and at the end of the semester we will evaluate their mastery of the subject by written and oral examination. The experiment will also include feedback from students through questionnaires and controlled interviews.

Based on our experience gained conducting this experiment, we have been able to review and improve our procedure of gathering Eye-Tracking data. We have found that in order to obtain data usable to create telling visualisations, it is advisable to adhere to these rules:

- Maintaining similar recording conditions – record using the same display, during similar time of date or ensure similar light in the room.
- Ensuring short recording durations – Head-mounted Eye-Tracking devices suffer from losing tracking precision with time. After ~10 minutes the tracking deviation is reaching the limit of usability
- Divide the text into single-frame parts – Solving the issues stemming from the variable scrolling behaviour of various users creates needless complexity in analysing the Eye-Tracking data. When possible, split the text into separate parts that will be fully shown on selected computer display.

We are confident that by complying with these observations and generating highly granular heatmaps, we will be able to combine the usage of different data gathering techniques, such as questionnaires, interviews, web data mining with Eye-Tracking in order to pinpoint the sections of e-courses, that prove to be difficult to be understood by our students and improve the readability of our study materials.

Our proposed usage of Eye-Tracking technology is in part inspired by similar uses by other educational researchers. Ozcelik et al. (2009) have described a method of using Eye-Tracking to investigate the effects of color coding on learning, especially using the same colors in parts of an illustration and the corresponding parts of text.

Figure 4: Word cloud

Eric Jamet (2014) has used Eye-Tracking as a method of exploring whether visual cueing effects help decreasing the amount of time spent fixating on less relevant areas of the interface, comparing the amount and duration of fixations on the content panel as opposed to the progress bar and the blank areas of the screen.

Mason et al. (2013) were researching the difference in cognitive processing of concrete and abstract illustrations. For this, they were looking at look-back fixation times spent on the text and illustration, in addition to other fixations metrics. Authors note, that the limitation of eye-fixation data is, that they are not self-explanatory and need to be interpreted to understand why a student looks at a particular part of a text or a figure for a certain amount of time.

For this reason, in our proposed method, we include further interaction with students - in the form of a questionnaire and a conversation to identify whether increased fixations were due to misunderstanding, memorization or due to the text syntax being hard to process.

Conclusion

From our experience using Eye-Tracking in our experiment, we can conclude that we are on the right track in our endeavour. Although direct adaptation or automated interaction with the student with regard to Eye-Tracking cannot be realistically realized in the conditions of daily use, as it requires students to access courses uniquely with computers equipped with Eye-Tracking devices, we can use the Eye-Tracking method in a similar way to assess the readability of learning materials and as a source of information needed to improve the quality of e-courses. In our work we have shown the methods of such use, the complications that need to be mitigated in the future and the applications that the data collected in this way may have in the field of continuous improvement of study materials. In our future research, we aim to use the knowledge gathered in this paper and extend the scope of our experiment to the whole e-learning course, including more students and comparing the study results, engagement and satisfaction of students learning using the unaltered course against the experimental group studying our new, reformed e-course. In this way, we will determine whether adhering to the rules of multimedia design and e-learning course creation does indeed result in more efficient and understandable study materials.

Acknowledgement

This paper was created with the financial support of the projects: 1. KEGA 036UKF-4/2019, Adaptation of the learning process using sensor networks and the Internet of Things.; 2. UGA VII/6/2020 Methods of gathering data on understanding of study materials by analyzing pupil movement of students.

References

Colvin C.R., and Mayer, R. (2016). *e-Learning and the Science of Instruction: Fourth Edition,* Hoboken: Wiley

Francisti, J., & Balogh, Z. (2019). 'Identification of Emotional States and Their Potential', In S. K. Bhatia, S. Tiwari, K. K. Mishra & M. C. Trivedi (Eds.), *Advances in Computer Communication and Computational Sciences*, Ic4s 2018 (Vol. 924, pp. 687-696).

Gupta, P. (2017) 'Constructivism: A new paradigm in teaching and learning', *International Journal of Academic Research and Development*, vol. 2, pp. 183–183.

Kuzu D.E., and Ceylan, B. (2010) 'Typographic properties of online learning environments for adults', *Procedia - Social and Behavioral Sciences*, vol. 9, pp. 879–883. https://doi.org/10.1016/j.sbspro.2010.12.253

Mayer, R.E. (2014) 'Introduction to Multimedia Learning', in Mayer, R.E. (ed.) *The Cambridge Handbook of Multimedia Learning*, 2nd ed., Cambridge: Cambridge University Press (Cambridge Handbooks in Psychology), pp. 1–24. https://doi.org/10.1017/CBO9781139547369.002

Mayer, R. (2017) 'Using multimedia for e-learning: Multimedia for e-learning', *Journal of Computer Assisted Learning*, vol. 33, pp. 403-423. https://doi.org/10.1111/jcal.12197

Pauline Chitra, A. and Antoney Raj, M. (2018) 'E-Learning', *Journal of Applied and Advanced Research*, vol. 3, pp. 11-13. https://doi.org/10.21839/jaar.2018.v3iS1.158

Petlák, E. (2005). *Kapitoly zo súčasnej didaktiky*. Bratislava: Iris.

Tsianos, N., Germanakos, P., Lekkas, Z., Mourlas, C. and Samaras, G. (2009) 'Eye-Tracking Users' Behavior in Relation to Cognitive Style within an E-learning Environment', *Proceedings - 2009 9th IEEE International Conference on Advanced Learning Technologies, ICALT 2009*, Riga, pp. 329–333. https://doi.org/10.1109/ICALT.2009.110

Magdin, M. and Turčáni, M., (2015) 'Personalization of student in course management systems on the basis using method of data mining', *Turkish Online Journal of Educational Technology,* vol. 14, pp. 58-67.

Ehinger, BV., Gross, K., Ibs, I. and König, P. (2019) 'A new comprehensive Eye-Tracking Test Battery concurrently evaluating the Pupil Labs Glasses and the EyeLink 1000', *PeerJ - the Journal of Life and Environmental Sciences*, vol. 7, p.e7086. https://doi.org/10.1101/536243

Ozcelik, E., Karakus, T., Kursun, E. and Cagiltay, K. (2009) 'An eye-tracking study of how color coding affects multimedia learning', *Computers & Education,* vol. 53, pp. 445-453. https://doi.org/10.1016/j.compedu.2009.03.002

Mason, L., Pluchino, P., Tornatora M.C., and Ariasi N. (2013) 'An Eye-Tracking Study of Learning From Science Text With Concrete and Abstract Illustrations', *The Journal of Experimental Education,* vol. 81, pp. 356-384. https://doi.org/10.1080/00220973.2012.727885

Jamet, E. (2014) 'An eye-tracking study of cueing effects in multimedia learning', *Computers in Human Behavior,* vol. 32, pp. 47-53. https://doi.org/10.1016/j.chb.2013.11.013

QUALITY OF SIBLINGS' RELATIONSHIP AND THEIR IMPACT ON ACADEMIC SELF-EFFICACY

[1]✉Kristýna Krejčová, [2]Hana Chýlová

[1]Department of Psychology, Faculty of Arts, Charles University, Czech Republic, kris.krejcova@gmail.com

[2]Department of Psychology, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

Educational processes are planted into a social context that significantly determines their efficiency. Apart from the immediate social environment in which formal learning takes place, a family is one of the most crucial elements that substantially affect not only the early development but the whole educational trajectory of an individual. The research mostly deals with the role of parents. However, also the siblings can influence educational success via the academic self-efficacy that may be affected by rivalry and mutual comparison. By the population of university students, we proved connections between specific dimensions of siblings' relationship and respondents' self-efficacy perceived in comparison with a sibling. The findings are applicable in counselling for university students, but they also draw attention to the importance of siblings' relationships and their impact on education.

Keywords

Academic self-efficacy, family, social determinants of education, siblings' relationship

Introduction

Learning is a long-life process that begins long before an entrance to an educational system. In the manner of speaking, learning begins during the intrauterine development (Vágnerová, 2000; Langmeier and Krejčířová, 2006) and intensively develops after birth, in interaction with both internal and external environment (Sternberg and Williams, 2010). Standing at the starting point of socialization processes, parents are crucial elements of early learning. Moreover, they strongly affect later, formal education at school and may be even more influential than teachers (Fischer and Lipovská, 2013; Lipovská and Fischer, 2016).

Inter alia, the family influences the education outcomes of an individual via the academic self-efficacy. The self-efficacy is a classical concept by Bandura (1994) representing an individual's opinion about his/her capacities to manage various challenges. It has internal as well as external sources including family influences. 'Different family structures, as reflected in family size, birth order, and sibling constellation patterns, create different social comparisons for judging one's personal efficacy' (Bandura, 1994: 11). The connection of the family with self-efficacy was acknowledged also by current studies (Lönnfjord and Hagquist, 2020). Unsurprisingly, the self-efficacy of a student plays an important role in educational processes (Alhadabi and Karpinski, 2020). Pajares (1996) described the academic self-efficacy, the application of the self-efficacy concept in the area of education.

Studying a family context of education, it is essential to realize that family is a system and we cannot understand its behaviour without involving siblings (McHale, Updegraff and Whiteman, 2012). Even the fact that a child has no siblings is significant and may bring some specifics in his/her style of learning, considering for example differences in a structure of free time activities (Dunifon, Fomby and Musick, 2017). Although siblings may not seem as influential as parents,

their connection is intensive and unique. 'The sibling relationship is not intrinsically positive or negative, but it is dynamic and critical bond' (Kyrkou, 2018: 75).

Davies (2019) explains that a sibling may influence an educational trajectory of an individual in many dimensions, even if their relationship is not perceived as positive. Attending the same school, firstborn children shape a reputation that influences an expectation of teachers towards their siblings. Through social learning by observation, younger children form their imagination about their future education considering their siblings' experiences.

The sibling's impact on an individual's images of school and education as well as the academic self-efficacy is amplified by a parental tendency to compare siblings and treat them differently Jensen and McHale (2015). Baier (2019) studied if a level of parent's education influence siblings and twins' similarity in cognitive abilities. The author confirmed the hypothesis about the higher cognitive similarity between siblings of less-educated parents who cannot afford the stratified approach to their children, so they invest all their effort to support the less talented child. On the contrary, the more educated parents with more resources manage to compensate their less capable child as well as support the development of the more talented one.

Regardless of the education level of parents, the pure fact of having a sibling influences the cognitive abilities of an individual. McAlister and Peterson (2013) proved that children with siblings develop more quickly a theory of mind – an understanding of other people's mental processes, namely their true or false belief, imagination and memory. These metacognitive skills enable them to predict other's people behaviour, which children with a sibling need to overplay them in competitive games. This advantage is obvious by later-born children. Paine et al. (2018) studied if also firstborn children take advantage of their siblings in metacognitive development. They found that the fact of having younger siblings facilitate respondents' ability to understand second-order false belief (a person may have mistaken belief about another person's belief), but only when the age distance between siblings is two and more years.

In our previous research (Krejčová, Chýlová and Michálek, 2019), we studied relations between siblings' constellation (gender, sibling's gender, birth order, and age-distance) and academic self-efficacy. We found a relatively higher level of academic self-efficacy by females and respondents with a brother, as well as by older siblings and respondents with a longer age-distance between them and their siblings. In the current study, we research a connection of academic self-efficacy and specific characteristics of sibling's relationships defined by the scales of Sibling Relationship Questionnaire (Furman and Buhrmester, 1985).

The aim of the research is to determine if the general characteristics of sibling relationship influence the academic self-efficacy of respondents in their subjective comparison with their siblings. We suppose a certain level of bidirectionality and research its consequences in young adulthood, similarly as Baier (2019), assuming that this population is suitable for researching of the long-term impact of social background. Hereby, it is important to realize that siblings' relations have their dynamics and changes even in this age (Jensen, Whiteman and Fingerman, 2018), so we affect only certain stage of their development.

Results are supposed to be applicable in university counselling services, namely for a more complex view on students' educational difficulties in connection with their social environment. The next field of application is educational counselling for parents of younger children, with the intention to observe and to support cultivation of siblings' relationships not only for the well-being of the whole family but also as a factor of an individual's educational achievement.

Materials and Methods

Our researched sample recruited from a population of students of the Czech University of Life sciences. We had 264 respondents, however, 32 were only children and could not be involved in

the data analysis. The sample of respondents with a sibling involved 232 respondents (134 females and 96 males; 2 respondents did not specify their gender) in the age between 18 and 29 years (the mean age was 20,2 years). We had 155 respondents with 1 sibling; 51 with 2 siblings; 17 with 3 siblings and 6 with 4 or more siblings (3 respondents did not specify the number of siblings). 101 respondents had a female sibling, 124 had a male sibling. 82 respondents had siblings of age distance up to 3 years, 82 respondents had siblings between 4 and 6 years of age distance. By the remaining 68 respondents, siblings were 7 and more years far from them.

To study connections between siblings' relationship and academic self-efficacy, we used two questionnaires. The academic self-efficacy was assessed by the questionnaire we constructed during our previous research (Krejčová, Chýlová and Michálek, 2019). A set of items asking for respondent's perceived school success, dispositions to learning, efficiency and ambitions; the participants responded to these questions on a three-stage scale, on the basis of relative comparison with their siblings. The siblings' relations were studied via Sibling Relationship Questionnaire (Furman and Buhrmester, 1985). The tool measures various characteristics of siblings' relations in 16 scales dealing with prosocial behaviour, parental partiality, dominance, similarity and intimacy, competition and other emotional dimensions like affection, antagonism, companionship, admiration, and quarrelling.

We set up the following hypotheses:

- H0-1: *The distribution of scales of siblings' relation is the same across the category of perceived school success.*
- H0-2: *The distribution of scales of siblings' relation is the same across the category of perceived efficacy in studying.*
- *H0-3: The distribution of scales of siblings' relation is the same across the category of perceived educational dispositions.*
- *H0-4: The distribution of scales of siblings' relation is the same across the category of perceived ambitions.*

The outputs were produced using data analysis software system IBM SPSS Statistics, version 25. Based on the outputs of the Kolmogorov-Smirnov test of normality, which proved that data do not come from a normal distribution, we decided to use a non-parametrical test Kruskal-Wallis analysis of variance in order to test the hypotheses.

Results

Our research revealed specific interaction of each measured dimension of academic self-efficacy with some scales of siblings' relation. We split the hypotheses into the sub-hypotheses according to observed variables (specific scales of the Sibling Relationship Questionnaire).

In terms of statistical significance, we found considerable specifics in the relation between the perceived school success and siblings' relationship (for a level of significance of all detected differences from expected distributions, see Tab. 1). Students with lower perceived school success feel more nurtured by their siblings (H0-1a). Respondents with a higher level of perceived success dominate more to their sibling (H0-1b). As expected, respondents with a higher level of similarity with a sibling perceived their level of school success more often as comparable (H0-1c). Further, we detected a significantly higher level of admiration of siblings by students with lower relative school success (in comparison with students who feel more successful than their sibling) (H0-1d).

Regarding the perceived energy needed to study something new (H0-2), we detected differences only by quarrelling – respondents who need less energy to study something new reported about more quarrelling than students who need similar amount as their sibling.

Unsurprisingly, students with comparable dispositions perceived also more similarity between

them and their sibling (namely in comparison with worse-disponed respondents) (H0-3a). We found also a highly significant difference between comparable and better-perceived dispositions regarding a level of admiration (H0-3b). Students with comparable educational dispositions referred about stronger admiration of siblings than respondents who feel better disponed than their siblings. The relation between comparably- and worse-disponed categories was similar but less significant.

According to our findings, respondents with comparable ambitions report more prosocial behaviour (cooperation, sharing, doing something nice for each other) (H0-4a). This category of respondents also referred to more nurturance by a sibling (H0-4b) and admiration by a sibling (H0-4c). On the other hand, we detected less parental partiality by respondents with similar ambitions in comparison with respondents with higher perceived ambitions (H0-4d). According to expectations, respondents with a higher level of ambitions admire their siblings less than respondents with similar ambitions (H0-4e).

	Observed variables	Result	Significance
H0-1a	school success/nurturance of sibling	Hypothesis was rejected	p=.043
H0-1b	school success/dominance by sibling	Hypothesis was rejected	p=.016
H0-1c	school success/similarity	Hypothesis was rejected	p=.023
H0-1d	school success/admiration of sibling	Hypothesis was rejected	p=.013
H0-2	efficiency/quarrelling	Hypothesis was rejected	p=.021
H0-3a	dispositions/similarity	Hypothesis was rejected	p=.032
H0-3b	dispositions/admiration of sibling	Hypothesis was rejected	p=.002
H0-4a	ambitions/prosocial	Hypothesis was rejected	p=.035
H0-4b	ambitions/nurturance by sibling	Hypothesis was rejected	p=.001
H0-4c	ambitions/ admiration by sibling	Hypothesis was rejected	p=.041
H0-4d	ambitions/parental partiality	Hypothesis was rejected	p=.003
H0-4e	ambitions/ admiration of sibling	Hypothesis was rejected	p=.013

Table 1: Siblings' relations and academic self-efficacy – summarization of main statistical outputs, 2020 (source: own calculation)

Discussion

In our research, we study the characteristics of siblings' relationships and their impact on educational self-view. Similarly as Davies (2019), we conclude that these relations influence the educational trajectory of an individual even if they are not positive. It is even an inherent characteristic of siblings' relationships that they are not clearly positive or negative from their nature (Kyrkou, 2018). Nevertheless, it is important to realize that the connection between siblings' interactions and their education is bidirectional, meaning that education trajectory of each sibling may influence their relationships as well.

Pike and Oliver (2017) also report the bidirectionality in their study of connections between the quality of siblings' relationship, prosocial behaviour, and conduct problems. Our findings could bring new, educational-related dimension into these relations, detecting more of prosocial behaviour, and cooperation by siblings with comparable ambitions; more quarrelling by respondents who need less energy to study something new than their sibling; more nurturing by sibling in case of less successful respondents and greater dominance of more successful sibling.

Despite the naturality of siblings' mutual personality differences (Hetler, 2017), we noticed also a considerable perceived similarity between respondents and their siblings. In some cases, the similarity leads to assessing some dimension of academic self-efficacy as comparable (namely perceived level of school success and educational dispositions). According to Baier (2019), a higher level of cognitive similarity can be detected by children of less-educated parents who

have restricted resources for cognitive stimulation and therefore invest only to the compensation of less talented child, not to the support of more talented one. However, the perceived similarity in education may be caused by the fact that both siblings in a family are similarly talented and that there was no need for their parents to stratify their approach.

Jensen and McHale (2015) proved that differences in school grades and academic interests between siblings are considerably influenced by the expectations of their parents. In this connection, we found more of parental partiality by respondents who assess themselves as more ambitious than their sibling. We may interpret this conclusion considering the findings of Bornstein, Putnick and Suwalsky (2018) who proved that the socioemotional reaction of mothers to their children differs even at the age of 20 months, according to their children's specifics. Thus, parents of more ambitious respondents of our research could support more the child that seemed more ambitious. On the other hand, higher ambition could be also created and escalated by higher parental investment into the child. We can also find a connection with less admire of a sibling by respondents with higher ambitions and we get a picture of the dynamics of a family system regarding children's ambitions.

Conclusively, it is important to realize that siblings albeit support an individual's cognitive development (McAlister and Peterson, 2013; Paine et al, 2018), however, they also play a crucial role in forming academic self-efficacy. This role may vary with the quality of the mutual relationship. In our research, students with a lower level of perceived school success refer to more nurturance by a sibling and admire them more; more successful students were more dominant to their siblings. Comparably disponed respondents admire their siblings more than better-disponed respondents. Therefore, besides studying the pure effect of siblings on cognitive development, we should also observe their role in forming an individual's self-assessment.

The main limit of our study consists of restricted external validity, dealing only with students Czech University of Life sciences. Although there is no reason to expect the results to be different by other university students, further research should reveal this presumption and extend the observation outside the population of university students. Moreover, we should enrich our data by school assessment that would help to objectivize the findings.

Apart from the slight gender incompatibility of the respondents, our sample is well-balanced regarding the gender of siblings as well as age-distance of siblings. However, we mapped only relation to one sibling even in bigger families, with the intention to collect our data in the same way, without an obligation to fulfil more questionnaires for respondents with more siblings. Following studies should research specific of relations in bigger families. Contextually, involving also the parents (or respondents' view of their parents) could bring us the insight into the whole family system.

The next issue of siblings' research is a biological relatedness. It is a question if to involve he half-related (or even no-related) siblings, because their relationships may have many specifics (Mostafa, Gambaro and Joshi, 2018). With the intention to observe the academic self-efficacy that is determined largely socially (Pajares, 1996), we decided to resign on the biological relatedness, in line with the strategy of Steelman (1985: 355) to 'include any living children present in the household, blood-related or not'. Moreover, our findings may be biased by an extreme age-distance between some siblings, namely in the case of very young siblings because of a very limited amount of information about their educational outcomes. However, these extreme age-distances are so rare in our sample that we do not expect their significant impact on our findings.

Conclusion

An impact of the family on the efficiency of education is considerable even by university students. Although their actual influence becomes mostly weaker, a way they supported (or suppressed) an

individual's potential still significantly affects their academic self-efficacy. The role of siblings is less researched, but not less important. The educational system (including counselling services) should reflect these influences in order to responsibly support the professional and personal growth of students. Our research proved that the quality of siblings' relationships influences academic self-efficacy and brings inspiration not only for more complex counselling of university students but also for studies of the impact of the siblings' relationship in earlier developmental stages on the educational trajectory of an individual.

Acknowledgement

The article was supported by the Charles University program Progres Q15 "Life course, lifestyle and quality of life from the perspective of individual adaptation and the relationship of the actors and institutions".

References

Alhadabi, A. and Karpinski., A.C. (2020) 'Grit, self-efficacy, achievement orientation goals, and academic performance in university students', *International Journal of Adolescence and Youth*, vol. 25, no. 1, pp. 519-535. https://doi.org/10.1080/02673843.2019.1679202

Baier, T. (2019) 'Does sibling and twin similarity in cognitive ability differ by parents' education?', *Zeitschrift für Familienforschung – Journal of Family Research*, vol. 31, no. 1, pp. 58-82. https://doi.org/10.3224/zff.v31i1.04

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory,* Englewood Cliffs, NJ: Prentice-Hall.

Bornstein, M.H., Putnick, D.L., and Suwalsky, J.T.D. (2018) 'Continuity, stability, and concordance of socioemotional functioning in mothers and their sibling children', *Social Development*, vol. 28, pp. 90-105. https://doi.org/10.1111/sode.12319

Davies, K. (2019) 'Sticky' proximities: Sibling relationships and education', *The Sociological Review*, vol. 67, no. 1, pp. 210–225. https://doi.org/10.1177/0038026118784832

Dunifon, R., Fomby, P., and Musick, K. (2017) 'Siblings and children's time use in the United States', *Demographic research*, vol. 37, pp. 1611-1624. https://doi.org/10.4054/DemRes.2017.37.49

Fischer, J. and Lipovská, H. (2013) 'Building human capital: the impact of parents´ initial educational level and lifelong learning on their children', *Journal of Efficiency and Responsibility in Education and Science*, vol. 6, no. 4, pp. 218-231. https://doi.org/10.7160/eriesj.2013.060402

Furman, W. and Buhrmester, D. (1985) 'Children's perceptions of the personal relationships in their social networks', *Developmental Psychology*, vol. 21, no. 6, pp. 1016–1024. https://doi.org/10.1037/0012-1649.21.6.1016

Hetler, S.C. (2017) 'Beyond birth order: The biological logic of personality variation among siblings', *Cogent Psychology*, vol. 4, no. 1, pp. 1-18. http://doi.org/10.1080/23311908.2017.1325570

Jensen, A.C. and McHale, S.M. (2015) 'What Makes Siblings Different? The Development of Sibling Differences in Academic Achievement and Interests', *Journal of Family Psychology*, vol. 29, no. 3, pp. 469–478. https://doi.org/10.1037/fam0000090

Jensen, A.C., Whiteman, S.D. and Fingerman, K.L. (2018) 'Can't live with or without them:" Transitions and young adults' perceptions of sibling relationships', *Journal of Family Psychology*, vol. 32, no. 3, pp. 385–395. https://doi.org/10.1037/fam0000361

Krejčová, K., Chýlová, H. and Michálek, P. (2019) 'A Role of Siblings in Perception of Academic Self-Efficacy and Social Support', *Journal on Efficiency and Responsibility in Education and Science*, vol. 12, no. 4, pp. 126-134. http://dx.doi.org/10.7160/eriesj.2019.120403
Kyrkou, N. (2018) 'Family Quality of Life and Nurturing the Sibling Relationship', *International Journal of Child, Youth and Family Studies*, vol. 9, no. 4, pp. 75–87. https://doi.org/10.18357/ijcyfs94201818641
Langmeier, J. and Krejčířová, D. (2006) *Vývojová psychologie*. Prague: Grada.
Lipovská, H. and Fischer, J. (2016) 'Gifted students and human capital accumulation', *Journal on Efficiency and Responsibility in Education and Science*, vol. 9, no. 3, pp. 60-69. https://doi.org/10.7160/eriesj.2016.090302
Lönnfjord, V. and Hagquist, C. (2020) 'The association of self-reported schoolwork pressure, family factors and self-efficacy with psychosomatic problems', *European Journal of Social Work.* https://doi.org/10.1080/13691457.2020.1722944
McAlister, A. and Peterson, C. (2013) 'Siblings, Theory of Mind, and Executive Functioning in Children Aged 3–6 Years; New Longitudinal Evidence', *Child Development*, vol. 84, no. 4, pp. 1442-1458. https://doi.org/10.1111/cdev.12043
McHale, S. M., Updegraff, K. A. and Whiteman, S. D. (2012) 'Sibling Relationships and Influences in Childhood and Adolescence', *Journal of Marriage and Family*, vol. 74, no. 5, pp. 913-930. https://doi.org/10.1111/j.1741-3737.2012.01011.x
Mostafa, T., Gambaro, L. and Joshi, H. (2018). 'The Impact of Complex Family Structure on Child Well-being: Evidence From Siblings', *Journal of Marriage and Family*, vol. 80, no. 4, pp. 902-918. https://doi.org/10.1111/jomf.12456
Paine, A. L., Pearce, H., van Goozen, S., de Sonneville, L., and Hay, D. F. (2018). 'Late, but not early, arriving younger siblings foster firstborns' understanding of second-order false belief', *Journal of Experimental Child Psychology*, vol. 166, pp. 251–265. https://doi.org/10.1016/j.jecp.2017.08.007
Pajares, F. (1996) 'Self-Efficacy Beliefs in Academic Settings', *Review of Educational Research*, vol. 66, no. 4, pp. 543-578. https://doi.org/10.3102/00346543066004543
Pike, A. and Oliver, B. R. (2017). 'Child behavior and sibling relationship quality: A cross-lagged analysis', *Journal of Family Psychology*, vol. 31, no. 2, pp. 250–255. https://doi.org/10.1037/fam0000248
Steelman, L. C. (1985) 'A Tale of Two Variables: A Review of the Intellectual Consequences of Sibship Size and Birth Order', *American Educational Research*, vol. 55, no. 3, pp. 353-386. https://doi.org/10.3102/00346543055003353
Sternberg, R. J. and Williams, W. M. (2010) *Educational Psychology*, New Jersey: Pearson.
Vágnerová, M. (2000) *Vývojová psychologie*, Prague: Portál.

UNT PETRI NETS THEORY APPLIED TO RICH-MEDIA RECORDINGS OF APPLE MOBILE DEVICES

Ivo Martiník

Department of Applied Informatics, Faculty of Economics, VSB-Technical University of Ostrava, Czech Republic, ivo.martinik@vsb.cz

Abstract

The "Everyone Can Code" worldwide program of Apple Inc. that was implemented also by VSB-Technical University of Ostrava is primarily focused on teaching programming technologies in the new Swift programming language with the support of the Swift Playgrounds development environment. It is the revolutionary graphical application implemented for the Apple iPad tablets which makes learning of the Swift programming language interactive and very fun. The main problem that had to be solved when deploying the Swift programming language learning process with the support of the Swift Playgrounds running on Apple iPad tablets was the need to record presentations with using of the rich-media technologies and publish them on-line and on-demand. Successful design and implementation of the parallel software environment that meets the requirements of comprehensive multimedia visualization of the educational process that is available on-line or on-demand required the use of the UNT (*Unique-Number Token*) Petri nets formal theory.

Keywords

Everyone Can Code, mobile technologies, UNT Petri nets, Swift Playgrounds, rich-media technologies

Introduction

The "Everyone Can Code" (ECC, 2020) worldwide program that was created and launched by Apple Inc. in 2017 is primarily focused on teaching the new Swift programming language with the support of the Swift Playgrounds (SWP, 2020) and Apple Xcode development environments. Swift Playgrounds is the new revolutionary graphical application implemented specifically for the Apple iPad tablets which makes learning of the Swift programming language interactive and very fun (see Fig. 1). Swift Playgrounds requires no knowledge of programming languages, programming paradigms, or coding, making it ideal for all students who are just starting out on this issue. The learning process begins with the interactive creation of the simplest algorithms and by gradually mastering the lessons in this environment one can learn even the basics of programming with using of augmented and mixed reality technologies. The Swift Playgrounds environment is also currently available for the MacOS operating system as the part of the Apple Xcode development environment, but it does not implement a number of interactive programming code options that are only available in the Apple iPad tablets. VSB-Technical University of Ostrava has been also actively participating in the "Everyone Can Code" worldwide program and has been teaching coding in the Swift programming language for the students of selected bachelor's study programs since 2018.

The Faculty of Economics VSB-Technical University of Ostrava has operated an authorized training center within the framework of Apple's worldwide Apple Authorised Training Centres for Education (AATCe, 2020) program since 2013. AATCe classroom equipment includes a wide range of mobile and also non-mobile technologies such as iMacs, iPads, iPhones, Macs Mini, Apple TV, AirPlay, FaceTime, etc., which have been successfully deployed in the teaching

process of bachelor, master and doctoral study programs. The AATCe training center with the current statuses of IT Focused AATCe and Media Focused AATCe has the university-wide scope and it aims to educate and train students and teachers in the areas of the MacOS operating system and multimedia technologies. Presentation recordings and "barrier-free" access to informations are the standard part of eLearning services at the universities in the Czech Republic (Hladká and Hrdlicka, 2005) and also in the world (Bos et al, 2016), (Dona et al, 2017). Recording of lectures and exercises with using of the rich-media (Mediasite, 2020), FaceTime and AirPlay technologies is therefore an integral part of the educational process in the AATCe training center (Martiník, 2018).

The main problem that had to be solved when deploying the learning process based on the Swift Playgrounds development environment was the need to record all the teacher and students presentations running made on the iPad tablets environment with using of the rich-media technologies and to publish them on-line and on-demand (the author of this article was not aware of any commonly available software solution to this problem at the time of its solving). It was then necessary to design and implement a single-purpose programming support based on Apple and Mediasite Recorder technologies determined for the generally distributed computing environment. The main purpose of this support is to ensure a high-quality learning process with using of mobile technologies and the ability to realize its audiovisual recording based on the rich-media technologies and available on-line or on-demand. Formal mathematical theory of Petri nets was chosen (Diaz, 2009) to design and implement a solution to this problem. The class of high-level UNT (*Unique-Number Token*) Petri nets based on the author's definition of the class of the SNT (*Single-Number Token*) Petri nets (Martiník, 2015) was introduced for these requirements. It has been significantly applied at the design, verification and implementation phases of the necessary hardware and software support preparation.

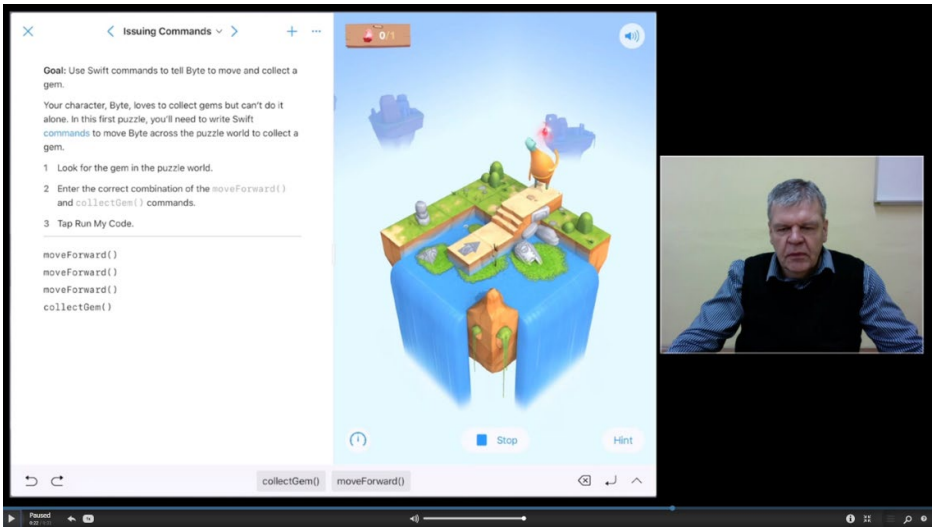


Figure 1: Rich-media recording of Swift Playgrounds application

Materials and Methods

UNT Petri nets and their static properties

Let $\boldsymbol{N}$ denotes the set of all natural numbers, $\boldsymbol{N}$:= {1, 2,…}, $\boldsymbol{Z}$ the set of all integer numbers, $\boldsymbol{Z}$:= {…, -1, 0, 1,…}, $\boldsymbol{Z}^-$ the set of all negative integer numbers, $\boldsymbol{Z}^-$:= {…, -3, -2, -1}, ∅ the empty set, $|A|$ the cardinality of the given set A, $\mathscr{P}(A)$ the class of all the subsets of the set A.
UNT Petri net (UNTPN) is the ordered 6-tuple $UNTPN := (P, T, A, AF, TP, M_0)$, where:

- P is finite non-empty set of the **places**;
- T is finite set of the **transitions** disjoint from P (i.e., $P \cap T = \emptyset$);
- A is finite set of the **arcs** (flow relation), $A \subseteq (P \times T) \cup (T \times P)$;
- AF is the **arc function**, AF: $((P \times T) \cup (T \times P)) \rightarrow \boldsymbol{Z}$, where:
  - $(AF(x, y) \neq 0) \Leftrightarrow ((x, y) \in A)$, $(AF(x, y) = 0) \Leftrightarrow ((x, y) \notin A)$;
  - $\forall t \in T\ \forall p \in t\bullet\ \forall q \in t\bullet$: $(p \neq q) \Rightarrow (AF(t, p) \neq AF(t, q))$;
  - $\forall t \in T\ \forall q \in t\bullet\ \exists p \in \bullet t$: $AF(p, t) = AF(t, q)$;
- TP is the **transition priority** function, TP: $T \rightarrow \boldsymbol{N}$;
- M_0 is the **initial marking**, M_0: $P \rightarrow \mathscr{P}(\boldsymbol{N})$, where:
  $\forall p \in P\ \forall q \in P$: $(p \neq q) \Rightarrow (M_0(p) \cap M_0(q) = \emptyset)$.

The system modeled by UNTPN is then described with the bipartite graph containing finite non-empty set P of the **places** represented by the circles and used for expressing of the conditions of the modeled system; finite set T of the **transitions** represented by the rectangles and describing changes in the system; finite set A of the oriented **arcs** that connect the given place with the transition or the given transition with the place and that are drawn as lines with the arrows; the **arc function** AF assigning each arc with the integer number expressing the kind of removed or added token from or to the place associated with that arc when firing a particular transition, such that the values of the arc function AF associated with each output arc of the given transition $t \in T$ must be different from each other (i.e., $\forall t \in T\ \forall p \in t\bullet\ \forall q \in t\bullet$: $(p \neq q) \Rightarrow (AF(t, p) \neq AF(t, q))$) and for the given value of the arc function AF of each output arc of the selected transition $t \in T$ there must be an associated input arc of that transition t with the same value of the arc function AF (i.e., $\forall t \in T\ \forall q \in t\bullet\ \exists p \in \bullet t$: $AF(p, t) = AF(t, q)$); the **priority function** TP associates with each transition its priority (such priority has the default value of 1, if not explicitly indicated in the net diagram); the **initial marking** M_0 then expresses the initial status of the modeled system and it assigns each place with the (possible empty) subset of mutually different natural numbers called **tokens** wherein the tokens located in different places are mutually different natural numbers (i.e., $\forall p \in P\ \forall q \in P$: $(p \neq q) \Rightarrow (M_0(p) \cap M_0(q) = \emptyset)$).
Some commonly used notations for UNTPNs are $\bullet y := \{x \mid (x, y) \in A\}$ for the **preset** and $y\bullet := \{x \mid (y, x) \in A\}$ for the **postset** of the net element y (i.e., place or transition). **Marking** M of the UNTPN $UNTPN$ is the mapping M: $P \rightarrow \mathscr{P}(\boldsymbol{N})$ and it expresses the current status of the modeled system. If $P := \{P1, P2,\ldots, Pn\}$, where $n = |P|$, marking M can then be written as the vector $M := (M(P1), M(P2),\ldots, M(Pn))$.

Dynamics of UNT Petri nets

With the given UNTPN not only the current status of the modeled system can be presented, but also dynamics of the transitions between its individual states. The transition $t \in T$ is **enabled** in the marking M of the UNTPN $UNTPN$ iff for every place p in the preset of the transition t there exists **input binding function** i_p of the tokens in the actual marking M of the place p, i.e., $\forall p \in \bullet t\ \exists i_p$: $\{AF(p, t)\} \rightarrow M(p)$ such that:

- $AF(p, t) \in \boldsymbol{N} \Rightarrow i_p(AF(p, t)) := AF(p, t)$, *where* $AF(p, t) \in M(p)$, (i.e., informally, if $AF(p, t) \in \boldsymbol{N}$ then the token with the numeric value equal to $AF(p, t)$ must be bound);
- $AF(p, t) \in \boldsymbol{Z}^- \Rightarrow i_p(AF(p, t)) := x$, *where* $x \in M(p)$, (i.e., informally, if $AF(p, t) \in \boldsymbol{Z}^-$ then the token with any numeric value can be bound).

If the transition t is enabled in the marking M of UNTPN *UNTPN*, we denote that fact in the form of t ***en*** M and for every place p in the postset of the transition t there exists **output binding function** o_p, i.e., $\forall p \in t\bullet\ \exists o_p$: $\{AF(t, p)\} \rightarrow \boldsymbol{N}$ such that:

- $o_p(AF(t, p)) := i_q(AF(q, t))$, if $((AF(t, p) \in \boldsymbol{Z}^-) \wedge (AF(t, p) = AF(q, t)) \wedge (q \in \bullet t)$;
- $o_p(AF(t, p)) := AF(t, p)$, if $AF(t, p) \in \boldsymbol{N}$;
- $o_p(AF(t, p)) := \varnothing$, otherwise.

Firing of the transition $t \in T$ itself consists in the removal of one token from each preset place p of the transition t as required by the value of the input binding function i_p of the particular place p, and adding of one token into each of the postset place p of the transition t as required by the value of output binding function o_p of the particular place p. It then results in changing the marking M into the marking M', where $\forall\ p \in P$: $M'(p) := (M(p) \setminus \{i_p(AF(p, t))\}) \cup \{o_p(AF(t, p))\}$, that is denoted by $M\ [t\rangle\ M'$. The set of all markings reachable from the marking M will be denoted by the symbol $[M\rangle$.

Fig. 2, illustrates the UNTPN $CONFL := (P, T, A, AF, TP, M_0)$, where $P :=$ {P1, P2, P3, P4, P5}, $T :=$ {T1, T2}, $A :=$ {(P1, T1), (P2, T1), (P2, T2), (P3, T2), (T1, P4), (T2, P5)}, $AF :=$ {((P1, T1), 1), ((P2, T1), 2), ((P2, T2), -1), ((P3, T2), 4), ((T1, P4), 2), ((T2, P5), -1)}, $TP :=$ {(T1, 1), (T2, 2)}, $M_0 := (M_0(P1), M_0(P2), M_0(P3), M_0(P4), M_0(P5)) = (\{1, 3\}, \{2\}, \{4, 6\}, \{8\}, \varnothing)$. The transition T1 is enabled in the initial marking M_0, because $\bullet T1 = \{P1, P2\}$; $\exists i_{P1}$: $\{AF(P1, T1)\} \rightarrow M_0(P1)$, i.e., $(AF(P1, T1) = 1 \in \boldsymbol{N}) \Rightarrow \exists i_{P1}$: $\{1\} \rightarrow \{1, 3\}$, such that: $i_{P1}(1) := 1 = AF(P1, T1) \in M_0(P1)$; $\exists i_{P2}$: $\{AF(P2, T1)\} \rightarrow M_0(P2)$, i.e., $(AF(P1, T1) = 2 \in \boldsymbol{N}) \Rightarrow \exists i_{P2}$: $\{2\} \rightarrow \{2\}$, such that: $i_{P2}(2) := 2 \in M_0(P2)$. The transition T2 is also enabled in the initial marking M_0, because $\bullet T2 = \{P2, P3\}$; $\exists i_{P2}$: $\{AF(P2, T2)\} \rightarrow M_0(P2)$, i.e., $(AF(P2, T2) = -1 \in \boldsymbol{Z}^-) \Rightarrow \exists i_{P2}$: $\{-1\} \rightarrow \{2\}$, such that: $i_{P2}(-1) := 2 \in M_0(P2)$; $\exists i_{P3}$: $\{AF(P3, T2)\} \rightarrow M_0(P3)$, i.e., $(AF(P3, T2) = 4 \in \boldsymbol{N}) \Rightarrow \exists i_{P3}$: $\{4\} \rightarrow \{4, 6\}$, such that: $i_{P3}(4) := 4 = AF(P3, T2) \in M_0(P3)$.

When enabling individual transitions of the given UNTPN so called **conflicts** can originate in its certain markings (or **conflict transitions**). At the enabling of the transitions t_1 and t_2 of the given net in its marking M the conflict occurs, if both the transitions t_1 and t_2 have at least one input place, each of the transitions t_1 and t_2 is individually enabled in the marking M, but the transitions t_1 and t_2 are not in the marking M enabled in parallel and enabling of one of them will prevent enabling the other, i.e., $(\bullet t_1 \cap \bullet t_2 \neq \varnothing) \wedge (t_1\ \boldsymbol{en}\ M) \wedge (t_2\ \boldsymbol{en}\ M) \wedge \neg(\{t_1, t_2\}\ \boldsymbol{en}\ M)$. The term of conflict transitions can be obviously generalized for the case of the finite set $t_1, t_2, \ldots, t_n$, $n \in \boldsymbol{N}$, of the transitions of the given UNTPN.

A typical example of the conflict transitions in the initial marking M_0 of the UNTPN *CONFL* is shown in Fig. 2, where the transitions T1 and T2 have the common input place P2, both are enabled, but they are not enabled in parallel. When solving such transitions conflicts we will therefore follow the rule which determines, informally said, that from the set of the conflict transitions the one will be enabled, whose value of the transition priority function *TP* is the highest. If such transition from the set of conflict transitions does not exist, the given conflict would have to be solved by other means. In our studied example will be then on the basis of that rule the transition T2 enabled (because $TP(T1) = 1$ and $TP(T2) = 2$). Firing of the transition T2 changes the initial marking M_0 of the UNTPN *CONFL* into its marking M' that can be shown in Fig. 2, where $M'(P1) := M_0(P1) = \{1, 3\}$, $M'(P2) := M_0(P2) \setminus \{i_p(AF(P2, T2))\} = \{2\} \setminus \{2\} = \varnothing$,

M'(P3):= M_0(P3) \ {i_p(AF(P3, T2))} = {4, 6} \ {4} = {6}, M'(P4):= M_0(P4) = {8}, M'(P5):= M_0(P5) ∪ {o_p(AF(T2, P5))} = M_0(P5) ∪ {i_p(AF(P2, T2))} = ∅ ∪ {2} = {2}.

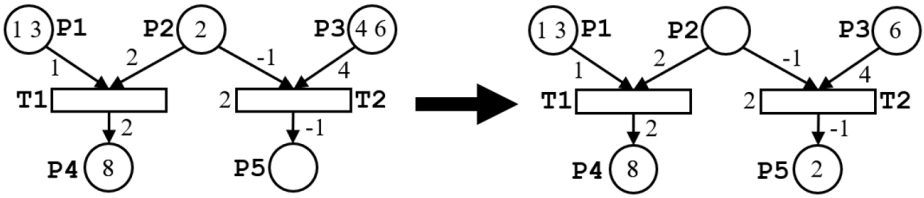


Figure 2: Firing of transition T2 in UNTPN *CONFL*

Let UNTPN *UNTPN:= (P, T, A, AF, TP, M_0)*. We will denote that UNTPN *UNTPN* is:

- **deadlock-free** iff $\forall M \in [M_0\rangle\ \exists t \in T$: t ***en*** M;
- ***k*-bounded** iff $\exists k \in \boldsymbol{N}_0\ \forall p \in P\ \forall M \in [M_0\rangle$: $M(p) \leq k$.

It can be easily shown that UNTPN *CONFL* in Fig. 1, is 2-bounded and not deadlock-free.

Apple technologies installed in AATCe training center

FaceTime is the proprietary videotelephony product available on mobile devices with MacOS and iOS operating systems. **AirPlay** is the technology that allows wireless streaming of the audiovisual content among AirPlay devices. **AirPlay Mirroring is the technology that allows broadcasting of the audiovisual content from a variety of Apple devices to the Apple TV.**

AATCe training center is equipped with the **iMac** computers, **iPad** and **iPhone** mobile devices, large format multi-touch display **65" NEC MultiSync V651 TM**, **Apple TV** and **AirPort Express** devices. AirPlay Mirroring technology is then intensively used during the teaching process to wirelessly mirror screen content of desktops or mobile devices of students and teacher (all these devices are used as AirPlay senders) on the NEC V651 HDTV with a large screen or on the teacher iMac computer (Apple TV equipment connected to these devices is used as AirPlay receiver) and for content sharing to other students. It is also possible to make a real-time recording of the teacher iMac screen content by the rich-media technology recorder software **Mediasite Recorder** (Mediasite, 2020) and to publish it on-line or on-demand.

Results and Discussion

The main problem that had to be solved when deploying the Swift programming language learning process in the Swift Playgrounds development environment running on the iPad tablets was the need to record all the parts of presentations with using of the rich-media technologies and to publish them on-line and on-demand. To solve this problem, the following solutions have been gradually reviewed:

- creating video recordings of the teacher iPad's screen content and their publishing; but this solution made difficult to post demanding postproduction to create a rich-media recording of the presentation making it virtually impossible to publish such the presentation on-line;
- creating video recordings of the teacher iMac's screen content with mirrored iPad's screen content and their publishing; but the problem of this solution was that during the lesson, individual students must be able to present their solutions of each algorithm, record them and then publish them on-line;

- the software solution utilizing the equipment of AATCe authorized training center and enabling presentation recording made in the Swift Playgrounds software environment on teacher and student iPad mobile devices and also on-line publication of this presentation; the main principles of this solution consisted in software realization of video recording of both the iPad‘s mirrored screens on the teacher iMac screen using the **QuickTime (QuickTime, 2020) and Mediasite Recorder software systems and the mirrored student iMac**’s screens containing mirrored student iPad‘s screens on the teacher iMac‘s screen using the MacOS **VNC Connect service.**

Design, simulation, verification and implementation of the generally distributed parallel programming support that meets all the above requirements required also the use of the appropriate formal method. Software engineering currently provides a number of methods and methodologies designed to implement the development of software systems (Sommerville, 2016). But most of these methods and methodologies (like Unified Modeling Language) are not based on the exact mathematical approach and they do not allow formal verification of the properties of the implemented software system and its simulation. Petri nets (Diaz, 2009) is one of mathematical modeling languages for the description of all the kind of parallel systems and they represent a popular method connecting advantages of the graphic representation of a modeled system with the possibilities of its simulation and the formal analyzability. Solving of the above problem then required the use of some of the classes of so-called high-level Petri nets which allow the application of the distinguishable tokens (because when designing a program system with using of Petri net, it was necessary, among other things, to represent individual classroom devices and other entities by means of distinguished tokens). However, the use of the coloured Petri nets class (Jensen and Kristensen, 2009), which is often applied in this context, has proved to be inadequate due to its relatively complicated definition and difficult verification of its properties. Therefore, UNTPN class was used for the design, simulation and verification of the final software solution. It was necessary to design the ***k*-bounded** and **deadlock-free** UNTPN for the above goals. This research target was achieved and the simplified UNTPN (detailed UNTPN capturing all the aspects of the resulting solution is much more complicated) that models of the given programming support is shown in the Fig. 3.

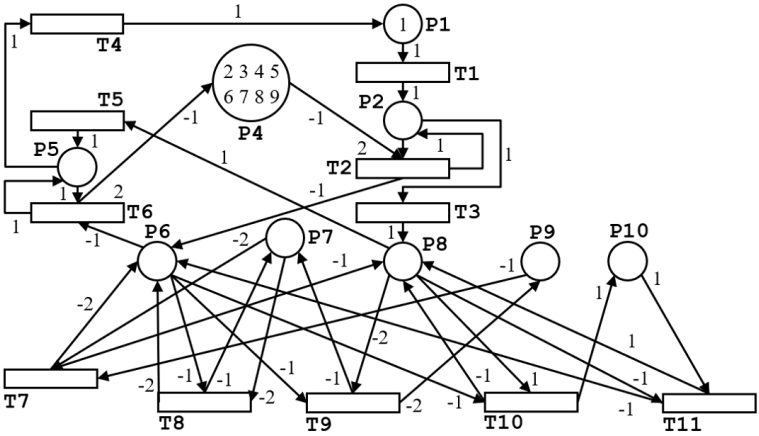


Figure 3: AATCe classroom functionalities modeling with using of UNTPN

The token 1 in the place P1 in the initial marking M_0 of the UNTPN represents the teacher iPad connected by cable to teacher iMac. The tokens 2..9 in the place P4 then represent the student iPads connected by cable to the appropriate student iMacs. The VNC Connect connectivity establishing

of individual student iMacs with the central teacher iMac is modeled by repeatedly firing of the transition T2 (i.e., the tokens 2..9 representing the student computers will be sequentially moved into the place P6). Firing of the transition T3 then represents the start of recording of the presentation on the teacher iMac. The only one token located in the place P8 in the appropriate marking of the UNTPN models the teacher or student computer whose screen content is simultaneously recorded and shared on the NEC MultiSync V651 display. If there is no token in the place P8 of the given net marking, then in this case the single token representing iMac whose screen content is shared on the NEC MultiSync V651 display is located in the place P7, and also the single token representing iMac whose screen content is being recorded is located in the place P9. If the token 1 representing the teacher iMac is located in the place P10 of the given net marking then the teacher iMac is not recorded and it is also not shared on the NEC MultiSync V651 display. If the transition T10 is fired then one of the selected student iMacs will begin both recording and sharing. If the transition T11 is fired then the teacher iMac will again begin both recording and sharing. If the transition T9 is fired then the teacher iMac will continue with recording and the selected student iMac will begin with sharing. If the transition T8 is fired then the teacher iMac will continue with recording and another selected student iMac will begin with sharing. If the transition T7 is fired then the selected (teacher or student) iMac will begin both recording and sharing. The completion of the lesson is allowed if the teacher iMac is recorded and shared and it is modeled by firing of the transition T5. The VNC Connect connectivity finishing of individual student iMacs with the central teacher iMac is modeled by repeatedly firing of the transition T6. The token 1 representing the teacher iMac will be moved back into the place P1 and the tokens 2..9 representing the student iMacs will be sequentially moved back into the place P4. It can be shown that the presented UNTPN in Fig. 3, is k-bounded (where $k = 8$) and deadlock-free.

The following significant results were achieved at the Faculty of Economics VŠB-Technical University of Ostrava:

- over 90 presentations and their recordings were realized with the support of AATCe training center equipment and the comprehensive collections of the following subjects are available: Systems Engineering and Informatics (1st year of Bachelor studies of Informatics in Economics – includes Swift programming languge lessons), Basic Programming (2nd year of Bachelor studies of Informatics in Economics - includes Swift programming languge lessons), Dynamic Web Pages Creation (2nd year of Bachelor studies of Informatics in Economics), Internet Applications Creation (3rd year of Bachelor studies of Informatics in Economics) and Economic Applications of Artificial Intelligence (2nd year of Master studies of Informatics in Economics); the rich-media recordings were published in the on-demand mode through the LMS system *Moodle*;
- three courses of the Swift programming language for the students of the fourth year of the Maticni Grammar School in Ostrava (MGO, 2020) have been successfully completed as the part of the implementation of the "Everyone Can Code" program; each of these courses was attended by 20 students;
- a total of 21 students with special needs are registered at the faculty in this academic year, who can use "barrier-free" access to informations through the recorded presentations; the next pilot activity prepared with using of the AATCe classroom equipment supporting these students mainly involve automated adaptation to their needs, e.g., transcription of spoken text of the lecture recorded by the recording and assistance service into the written text and their availability on-demand;
- various forms of asynchronous communication between the teachers and the students were initiated and started to be used in the so-called pre-learning process, where students have available records of selected topics of the subject before the lesson and they can study them in advance and they are already equipped with the information about the given topic;

- asynchronous communication is used when students are actively involved in the realization of recording of their individual presentations, especially when defending their processed projects.

Conclusion

In general, the implementation of the rich-media technologies and the "Everyone Can Code" worldwide program at the Faculty of Economics contributes significantly to the mobilization of students in the learning process. Coding is an essential skill for the students of our university and learning to code teaches them how to solve general problems with using of the algorithmic techniques and the formal procedures. Through realized records of lessons the students can repeat and better understand the topic, which of course has a positive impact on their overall level of knowledge and improvement in their learning outcomes. Therefore, asynchronous communication becomes an excellent tool for promoting inclusive education by providing access to the learning process from multiple points, different times and any number of repetitions. With regard to the level of equipment of the school and students using mobile tools (tablets, notebooks), nothing prevents immediate frontal implementation.

Acknowledgement

This article was supported by the Operational Program Education for Competitiveness under Grant Research team for modelling of economic and financial processes at VSB-TU Ostrava, number OP VK CZ.1.07/2.3.00/20.0296.

References

AATCe (2020) *Apple Authorized Training Centres for Education* [Online], Available: https://training.apple.com/us/en/programs/aatce [10 Feb 2020].

Bos, N., Groeneveld, C., van Bruggen, J. and Brand-Gruwel, S. (2016) 'The Use of Recorded Lectures in Education and the Impact on Lecture Attendance and Exam Performance', *British Journal of Educational Technology,* vol. 47, no. 5, pp. 906-917. http://dx.doi.org/10.1111/bjet.12300

Diaz, M. (2009) *Petri Nets: Fundamental Models, Verification and Applications*, London: John Willey & Sons, ISTE Ltd.

Dona, K.L., Gregory, J. and Pechenkina, E. (2017) 'Lecture-recording Technology in Higher Education: Exploring Lecturer and Student Views Across the Disciplines', *Australasian Journal of Educational Technology,* vol. 33, no. 4, pp. 122-133. http://dx.doi.org/10.14742/ajet.3068

ECC (2020) *Everyone Can Code,* [Online], Available: https://www.apple.com/everyone-can-code/ [10 Feb 2020].

Hladká, E. and Hrdlicka, T. (2005) 'Mobile Access to Streamed Lecture Materials', *Technology and Health Care*, vol. 13, no. 5, pp. 397-398.

Jensen, K. and Kristensen, L.M. (2009) *Coloured Petri Nets*, Berlin: Springer-Verlag.

Martiník, I. (2015) 'Automation of Presentation Record Production Based on Rich-Media Technology Using SNT Petri Nets Theory', *Scientific World Journal*. http://dx.doi.org/10.1155/2015/303705

Martiník, I. (2018) 'SNT Process Petri Nets Theory Applied to Recordings of Remote Presentations', *Proceedings of the 15th Conference on Efficiency and Responsibility in Education (ERIE 2018)*, Prague, pp. 195-202.

Mediasite (2020) *Mediasite Recorder*, [Online], Available: https://mediasite.com/ [10 Feb 2020].

MGO (2020) *Maticni Grammar School,* [Online], Available: http://mgo.cz/ [10 Feb 2020].

QuickTime (2020) *Apple QuickTime*, [Online], Available: https://support.apple.com/quicktime [10 Feb 2020].

Sommerville, I. (2016) *Software Engineering, Tenth Edition*, Boston: Pearson Education Limited.

SWP (2020) *Swift Playgrounds,* [Online], Available: https://www.apple.com/swift/playgrounds/ [10 Feb 2020].

USING STATISTICAL SOFTWARE AT CZECH UNIVERSITIES

[1]✉Aneta Mazouchová, [2]Tereza Jedličková, [3]Lucie Hlaváčová

[1]Department of Economic Statistics, University of Economics, Prague, Czech Republic, anetahybsova@gmail.com

[2]Institute of Geology and Paleontology, Faculty of Science, Charles University, Czech Republic

[3]Department of Biology and Environmental Studies, Faculty of Education Charles University, Czech Republic

Abstract

Statistics is considered an unpopular and demanding course. It is partly caused by an obsolete concept of teaching disregarding modern methods. Consequently, students lack the necessary knowledge e.g. of available statistical software. The objective of this paper is to motivate faculties to change the approach to teaching statistics and to modify materials and methods used in their courses according to the specific needs of their students. The questionnaire survey involved by 763 respondents was applied. Results show that respondents often involve another person in processing their statistical data. Those who process the data themselves mostly tend to use MS Excel. Cluster analysis formed four groups of respondents according to their attitude to statistics. Three of them show the potential to change their negative or neutral attitude towards statistics by suitable methods and tools, such as using the software. The results may improve statistic courses and teachers' approach towards students.

Keywords

Statistical curriculum, statistical software, teaching statistics, university students

Introduction

University students frequently consider statistics as one of the most difficult subjects. They often even speak about the fear of statistics (Ralston et al., 2016). Teachers of statistics and other statistical subjects have to tackle this prejudice. Most importantly, the subject should be didactically adapted to the specific field of study in order to interpret statistics as a science that will accompany and help students to find answers for scientific questions (Hybšová, 2017). It is the development and increase of teaching quality that can help to raise popularity and understanding of statistics as a scientific discipline.

Given the above mentioned, the preparation of a quality statistical course is highly demanding. Numerous factors affect the process (e.g. the field of study, the initial level of mathematical and statistical knowledge that may differ from student to student). The scheduling of statistical subjects during the study also plays a significant role. Students in higher study groups are more likely to be motivated in statistics courses because they can assume they would use statistics when working on their thesis. According to Velleman and Moore (1996) it is important to motivate especially students of basic courses and to change their negative approach towards statistics mainly influenced by negative perceptions of statistics by general public.

Selection and utilization also affect the resulting quality (Hybšová, 2017). Despite numerous studies about innovations in teaching statistics (see, e.g. Huynh and Baglin, 2017, Ben-Zvi, Makar and Garfield, 2017) the practice in the Czech Republic remains very rigid. Teachers often prefer the "pen-and-paper" method while other crucial didactic tools, such as statistical software, remain unused. However, teachers can choose a number of paid as well as free types of statistical

software to use in a course. Understandably, the teacher should consider the selection of software carefully. Such choice predetermines the statistical software that students are most likely to use when writing their thesis. Besides, if the teacher wants students to use statistics after graduation, software that does not require an expensive licence should be picked.
The objective of this paper is to motivate faculties to change the approach to teaching statistics and to modify didactic materials (e.g. using of statistical software) and teaching methods (leading to establish a clear link between statistics and its uses in the real world) used in their courses according to the specific needs of their students. The paper is divided into method description, results and discussion. The conclusion summarizes the most important results and recommendations for further research.

Materials and Methods

This study focuses on the use of statistical software in university studies. The respondents were students at least in their second year of study and fresh graduates from all Czech public universities. A self-administered survey was employed. The respondents received an email that invited them to respond to a web-based survey, using a clickable link for easy access included in a personalized email (De Leeuw et al., 2008). Respondents were addressed through all public Facebook groups for students and graduates from Czech public universities. The questionnaire included a sorting question about the year of study of the respondent. If a student stated that they were studying at least the second year of a bachelor programme, or that they finished the university less than 5 years ago, they could continue answering the questionnaire.
We received a total of 763 fully completed questionnaires. Women represented 79% of the respondents, men 21%. 39% of the questionnaires were responded by university graduates. 18% of respondents were students of a bachelor study programme, 36% studied in a master programme and 7% of the respondents studied in doctoral studies.
The first part of the questionnaire focused on finding out whether the respondents attended any statistics course during their university studies. The next part concentrated specifically on the use of statistical software in their classes and the student's ability to use the given software. Subsequently, the respondents were asked about the use of statistical methods when processing their final theses. Finally, respondents evaluated several statements related to statistics and its use during their university studies on the 5-point Likert scale.
The Hierarchical Cluster Analysis with Ward's Method was used to verify the structure of the responses to the sentiment questions. The arising clusters divided respondents to 4 groups (see Table 2). The clusters were frequent and demonstrated rather even distribution.
Due to the fact that the respondents studied a wide range of study fields, this paper rather represents a survey. It is not advisable to generalize the conclusions using inductive statistical methods. The acquired data were evaluated only by means of descriptive statistics.
Three research questions were specified to define the objectives:

- What statistical software do university students know and can use?
- What problems do students face when using statistical software?
- Do university students process the statistical data for their theses themselves?

Results

Initially, respondents were asked if they completed any statistics course during their studies. 31% of respondents did not complete any statistics subject while 34% of respondents completed one semester of statistics and 35% completed two and more semesters.
The following part of the questions was intended only for students who completed at least one statistics course (n=526). The questions concentrated on the statistical software used in the

classes. Respondents could choose from suggested answers with various types of statistical software (including MS Excel) or write their own response.
More than a half of the respondents (53%) used MS Excel while 28% stated they used no statistical software at all. Some students also used Statistica (19%), SPSS (13%) and R (10%) in their classes. Jamovi (3%), SAS (2%), JASP (2%), Gretl (1%) and GraphPad (0,5%) remain virtually unused. Figure 1 shows software mentioned more than once in the responses.

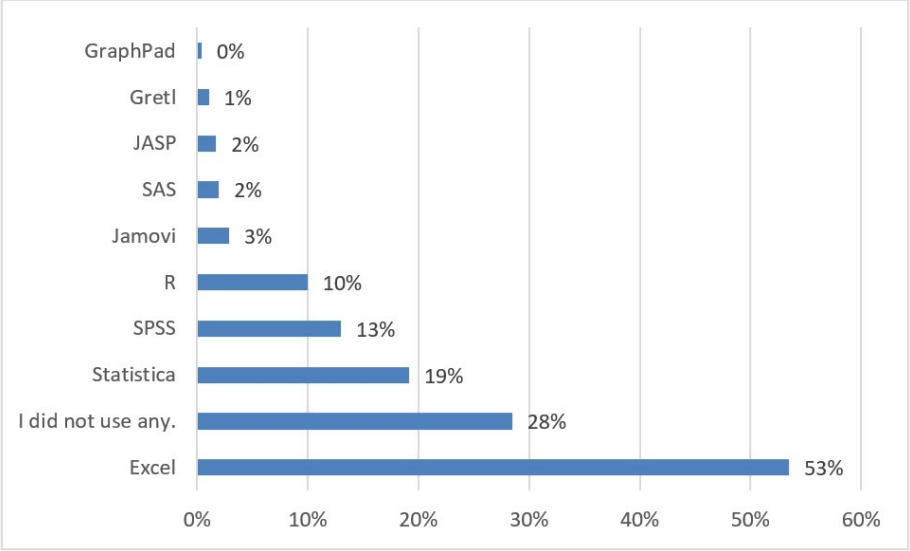


Figure 1: Statistical software used in lessons (*n*=526, students who completed at least one statistics course)

The third part of the questionnaire concentrated on the use of statistical methods when processing a thesis. 72% of respondents stated that they used statistical methods to process their theses. 20% out of them admitted that the data for their theses were processed by a statistician, their supervisor or another person.
The next question of the survey asked what statistical programme respondents know and are able to use. The one known and used by almost all respondents was MS Excel, which, according to their opinion, they can use well or at least partially. Other known programmes include Statistica, SPSS, R and SAS. Paradoxically, the JASP and Jamovi freeware software are the least known and used (see Figure 2).
The final part of the questionnaire asked the respondents to evaluate 8 statements. They had a five-point scale available to express their sentiment. Table 1 shows the statements and answers. 55% of the respondents claim that statistical software in English represents no problem. Understanding statistics constitutes a more complicated issue for students with 55% of respondents stating that they do not understand statistics. Moreover, respondents have no preference between qualitative and quantitative research (38% prefer quantitative and 36% qualitative research). Almost a third of respondents (32%) state that their supervisor advised them on the appropriate methods for data processing.

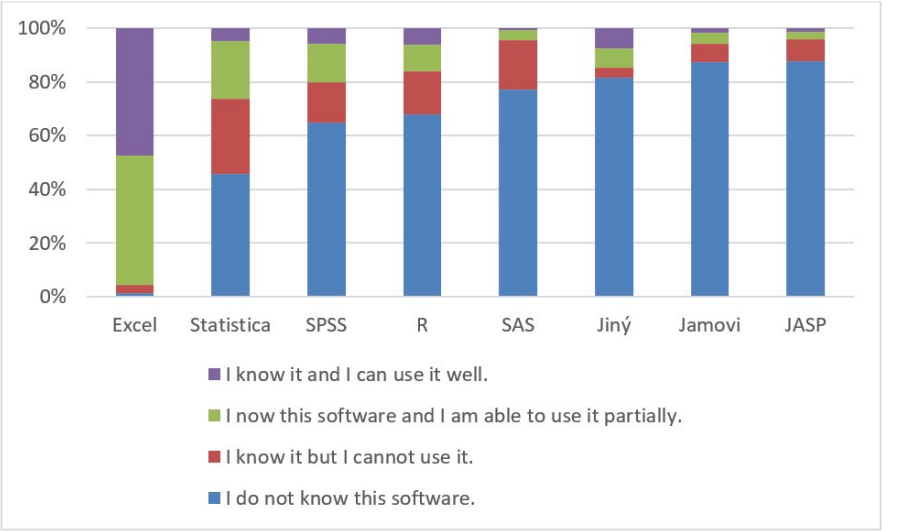


Figure 2: Answers to the question „What software do you know and can use" (*n*=763)

Statement	I totally disagree (1)	I do not agree (2)	I do not know (3)	I agree (4)	I completely agree (5)
Statistical software in English is a problem.	25%	30%	15%	22%	7%
The problem is that I do not understand statistics.	10%	22%	13%	36%	19%
The problem is that I do not understand statistics and the software is in English.	17%	28%	18%	21%	15%
I have a block towards statistics. I do not understand it and I do not want to understand it.	23%	37%	16%	15%	8%
I prefer qualitative research to quantitative one.	13%	25%	27%	23%	13%
My supervisor does not understand statistics.	27%	22%	37%	8%	4%
My supervisor required use of statistical method in the thesis.	23%	23%	16%	21%	17%
My supervisor suggested me appropriate method of data processing.	24%	27%	18%	23%	9%

Table 1: Relative frequencies of statements (*n*=763)

Cluster analysis divided respondents to 4 clusters according to their answers to sentiment questions. Centroids were calculated for individual clusters (see Table 2). *Cluster 1* (*n*=171) includes respondents who assessed a lot of the statements in a neutral manner being unable to judge them. However, they feel no block in terms of statistics and they assume that their supervisor understands statistics and required that the thesis includes statistics. *Cluster 2* (*n*=163) groups respondents stating that they do not understand statistics and prefer qualitative research. Statistical software in English represents a problem for them. However, their thesis supervisor did not require the

use of statistics when working on the thesis or suggest any statistical methods. *Cluster 3 (n=132)* includes respondents who have no problem with statistical software in English. They do not understand statistics as such, do not wish to understand it and feel that they have a mental block in terms of statistics. They prefer qualitative research although their thesis supervisor requested the use of statistics in the thesis and suggested specific statistical methods. *Cluster 4 (n=228)* groups respondents who stated negative sentiment towards all statements. They have no problem with statistical software in English, they understand statistics and prefer quantitative research. They assume that their thesis supervisor understands statistics although no use of statistical data processing was required in the thesis. These respondents found their respective data processing methods themselves.

Statement / Cluster	1	2	3	4
It is a problem if statistical software is in English.	3	3	2	2
It is a problem that I do not understand statistics.	3	4	4	2
The combination of the fact that the software is in English and that I do not understand statistics represents a problem.	3	4	3	2
I feel a mental block towards statistics. I do not understand it and I do not wish to.	2	3	4	2
I prefer qualitative research to quantitative.	3	4	4	2
My thesis supervisor does not understand statistics.	2	3	3	2
My thesis supervisor required that my thesis includes the use of statistics.	4	2	4	2
My thesis supervisor suggested what statistical methods I should use to process the data.	3	2	4	2

Table 2: Final Cluster Centres

Discussion

It is alarming that in the era of daily use of digital technologies almost a third of the respondents who completed statistical subjects during their university studies did not get familiar with any statistical software, not even with MS Excel. The importance of using statistical software is emphasized by numerous researchers involved in the teaching of statistics (e.g. Velleman and Moore, 1996; Pratt, Davies and Connor, 2011; Davidson et al., 2019). Moreover, Davidson et al. (2019) stress the development of statistical freeware such as JASP. The advantage of free software is that students can use them even after graduation as they do not need to acquire a paid license. However, JASP and Jamovi are the least known among Czech students. They are rarely used in classes (3%, resp. 2%) although they both offer a huge variety of statistical procedures that cover syllabi of basic statistics courses.

Using software in classes is both practical and motivational. Students are usually afraid of calculations in statistics (Cobb, 1992). When using software, the calculations are carried out by a computer and students can focus on input conditions of statistical methods and on the interpretation of results. Beside not being stressed by calculations, a student focuses more on the use of statistics in the field of his study and its practical significance (Hsu, Wang and Chiu; 2009). Consequently, using statistics becomes more natural for students.

The cluster analysis grouped respondents into 4 clusters according to their responses to the sentiment questions about using statistics. Respondents in each cluster exhibit different potential and needs in terms of statistics classes and the use of statistical software in the courses. Cluster 1 members may be characterized as undecided, cluster 2 respondents as eternal statistics adversaries, cluster 3 members as temporary statistics adversaries, and cluster 4 as statistics fans. The group of the *undecided respondents* includes respondents with a high probability to get convinced of the benefits of statistics. They feel no mental block against statistics and can admit the importance of

the field. They are not completely convinced and adhere to neutral sentiment in their statements. Suitably built classes would draw statistics nearer to Cluster 1 members. Teaching about statistical software might play a significant role in the process, as described by Hsu, Wang and Chiu (2009). The cluster of *eternal statistics adversaries*, however, gives the impression that even completing a customized statistics course would not convince them of the advantages. They do not comprehend statistics, never needed it and never will. They probably see no benefit in statistics. Therefore, working with statistical software might represent a further burden and turn-off for them. Griffith et al. (2012) provided a similar description of people who view statistics negatively. The group considers the difficulty and complexity to be the largest issue of statistics. Besides, they described its non-use in future careers and stated that they dislike mathematics as well (Griffith et al., 2012). The so-called *temporary statistics adversaries* in Cluster 3 have no inclination towards statistics and will never pursue it on their own. As they may have come across statistics due to their thesis supervisors' requirements, they may even admit the importance of statistics. A suitably prepared statistics course would help the group to get rid of the mental block against the field. Since they state that they do not wish to understand statistics, working with statistical software might provide an opening to use statistics. The fact that software actually does a lot of the work for them might convince them. They do not need to deal with the "tyranny of the computable" as Cobb (2007) describes the need to understand necessary calculations. This group might also be persuaded by real-life data use in classes. Gould (2010) claims that a modern statistics courses must adjust to the fact that students' first exposure to data occurs outside academia– in the newspaper, on the internet… The classes should use students' knowledge of some diagrams and basic statistical terms and use their own experience as a starting point, describing the statistics surrounding us and showing them its practical use. Bibby (2003) supports this idea by stating that statistics classes should take into account a student's real-life and world perception.

Cluster 4 includes so-called statistics fans, i.e. people who have some command of statistics and understand its importance. This group shows the potential to develop their statistical literacy, e.g. by using statistical software in classes. This might broaden their knowledge and skills by new statistical tests, better assessment of the use of individual tests.

Considering the curriculum, its range and conception of a potential statistics course proves relevant for all clusters. Each group exhibits different needs. Group 2 (eternal adversaries) will probably perceive even the introduction to statistical methods as a necessary evil. The content of the course will be crucial for remaining three groups, however. Ideally, completing such a course should overlap into initial research phases, i.e. the research design, compiling the research tool, selecting suitable methods etc. (Justice, Zieffler and Garfield, 2017; Holmes, 2003). Deciding on the statistical software, working with it and assessing its usage potential plays an important role in all these groups although the role differs in each group (see above).

According to the results, 38% of thesis supervisors demanded the use of statistics from their students. However, if a student only completes a single statistically oriented course during their study, the student is not likely to be able to interpret the results for the thesis. This corresponds to the fact that 20% of respondents that used statistics in their thesis did not process the data themselves. They rather leave a statistician, supervisor or someone else to take care of the statistics. After a single semester of statistics and students are not sure about the calculations. Therefore, it is understandable that they leave data processing to someone else. Moreover, not everyone who did not process the data themselves would admit it.

The results show that teaching statistics at universities is still implemented in traditional teaching methods which, according to Mustafa (1996), are not effective. The main problem is that students fail to establish a clear link between statistics and its uses in the real world and ask themselves: What am I going to use it for? Nonetheless, university studies anticipate the use of statistics,

mainly for the thesis. Sufficient knowledge of different possibilities of statistical data processing influence the design of a thesis and give students new possibilities not only for evaluating data but also for creating research tools and their distribution. Before each statistic course, individual faculties should make their own analysis of students' attitudes and the level of their current knowledge of statistics. Only if the needs of specific students are taken into account, the teaching of statistical courses will be maximally effective. Suggestions from teacher preparation efforts include a stronger focus on learning and teaching statistics and preparing teachers to use tools such as dynamic statistical software tools (e.g. Lee and Hollebrands, 2008, 2011; Pfannkuch and Ben-Zvi, 2011; Pratt, Davies and Connor, 2011). Moreover the use of statistics in the current world grows in importance as the development in contemporary society is connected to the data boom. Teaching statistics should reflect this fact. Data and research method knowledge can help graduates not only in the labour market, but also to assess the socioeconomic situation, for example. Since media widely use numbers and statistics as arguments, basic knowledge of statistics and its application represents a necessary skill of a university educated person.

Conclusion

The reason for the unpopular position of statistics as a university course can lie – to a certain extent – in an unsuitably selected curriculum and obsolete teaching approach. The importance of quantitative research is getting more important along with the question of how to teach the current generation necessary statistical thinking. Traditional teaching methods prove inefficient in the present dynamic world and teaching requires updating and finding an innovative approach. The paper's results serve as a reflection of methods applied in statistics courses and the application of statistical software in them. The results of the survey can trigger improvement not only of teaching statistics, but also of teachers' approach towards students. The differences in the students' fields and consequent needs prevent designing a unified methodology for teaching statistics. However, a course for further education of statistics teachers might represent a way. Such a course would introduce all factors to consider in the classes and suggest solutions. Further education should emphasize updating teaching methods, implementing specific real life examples and using statistical software. These aspects constitute a powerful tool for the popularization of statistics as a science to all students.

References

Ben-Zvi, D., Makar, K. and Garfield, J. (Eds.). (2017) *International handbook of research in statistics education*. Springer. http://dx.doi.org/10.1007/978-3-319-66195-7

Bibby, J. (2003) Rejoinder to '50 Years of Statistics Teaching in English Schools: Some Milestones', In Holmes, P. *Statistician 52*, Part 4, pp. 439-474.

Cobb, G. (1992). Teaching statistics. *Heeding the call for change: Suggestions for curricular action*, vol. 22, pp. 3-43.

Cobb, G.W. (2007) 'The introductory statistics course: A Ptolemaic curriculum? ', *Technology innovations in statistics education*, vol. 1, no. 1.

Davidson, H., Jabbari, Y., Patton, H., O'Hagan, F., Peters, K. and Cribbie, R. (2019) 'Statistical Software Use in Canadian University Courses: Current Trends and Future Directions', *Teaching of Psychology*, vol. 46, no. 3, pp. 246-250. http://dx.doi.org/10.1177/0098628319853940

De Leeuw, E.D. and Hox, J.J. (2008) 'Self-administered questionnaires: mail surveys and other applications', *International handbook of survey methodology*, pp. 239-263. http://dx.doi.org/10.4324/9780203843123.ch3

Gould, R. (2010) 'Statistics and the modern student', *International Statistical Review*, vol. 78, no. 2, pp. 297-315. http://dx.doi.org/10.1111/j.1751-5823.2010.00117.x

Griffith, J. D., Adams, L. T., Gu, L. L., Hart, C. L. and Nichols-Whitehead, P. (2012) 'Students' attitudes toward statistics across the disciplines: a mixed-methods approach', *Statistics Education Research Journal*, vol. 11, no. 2, pp. 45-56.
Holmes, P. (2003) '50 years of statistics teaching in English schools: some milestones', *Journal of the Royal Statistical Society: Series D (The Statistician)*, vol. 52, no. 4, pp. 439-463. http://dx.doi.org/10.1046/j.1467-9884.2003.372_1.x
Huynh, M. and Baglin, J. (2017) 'Teaching statistics through data investigations in Australian secondary schools: An island-based pilot project', *International Journal of Innovation in Science and Mathematics Education (formerly CAL-laborate International)*, vol. 25, no. 1, pp. 49-64.
Hybšová, A. (2017) Statistická gramotnost studentů učitelství přírodopisu/biologie v České republice. *Dizertační práce.*
Hsu, M.K., Wang, S.W. and Chiu, K.K. (2009) 'Computer attitude, statistics anxiety and self-efficacy on statistical software adoption behavior: An empirical study of online MBA learners', *Computers in Human Behavior*, vol. 25, no. 2, pp. 412-420.
Lee, H.S. and Hollebrands, K. (2008) 'Preparing to teach mathematics with technology: An integrated approach to developing technological pedagogical content knowledge', *Contemporary Issues in Technology and Teacher Education*, vol. 8, no. 4.
Lee, H.S. and Hollebrands, K.F. (2011) 'Characterizing and developing teachers' knowledge for teaching statistics', In C. Batanero, G. Burrill and C. Reading (Eds.), *Teaching statistics in school mathematics - Challenges for teaching and teacher education: A joint ICME/IASE study*, pp. 359–369. New York: Springer. https://doi.org/10.1007/978-94-007-1131-0
Mustafa, R.Y. (1996) 'The challenge of teaching statistics to non-specialists', *Journal of statistics education*, vol. 4, no. 1. https://doi.org/10.1080/10691898.1996.11910504
Justice, N., Zieffler, A. and Garfield, J. (2017) 'Statistics Graduate Teaching Assistants' beliefs, Practices And Preparation For Teaching Introductory Statistics', *Statistics Education Research Journal*, vol. 16, no. 1, pp. 294-319.
Pfannkuch, M. and Ben-Zvi, D. (2011) 'Developing teachers' statistical thinking', In C. Batanero, G. Burrill and C. Reading (Eds.), *Teaching statistics in school mathematics-Challenges for teaching and teacher education: A joint ICMI/IASE study* (pp. 323–333), New York: Springer. http://dx.doi.org/10.1007/978-94-007-1131-0_31
Pratt, D., Davies, N. and Connor, D. (2011) 'The role of technology in teaching and learning statistics', In *Teaching statistics in school mathematics-challenges for teaching and teacher education* (pp. 97-107), Springer, Dordrecht. http://dx.doi.org/10.1007/978-94-007-1131-0_13
Ralston, K., MacInnes, J., Crow, G. and Gayle, V.J. (2016) 'We need to talk about statistical anxiety', *A review of the evidence around statistical anxiety in the context of quantitative methods pedagogy.* NCRM Working Paper. NCRM. (Unpublished)
Velleman, P.F. and Moore, D.S. (1996) 'Multimedia for teaching statistics: Promises and pitfalls', *The American Statistician*, vol. 50, no. 3, pp. 217-225. http://dx.doi.org/10.2307/2684658

QUANTITATIVE STUDY OF FULL-TIME AND PART-TIME BACHELORS' STUDENTS DROPOUT

[1]✉Libor Měsíček, [2]Pavel Petrus

[1]Department of Economics and Management, Faculty of Social and Economic Studies, Jan Evangelista Purkyně University in Ústí nad Labem, Czech Republic, l.mesicek@ujep.cz

[2]Department of Primary and Pre-Primary Education, Faculty of Education, Jan Evangelista Purkyně University in Ústí nad Labem, Czech Republic

Abstract

The main objective of this paper was to present and analyze results of the most problematic courses and success rates of all students in bachelor programmes at Faculty of Social and Economic Studies, Jan Evangelista Purkyně University, Czech Republic. As a source of data, the University information system was used. Most problematic courses with high dropout rates are Mathematics and Statistics. Part-time students have lower success rate than full-time students in these courses. Authors were able to confirm, that there is a difference between success rates of part-time and full-time students to the detriment of part-time students (in courses Mathematics and Statistics). Students in part-time bachelor study programmes often need at least one additional year to finish their study.

Keywords

Bachelors', dropout, mathematics, statistics, student, study

Introduction

Educational institutions in the Czech Republic have to deal with changing demographics of population. The shrinking number of potential young students, dropping or at least stable number of students in actual of bachelor, masters and doctoral study programmes is one of the concerns. On the other hand, there is a potential of older people who may decide to join a study program at a University or continue in their previous studies. Another factor of this is percentage of part-time students who dropout from their study programmes. There are several reasons why this could be happening, according to Deniz (2020) such as group cohesion, general quality of education, change in interests and transportation. Another approach how to view the study results and the dropout could combine both quantitative and qualitative methods. Buizza et al. (2019) used this approach to analyze dropouts from an Italian university. They found that unsuccessful ending of a study could be in some cases positive outcome for the students. Study of Reissova (2018) took place at the same Faculty and analyzed eleven reasons which could lead to premature end of study. Most important factors were laziness; preference of working to studying and lack of skills. Significant difference between full-time students and part-time students were identified. These findings were quite consistent with findings in (Salas-Morera et al., 2019) e. g. lack of motivation, bad planning of the course by the students, high level of the course's starting point, etc. Fortin et al. (2016) performed another holistic approach, the identified problems were almost identical to the previously stated ones.

Mesicek, Petrus and Kovarova (2019) confirmed that students who pass the admission process with a higher score are less likely to fail in the study.

Study of Berka, Vrabec and Marek (2019) used LISp-Miner (the system can be freely downloaded from https://lispminer.vse.cz) to analyze bachelor students dropout. They were able to confirm the number of lost credits (results of failing a course in one semester) during the study to be a risk

factor. They also confirmed that full-time students who start at the university right after finishing high schools are more likely to successfully finish their studies.
Overall students dropout in Germany in the first year of bachelor degree programmes is 28% (Heublein, 2014). In the Czech Republic it represents 40% (Ministry of Education, Youth and Sports, 2018).
According to the Ministry of Education, Youth and Sports (2019) the overall dropout rate of bachelors' students is 60% in some cases after trying several study programmes. These students were unable to successfully reach bachelor degree despite several attempts in several study programmes.
Newberry, Miller and Stevenson (2011) identified that dropout rates of the first year students correlate with the individual performance in the first-level calculus courses. Hayes, Fry and Cummings (2018) suggested changes in study programs to suit better non-traditional students who must combine study with e.g. full-time employment.
Three bachelors study programmes/specializations at the Faculty of Social and Economic Studies (FSE), Jan Evangelista Purkyně University in Ústí nad Labem, Czech Republic are offered in both full- and part- time form. They are Economics and management, Regional development and public administration, Social work. After successful awarding of bachelors' degree student can continue in full-time masters' study (Economics and management, Regional development and public administration, Management in social work). The FSE also offers doctoral study program Applied economy and public administration.
The aim of this paper is to present and analyze quantitatively the results of the most problematic (with highest dropout rates) mandatory and mandatory voluntary courses and success rates of all students in bachelors programmes. The main reason for quantitative approach is limited access to information about the state at other universities as well as to demonstrate what could be done to reduce dropout rate in first academic year as well as impacts of GDPR.
The paper is divided into chapters, the first chapter is introduction, the second one describes materials and methods, the third one provides results, the fourth chapter is discussion and the final chapter is conclusion.

Materials and Methods

To conduct this study (partly inspired by Berka, Vrabec and Marek (2019)), the data from the information system from UJEP was required. From this system, the data about students' study results (beginning study year 2015 to 2019) were exported into MS Excel from an Oracle database. Every student had several rows with results for each course. Every course has its name, last attempt number, results, year of study, etc. Also, the information about successful or unsuccessful end of particular study was included. Since the amount of information about the students is vast, we had to create own program in C++ (Stroustrup, 2013) to be able to analyze and process the data. C++ was preferred to MS Excel (or VBA) mainly because the output from the information system was in form of two files (students and courses) with different structure and it was necessary to check the data for abnormalities (e.g. missing records in the year when the student stopped his/her study, more than two records about one course etc.).
First, descriptive statistics was used to find out more about current and former students of the Faculty of Social and Economic Studies, Jan Evangelista Purkyně University in Ústí nad Labem, Czech Republic. It was found, there is a difference in relative number of males and females in chosen study programmes. In Economics and management the ratio of male and female is approximately 45/55 in full time study and 35/65 in part time. In Regional development and Public Administration the ratio is around 25/75 in both study forms. The Social work is dominated by female students 15/85.

Table 1 shows relative number of males and females in chosen study programmes who started in academic year 2015/2016 and percentage of dropout according to their academic years (AY).

Year/Study program	Type	Gender	Started	1. AY	2. AY	3.AY	4. AY	5. AY
Economics and Management	Full-time	Male	45%	26%	26%	4%	5%	
		Female	55%	25%	20%	3%	2%	
	Part-time	Male	29%	47%	36%	3%	3%	
		Female	71%	41%	29%	5%		
Region. Dev. and Pub. Adm.	Full-time	Male	37%	34%	28%	19%	6%	
		Female	63%	47%	20%	4%		
	Part-time	Male	31%	67%	19%			
		Female	69%	47%	31%	3%		
Social Work	Full-time	Male	17%	18%	45%			
		Female	83%	30%	6%	8%	2%	4%
	Part-time	Male	10%	60%	7%	7%	13%	
		Female	90%	40%	12%	7%	3%	1%

Table 1: Percentage of male and female who started their study in bachelor's study programmes in academic year 2015/2016 and percent of dropout at their academic year (AY) (source: own calculation)

The dropout in their first academic year of the study program Economics and management is equally divided between male and female students in full-time study form.
Table 2 shows some of the most problematic mandatory courses as well as other courses with unusual dropout rate were identified for full-time study programmes.

Year/Failure rate	Semester	Type	2015/16	2016/17	2017/18	2018/19
Mathematics	1.	Mandatory	59.7%	52.3%	59.3%	61.3%
Public services	2.	Voluntary-mandatory	88.4%	85.9%	63.6%	63.6%
Regional Development: Introduction	1.	Mandatory	63.9%	42.4%	46.2%	34.6%
Methods of Scientific Work	2.	Mandatory	61.3%	61.5%	43%	41.7%
Statistics	2.	Mandatory	64%	58.2%	57%	62.1%
Regional Management	3.	Mandatory	-	56.8%	10%	60%

Table 2: Percentage of full-time students who failed to pass problematic courses at given academic years (source: own calculation)

Table 3 shows some of the most problematic mandatory courses as well as other courses with unusual dropout rate were identified for part-time study programmes.

Year/Failure rate	Semester	Type	2015/16	2016/17	2017/18	2018/19
Mathematics	1.	Mandatory	78.8%	66%	65.5%	65.8%
Public services	2.	Voluntary-mandatory	81.6%	86.4%	74.3%	63%
Regional Development: Introduction	1.	Mandatory	52.7%	67.9%	39.5%	41.7%
Methods of Scientific Work	2.	Mandatory	57.8%	76.1%	68.4%	62.5%
Statistics	2.	Mandatory	83.1%	62.9%	61.7%	69%
Regional Management	3.	Mandatory	-	46.4%	7.1%	57.1%

Table 3: Percentage of part-time students who failed to pass a course (source: own calculation)

Five out of six courses from the studied period take place in the first year of bachelors' study programmes.

Mathematics and Statistics are one of the courses with significant effect on students in the first year of study. Overall rate of unsuccessful students in Mathematics is around 60% in full-time students and from 65.5 to 78.8% in case of part-time students.
The overall rate of unsuccessful students in Statistics is around 60% in full-time students and from 61.7% to 83.1% in case of part-time students.
The course Public services take place in the second semester and students must choose between Public services and Managerial skills. The overall rate of unsuccessful students in Public services is from 63.6% to 88.4% in case of full-time students and from 63% to 86.4% in case of part-time students.
The Regional development: introduction is in the first semester and the overall rate of unsuccessful students is from 34.6% to 63.9% in full-time students and from 39.5% to 67.9% in case of part-time students.
The Methods of scientific work is one of the mandatory courses with the current dropout rate at 41.7% in full-time and 62.5% in part-time form, with the dropout rate in recent years over 61% in full-time and 76% in part-time study programmes.
Regional management is a mandatory course in the third semester. Overall rate of unsuccessful students is from 10% up to 60% in case of full-time students and from 7.1% up to 57.1% in case of part-time students. We were unable to identify reason of the one-year drop of unsuccessful rate.
After statistical description and identification of those courses with the highest dropout rate following hypothesis were tested.
Three sets of hypotheses focused on differences between full-time and part-time students were tested.

- H01: There is not statistically significant difference between the number of full-time and part-time students who passed or failed in an academic year in course Mathematics.
- A1: There is statistically significant difference between the number of full-time and part-time students who passed or failed in an academic year in course Mathematics.
- H02: There is not statistically significant difference between the number of full-time and part-time students who passed or failed in an academic year in course Statistics.
- A2: There is statistically significant difference between the number of full-time and part-time students who passed or failed in an academic year in course Statistics.
- H03: There is not statistically significant difference between the number of full-time and part-time students who finished their bachelors' study in three years in study program Economics and management.
- A3: There is statistically significant difference between the number of full-time and part-time students who finished their bachelors' study in three years in study program Economics and management.

Results

First set of hypotheses were tested with use of Pearson's chi-squared test (Pearson, 1900). Authors were not allowed to publish exact numbers of students in the courses. For this reason we publish only significance level in Table 4 at Chi critic at $\alpha = 0.05$.

Hypothesis	2015/16	2016/17	2017/18	2018/19
Mathematics (A1, H01)	0.005	0.262	0.738	0.706
Statistics (H02)	0.586	0.0877	0.619	0.187
Duration of study (A3)	0.0002	-	-	-

Table 4: Results of Pearson s chi-squared test, 2015-2018 (source: own calculation)

From these results, we can conclude, that in academic year 2015/2016 there is a significantly different success rate between the full-time and part-time students in course Mathematics. In later years there is not.
In all studied years, there is no significant difference between full- and part- time students' success rate in course Statistics.
These results show that the part-time students are not handicapped by the different form of study. The FSE provides study materials as well as consultations.
There is a significant difference between full-time and part-time students from the point of view of duration of their study. Bachelors' students of program Economics and management in the part-time form need significantly longer time to finish their study. The main reason is extensive work on bachelor theses. Part-time students need more time to prepare bachelor theses on the same quality level as full-time students.

Discussion

High percentage of students in the study programmes are leaving within the first academic year. Au-Yong-Oliveira et al. (2017) found that the adaptation in the first year is, not only the main obstacle to the successful beginning of their university studies, but it could be also another possible causes for the later dropout. The FSE offers courses to help our first year students (and those who have not started the first year yet) to refresh and improve their knowledge and skills in mathematics and languages. This measure helped to, despite dropping quality of candidates, keep requirements on students to pass courses at steady levels.
Hovdhaugen (2015) found that the students who work along full-time study have higher chance to dropout out of school. Also, this could be one of the factors, why the observed dropout rates of part-time students were higher than in case of full-time students. Hayes, Fry and Cummings (2018) suggested to make changes in study programmes for these students to meet their needs.
Dropout of students in early semesters is often caused by underestimating of how difficult it is to pass some courses. When the students realize this fact, it is already too late (Safrankova and Sedlacek, 2014). Zamkova, Prokop and Stolin (2016) analyzed data about Mathematics at College of Polytechnics in Jihlava, Czech Republic. In years 2006-2015 the success rate was decreasing but in our case from academic year 2015/2016 to 2018/2019 the success rate is increasing. In addition, the percentage of dropout in part-time study programmes is higher than in full-time study programmes as well.
Additional support in form of peer to peer consultations may be provided as well as additional interactive study materials to improve further motivation and success rate.
For part-time students it is more complicated, not only to meet their teachers in person, but to fulfill the requirements applied on full-time students (mainly the quality of bachelors' theses methodology, research design and data gathering) as well. This leads to extended time needed to successfully defend the theses. Overall success rate of bachelors' theses defense at first attempt is lower in case of part-time students. This fact also leads to the extended time needed to successfully finish their studies. Another factor could be that part-time students are on average older then full-time students and usually work full-time, have their own family and other time consuming activities that full-time students do not have. Berka, Vrabec and Marek (2019) also concluded that students who continue their university studies right after high school are more likely to finish their studies successfully.
Gascuena and Guadalupe (2012) observed that rewarding students for their assistance and participation in lectures is one of the significant factors that affects the success rate. Portfolio of possible tools how to effectively motivate part-time students is limited in comparison with full-time students. Reduction of differences between the ways how to motivate students of part and

full-time could be one of the possible ways to reduce the dropout rate. We can also further discuss whether the early dropout is positive or negative for stakeholders (Buizza et al., 2019), (Reissova, 2018).

Conclusion

The aim of this paper was to present and quantitatively analyze results of the most problematic (with the highest dropout rates) mandatory and mandatory voluntary courses as well as comparing male and female students dropout rates and success rates of all students in bachelors programmes. The Data from the University information system were exported, processed and evaluated, both by descriptive statistics and Pearson's chi-squared test.

It was confirmed, that most of the study programmes were dominated by female students, but dropout rates of male and female students were equally divided between both genders in full-time study form (e.g. study programme Economics and management). The most problematic courses with high dropout rates are among others Mathematics and Statistics. The part-time students have lower success rate than the full-time students in these courses. The sets of three hypotheses were tested. The authors were able to confirm, that there is a difference between the success rates of part-time and full-time students to the disadvantage of part-time students (in subjects Mathematics and Statistics).

Also, the students in part-time bachelor study programmes are usually not able to finish their study in standard 3 year course and need at least one additional year. The main reason for this is lower success rate at first attempt to defend their bachelors' theses and therefore extension of study time to the following academic year and second attempt to defend the theses. As (Safrankova and Sedlacek, 2014) found, students underestimate difficulty of particular course in the first year. Possible solution could be to move courses that are more demanding to the second semester of academic year. After they passed this transformation period, the success rate of students who are already familiar with all routines of study at a University should rise. This finding will be discussed by academics during preparations of a new version of study programmes.

References

Au-Yong-Oliveira, M., Vitoria, A., Silva, C., Carlos, V., Moutinho, V., Moreira, G. and Paiva D.G. (2017) 'Higher Education and the Problem of Abandonment - How Can We Keep Students from Leaving?', *Proceedings of the Inted2017: 11th International Technology, Education and Development Conference*, Valencia, pp. 7288–7298.

Berka, P., Vrabec, M. and Marek, L. (2019) 'Analyzing Bachelor Students Dropout at the University of Economics', *Proceedings of the 16th International Conference Efficiency and Responsibility in Education,* Prague, pp. 21–26.

Buizza, C., Ghilardi, A., Olivetti, E. and Costa, A. (2019) 'Dropouts from a university counselling service: a quantitative and qualitative study', *British Journal Of Guidance And Counselling*, vol. 47, pp. 590–602. https://doi.org/10.1080/03069885.2019.1566513

Deniz, U. (2020) 'The Hidden Crisis in Graduate Education: Why do Students Drop out of School?', *Pamukkale Universitesi Egitim Fakultesi Dergisi-Pamukkale University Journal Of Education*, pp. 61–83. https://doi.org/10.9779/pauefd.528019

Fortin, A., Sauve, L., Viger, C. and Landry, F. (2016) 'Nontraditional student withdrawal from undergraduate accounting programmes: A holistic perspective', *Accounting Education*, vol. 25, pp. 437–478. https://doi.org/10.1080/09639284.2016.1193034

Gascuena, C.M. and Guadalupe, R. (2012) 'Study About the Problem of Dropping of Subjects by Students During an Academic Year at the University', *Proceedings of the Inted2012: International Technology, Education and Development Conference*, Valencia, pp. 2588–2597.

Hayes, N.A., Fry, S.T., and Cummings, K. (2018) 'Designing a Writing Program for non-traditional adult students: A case study (HETL Scotland 2017)', *Journal of Applied Research in Higher Education*, vol. 10, pp. 130–139. https://doi.org/10.1108/JARHE-04-2017-0046
Heublein, U. (2014) 'Student Drop-out from German Higher Education Institutions', *European Journal Of Education*, vol. 49, pp. 497–513. https://doi.org/10.1111/ejed.12097
Hovdhaugen, E. (2015) 'Working while studying: the impact of term-time employment on dropout rates', *Journal Of Education Work*, vol. 28, pp. 631–651. https://doi.org/10.1080/13639080.2013.869311
Mesicek, L., Petrus, P. and Kovarova, K. (2019) 'Do Admission Procedure Scores Correlate with University Study Results?', *Proceedings of the 16th International Conference Efficiency and Responsibility in Education,* Prague, pp. 190–196.
Ministry of Education, Youth and Sports (2018) *Studijní úspěšnost na českých vysokých školách v roce 2018*, [Online], Available: http://www.msmt.cz/uploads/odbor_30/TF/Analyticke_materialy/Studijni_uspesnost_na_ceskych_vysokych_skolach_v_roce_2018.pdf [30 Jan 2020].
Ministry of Education, Youth and Sports (2019) *Vysoké školy zlepšují podmínky pro úspěšné studium*, [Online], Available: http://www.msmt.cz/ministerstvo/novinar/vysoke-skoly-zlepsuji-podminky-pro-uspesne-studium [24 Jan 2020].
Newberry, B.L., Miller, R. and Stevenson, R.A. (2011) 'Engineering Enrollment Retention Improvement by Application of the Wright State Mathematics Education Model', *Proceedings of the Asee Annual Conference and Exposition*, Vancouver.
Pearson, K. (1900) 'On the criterion that a given system of deviations from the probable in the case of a correlated system of variables is such that it can be reasonably supposed to have arisen from random sampling', *Philosophical Magazine*, vol. 5, pp. 157–175. https://doi.org/10.1080/14786440009463897
Reissova, A. (2018) 'Why Students Fail to Finish University (current Dilemma: To Study or to Work?)', *Proceedings of the 15th International Conference Efficiency and Responsibility in Education (ERIE 2018),* Prague, pp. 290–298.
Safrankova, H. and Sedlacek, J. (2014) 'Manager Primary Tools in the Hands of Students of "Aite" Subject', *Proceedings of the Hradecke Ekonomicke Dny 2014: Ekonomicky Rozvoj a Management Regionu*, Hradec Kralove, pp. 204–210.
Salas-Morera, L., Antonia Cejas-Molina, M., Olivares-Olmedilla, J.L., Garcia-Hernandez, L. and Palomo-Romero, J.M. (2019) 'Factors Affecting Engineering Students Dropout: A Case Study', *International Journal Of Engineering Education,* vol. 35, pp. 156–167.
Stroustrup, B. (2013) *The C++ Programming language*, Boston: Addison-Wesley.
Zamkova, M., Prokop, M. and Stolin, R. (2016) 'Mathematics Exam Success Rate at the College of Polytechnics Jihlava (2006-2015)', *Proceedings of the 13th International Conference Efficiency and Responsibility in Education (ERIE 2016),* Prague, pp. 674–681.

PRIMARY SCHOOL TEACHERS' PERCEPTION OF THE CLASSROOM CLIMATE: CREATING AND INFLUENCING IT

[1]Hana Mončeková, [2]✉Miluše Vítečková, [1]Miroslav Procházka, [1]Martina Faltová

[1]Department of Pedagogy and Psychology, Faculty of Education, University of South Bohemia in České Budějovice, Czech Republic

[2]Department of Pedagogy and Psychology, Faculty of Education, University of South Bohemia in České Budějovice, Czech Republic, mviteckova@pf.jcu.cz

Abstract

The presented paper provides results obtained from two research projects realized under the aegis of the Grant Agency of South Bohemia University in České Budějovice (*Preparedness of students and graduates of the Faculty of Education of the South Bohemia University on solving behaviour issues of pupils*, and *School – a threat or a chance for vulnerable individuals?*) The aim of the partial research realized within the two projects was to evaluate primary school teachers' perception of the classroom climate, and the way that they influence this climate through various teaching methods and strategies. Selected participant teachers answered questions related to the climate in their current classrooms. Their answers were compared to data obtained from the questionnaire "Naše třída" (Our Class). Overall, the research provided data from six questionnaire-based surveys of "Naše třída" in primary school classes and six interviews with the tutors of tested classes.

Keywords

Classroom climate, diagnostics, primary school, teacher

Introduction

Educational research targets classroom climate phenomena on a regular basis. One of the key factors connected to the quality of a school, primarily given by the fundamental characteristics of its climate and simultaneously the requirement for the creation of an educationally supportive environment, is the quality of the relationship between all participants of the educational process. According to this claim, we consider the ability to intervene in the classroom environment and influence the quality of the classroom climate with a communication style and personal and social competences as one of the key qualities of an efficient teacher. Our research provides a current perspective on the classroom climate, and it attempts to identify the personal beliefs and experiences of primary school teachers as they contribute to creating a positive classroom climate. According to Petlák (2006), since all participants remain in continuous mutual contact, and they influence and continually change their social environment, the term climate is generally defined as both, the phenomenon and the process. Průcha (2013) emphasizes the effect of communicative and teaching techniques of teachers on the climate (in the sense of a positive/supporting climate, or on the other hand a defending/defensive climate), as well as their preferences and expectations. Pupils in a given class also influence the climate, and the climate of the classes then reflects the climate of the whole school. Průcha (2013) adds the important fact that various authors understand the concept of the classroom climate differently, and they describe various important factors. In addition, Mareš (1998) points out the ambiguity of the terminology and its further attributions (as education climate, social environment, etc.). Most authors agree on the definition of a teacher as a participant of an educational process who influences the classroom climate extensively. This perspective is based on the generally affirmed influence of an adult on children's development of

socializing and educative effects (e. g. Bronfenbrenner, 1996; Helus, 2004; Králik and Mahrik, 2019; Matějček, 2003).

In the context of creating the classroom climate, Spilková (2013) describes teachers as one of the major forces in that they are able to influence the climate in a positive way – through the way they communicate, by the strategies and methods of their teaching, or through the form of an assessment. Similarly, Čapek (2010) emphasizes that the teacher is responsible for the climate evaluation as well as for initiating positive relationships, equality in communication, partnership and cooperation, safe environment, and appropriate teaching strategies and teaching assessment in class. In connection to the relationship with teacher, another effect of classroom climate is important to mention, as Jensen and Solheim (2019) emphasize, and this effect is represented by the influence of the emotional classroom climate on the burnout effect of the teacher. Lašek and Mareš (1991) comment on the fact that most previous research considered the teacher to be the creator of the classroom climate. Contemporary concepts work with the theory that teachers create the classroom climate together with pupils. Pupils should be defined as participants fully involved in classroom life. Research connected to teachers' efficiency (Walls et. al., 2002) describes the ability of the pupils' involvement, in the sense of the teachers supporting them in discussions and mutual interactions, as one of the characteristics of classroom life. Specific skills of teachers required for working with the classroom climate are described and specified by Koštrnová (2014). We also need to emphasize the important fact that pupils' perception of the classroom climate is highly individual (Rohatgi and Scherer, 2020). However, according to Eliam (2019), emotions expressed by people and specified as autonomic rhythmic oscillators are able to synchronize themselves mutually.

The classroom climate is also influenced by a number of social aspects (Lašek, 2012) such as the specifics of a given school (the type of school, specialization of the school, school rules, etc.), the specifics of the study subjects, (practical learning in laboratories, etc.), or personal characteristics of the pupils, teachers, etc. According to Mareš (1998), to evaluate the classroom climate, we need to integrate the variables such as the level of school, concept of the teaching (traditional, alternative), or the specific and distinctive traits of communication. Gracmanová (2008) sees an important influence on the classroom climate in the contexts of ecology (position of class, class equipment, teaching aids, classroom modification), demographic factors (number of pupils, the ratio between girls and boys in the classroom), and the personal interests of participants in the classroom climate, preceding knowledge, and the qualities and competencies of teachers. Gracmanová (2008) adds that other important factors influencing the educational climate are also the age of the pupils, gender, values, interests, and attitudes. In addition, according to Barrientos, Sánchez and Arigita (2019), Gutiérrez-Torres and Buitrago-Velandia (2019), it is important to respect pupils' emotional intelligence and their preparedness on working with the classroom climate as well. Spilková (2013) presents three different key aspects that are represented by the emotional aspect (safety, well-being, trust, assurance, happiness x sorrow, fear, tension), the social aspect (respect, thoughtfulness, tolerance, empathy x competitiveness, tattling, envy, mockery), and the learning rules aspect (respecting the rules, concentration, finishing activities, hardworking x distracting, passivity, boredom, laziness). Predominate aspects lead to either a positive or a negative climate.

The aspects mentioned above indicate the essential role of the teacher. According to Petlák (2006), teachers create the desired classroom climate mainly through their authenticity, empathy, honesty, and acceptance of every pupil in the class. The more empathetic a teacher is, the better his/her level of understating the needs of individuals and the whole class will be. Karns (1995) assumes that in order to have a real influence on the climate, teachers should not be passive and automatically anticipate their pupils' obedience and attachment. Teachers should play a role in the

life of pupils, and they should build a proper mutual relationship. As expected, primary school teachers tend to have a closer relationship to their pupils, because they are used to spend a larger part of the day together, resulting in the pupils' tendency to create a strong bond with them. Salend (2008) adds the fact that a teacher with a positive attitude towards children should use this ability to create a positive classroom climate.

According to prior facts and to Salend (2008) describing the teacher as one of the major aspects influencing the classroom climate, this presented paper and its outcomes are oriented towards primary school teachers' perspective on classroom climate and on the possibilities connected to creating and influencing it. The research was realized as a part of two projects financed by the South Bohemia University grant agency *The preparedness of students and graduates of the Faculty of Education of South Bohemia University on solving behaviour issues of pupils*, and *School – a threat or a chance for vulnerable individuals?* Both projects were aimed at the topics of school discipline and preparedness of teachers to create positive classroom climate in their classes. The aim of the partial research was to examine, how primary school teachers' perceive the classroom climate, how they influence this climate, and the strategies and methods they use in this process. Teachers involved in this research were interviewed about the current situation in their classes. As the results of his research, Lašek (2012) mentions that teachers of primary schools tend to evaluate the classroom climate in a more negative way than the pupils themselves do. One part of this research, a questionnaire-based survey "Naše třída" (Our class) entered by primary school pupils, is oriented towards verifying this claim.

Materials and Methods

The survey was realized in two stages. The first stage consisted of interviews with primary school teachers. We addressed experienced teachers practicing teaching for at least ten years. Since the research was not primarily oriented towards long-term experience with creating the classroom climate, but rather teachers' work with the current climate was involved, we added the condition that teachers had to spend at least two years by teaching in the class participated in the research. This condition was essential for the teachers' ability to describe the achievements and difficulties they encountered.

The second stage of the research consisted of a questionnaire-based survey realized by the questionnaire "Naše třída" (Our Class, Lašek 2012), designed for pupils from the third to sixth grades of primary school. This scale was respected in the process of selecting eligible classrooms along with the condition of the selection of classes taught by teachers participating in the first stage of this research. Lašek (2012) claims that the type of school partly influences the classroom climate as well. We selected six school collectives consisted of two city schools (400 – 600 pupils), two rural schools (up to 200 pupils), and two small rural schools (up to 30 pupils). All participant teachers were well-experienced in teaching. The research sample consisted of six teachers (interviewed) and their pupils (questionnaire "Naše třída") (see table 1). The selection of schools was intentional, based on the conditions specified above – the type of selected schools.

The interviews were recorded, transcribed, and analysed via the system of open coding (Straus and Corbinová, 1999). The presented paper provides an interpretative technique called "laying cards" (Šeďová, 2007). The questionnaire used in the "Naše třída" survey was evaluated according to Lašek and Mareš (1991), and the results were interpreted on the basis of a comparison of resulting values. These values, along with the description of the situation according to class tutor, are presented below.

Teacher	Length of practice	Class	Number of pupils in class	Type of school
Romana	21	4	25	City school
Hana	31	3	25	City school
Eva	20	3	20	Rural school
Lenka	30	4	24	Rural school
Věra	41	2, 3, 5	14	Small rural school
Jana	38	1, 4	16	Small rural school

Table 1: Research sample characteristics

Results

Regarding the question of the meaning of the term "classroom climate" for the teachers, they mainly connect it with positive feelings. The most common term used within their answer was well-being – the classroom climate is represented by a safe environment without stress for the children. Very frequently, teachers described more general subjects in their answers. However in terms of the classroom climate, they tend to be concerned more about the pupils than themselves. In connection with the classroom climate, only Eva mentions the teacher: "For me, the classroom climate is represented by a good mood, the children's good feeling of going to school and having energy, as well as the teacher who should be enthusiastic about his work." Teachers also commented on the importance of positive mutual relationships between pupils and of coexistence without bullying. They did not mention the mutual relationship between the teacher and pupils.

What methods do teachers use in order to fulfil their idea of a positive classroom climate? Despite the fact that teachers did not reflect the role of a teacher, the answers show the tendency to influence a great part of classroom life, which clearly refers to the very important role of the teacher in creating and maintaining the classroom climate. The interviews provided the following categories: *effort to teach children collegiality*, *effort to cooperate*, *the use of suitable forms and methods of teaching*, *success for everyone*, *consistency and justice*, *diagnostics*.

Teachers mentioned making classroom rules, using different types of assessments, group work, dramatization, mind maps, and game-based activities oriented towards communication between pupils and cooperation and trust as the most important part of the teaching process. Another important part of creating a positive climate is community circle providing pupils with the opportunity to get to know each other, as well as solving possible problems and practicing rules of communication, listening, and expressing opinions. In addition to these methods, teachers added the beneficial aspects of organizing non-school events and meetings outside of school, for example, adaptation courses – the teacher and pupils get to know each other in a different environment from school, which leads to deeper and more familiar relationships free from the prejudices connected to teaching.

Despite their efforts, however, teachers admitted that in some classes was not possible to create the desired climate. They refer to the composition of the class collective as the main reason for such a failure. This proves our claim of the importance of involving pupils in the context of creating the classroom climate. Teachers emphasized one important fact – working with the classroom climate and influencing it are both connected to the length of their teaching practice and experience. None of the interviewed teachers was convinced that their university studies helped them to be more prepared to practice. They mentioned that various types of training courses provided them with new ideas, but not in a form of compact instructions ready to be implemented into their teaching practice.

The text provides a comparison of rural and city school teachers' perception of the climate in their current classes with data obtained from the questionnaire-based survey "Naše třída". Interestingly, the teachers perceive the classroom climate more positively than pupils, which opposes Lašek's conclusions (2012).

Variables	Arithmetic mean in a given class				Arithmetic mean according to Lašek and Mareš (1991)	Range of common values (Lašek and Mareš, 1991)
	City school		*Rural school*			
	4th grade (Romana)	3rd grade (Hana)	*4th grade* (Lenka)	*3rd grade* (Eva)		
Cohesiveness	9	8.8	8	7.5	9.6	6.4 – 12.9
Contentment	12.96	14.1	11.9	12.5	12.2	10.0 – 14.4
Friction	8.83	8	9.8	10.6	9.9	6.9 – 13.1
Competitiveness	8.65	9.6	11	13	12.2	9.7 – 14.8
Difficulty of learning	6.74	6	8.6	7.9	8.6	6.2 – 11.1

Table 2: Data gained from the questionnaire „Naše třída" in selected classes (source: own calculation)

Romana (21 years of teaching practice, fourth grade, 25 pupils, city school specialized in sports) describes her class as a "lively and joyful collective" According to Romana, the "lively" collective is caused mainly by the presence of athletes showing a high level of competitiveness, which is reflected in their learning as well. According to the questionnaire-survey results, we can determine that the level of pupils' Contentment in school is quite high (12.96). The lower level of classroom Consistency (9) would be caused by problematic relationships between pupils, as mentioned by the teacher of the class. According to the results, the classroom climate should be expected as "joyful" and positive, as the teacher stated. To improve the classroom climate, one possible way would be to strengthen the classroom relationships.

Hana (31 years, third grade, 25 pupils, city school) comments on the climate of her current classroom in terms of "calm and cosiness". She stated that she likes to work in an easy-going and funny environment, but pupils tend to take advantage of such situations – often they are not able to understand the necessity of coming back from fun to learning. The teacher claims that pupils get along very well and help each other, despite the fact that one child's behaviour deviates from the rest of the class, and other children do not accept him well. The classroom climate is described as stable and maintained. In general, the realized questionnaire-based survey provided results showing the children's high level of Contentment in school. Values reaching the maximum point of the scale represent an important aspect in evaluating a positive classroom climate, despite the fact that some of the pupils expressed their negative feelings associated with going to school. The interview with the teacher regarding the cooperation and collaboration of children indicated slightly different values of the given variable, as was discovered by the questionnaire afterwards.

Lenka is an experienced teacher with thirty years of teaching practice (fourth grade, 24 pupils, rural school). She admits a certain discrepancy in the class – she would divide the class collective into calm children and children with a tendency to tease and provoke others, which naturally causes frictions. Referring to the classroom climate as "quite stable", she believes she is able to solve current issues in the class, but she is aware of new problematic issues recently appearing. Despite the issues addressed by the teacher, the pupils evaluate their class in a positive way, although the level of Contentment is slightly lower than the average level of contentment among pupil participants of previous research realized by Lašek and Mareš (1991). Cohesiveness of the class collective is evaluated on a lower level with the value reaching only to the point eight of fifteen – this was partly confirmed by the teacher as well. Surprisingly, the level of Friction complies with average values. Based on the teacher's reference to a frequent occurrence of this particular aspect in the class, we would have expected a rather high level.

Eva (20 years of teaching practice, third grade, 20 pupils, rural school) evaluates her contemporary class as "positive, playful, and rarely bored". The teacher claims that the collective is very cohesive, children have positive mutual relationships with each other. The questionnaire results show that despite the claims of teacher evaluating mutual relationships positively, the children do not experience

a high level of Cohesiveness in their class collective (the value reaches the lower limit). According to the pupils, the level of Competitiveness is quite high; this corresponds to the teacher's claim about arguments between children caused by their efforts to be in first place. Improving levels of values of Competitiveness and Friction would probably lead to an improvement in mutual relationships within the class collective.

The survey realized in small rural school classes showed that Cohesiveness of one of the examined class collectives oscillates around the values of lower average, which could possibly be caused by differences in the age of children (second, third, and fifth grades together), however, this fact was not proven in another class that participated in the research. Both examined small rural schools demonstrated very high level in the aspect of Contentment with classroom life. The level of Competitiveness and Friction both show low values. Due to the necessity of working individually in age-heterogeneous class, pupils do not express a high level of learning difficulties.

All results provided can be considered as optimal and reflecting an efficient classroom climate. According to the teachers, pupils can feel a safe climate due to a "family" environment leading to better acquaintances and making deeper connections. The level of alienation should be possibly lower than in larger, fully organized city schools. Lašek (2012) mentions the influence of the school type on the climate of individual classrooms. Our research does not provide results leading to the generalization of findings; our research sample did not show a significant relation between classroom climate and type of school. However, in means of classroom climate, the type of selected school grade (primary school) should definitely be considered.

Discussion

All participant teachers expressed similar opinions on the definition of classroom climate: a peaceful and easy-going environment for all participants. This definition demonstrates the interesting fact that teachers do not express differences in terminology in proper terms as climate, environment, or atmosphere, as for example Průcha provides (2002), but they express themselves intuitively and use terms in free combinations. Similar to experts in a given field (ex. Spilková, 2013), teachers emphasize two important factors influencing the learning process and being a part of an educational environment: the importance of experience and emotional involvement. Connected to the classroom climate, teachers also emphasize the importance of content mutual relationships, coexistence in a class with no oppression, calm for learning, and an active environment. Although the question for teachers was oriented only to the classroom climate in its general definition and general characteristics, teachers provided answers indicating a positive perception of climate instead of neutral expressions – for example, teachers used characteristics such as good environment, comfortable environment, positive environment for learning, etc., instead of a classroom environment in general terms. Mareš (1998) emphasizes that some authors tend to work with expressive terminology evaluating subject matter in a positive way instead of neutral.

According to literature, the teacher is one of the major factors influencing the classroom climate. Petlák, for example (2006), states that it is primarily the teacher, who influences the classroom climate in a positive way. Research interviews provided different data: interviewed teachers tended to determine pupils, their feelings, and experiencing and relationships in class as the major forces creating the classroom climate. In connection with the classroom climate, they did not reflect the position of the teacher, and neither did they mention the importance of the relationship between teacher and pupil. Bendová (2017), however, claims that the relationship between teacher and pupil is crucial not only for achieving better learning results, but also for improving the quality of class in a complex way.

Teachers also mentioned issues influencing the creation of a positive classroom climate connected to inappropriate or deviating behaviour of either the individual or the entire group. Pupils suffering from behaviour or attention disorders tend to be named as one of the major factors influencing the classroom

climate. Teachers associate inappropriate behaviour with distorted communication between children, the lack of elementary politeness, and disrupted discipline. In connection with an improvement in bad behaviour habits, they describe similar steps as Olivar (1992): to teach children to listen to each other, to greet, to say thank you, to ask politely, to be able to wait patiently, and to know how to ask for something. Teachers try to teach pupils to communicate properly on special occasions ("communication circles") that considerably support mutual communication. Moore (2007) describes the potential of this method in detail. In order to support cooperation among pupils, teachers also employ proper forms and methods of teaching.

In conclusion, despite the fact that teachers did not integrate themselves into the definition of the climate in the interviews, they are aware of their ability to influence the classroom climate, thus becoming a major influencing factor. Teachers described a number of other activities integrated into their teaching (adaptation of teaching, empathetic approach, diagnostics, consistency, making rules, etc.) which they use in order to influence the classroom climate. We can perceive not only their interest in the issue of the classroom climate, but also the personal belief of being able to have a direct influence on it. Spilková (2013), Čapek (2010), Lašek (2012), Mareš (1998) and others describe teachers in terms of being strong (in some cases the strongest) factor of the classroom climate, since they are able to change the climate through different approaches to teaching. This claim is in concord with the results of our research.

Conclusion

The classroom climate is one of the major indicators of how relationships function in school. The paradox is that the participants, being continually influenced by the climate, also create the climate itself. As a result, numerous social relationships arise between the participants of the learning process, burdened by the loss of general trust in creating a quality of mutual relationships. An analysis of the perception of this mutual coexistence in educational processes of both teachers and pupils, and an examination of their mutual relationships and coherence are all crucial aspects of evaluating the classroom climate. Our research has proven teachers' interconnection of the climate to individual characteristics of pupils or subgroups participating in the classroom group. The participants of our survey are fully aware of their influence on creating the classroom climate; they link it with their ability to be empathetic and with a consistent approach and resistance to expressions of indiscipline as well. The problem with discipline and behaviour is considered to be one of the major sources of relationship destruction within a classroom group. Research detected one of the key issues that contemporary schools are dealing with: the teachers' ability to manage a negative manifestation of pupils' behaviour, while maintaining their positive relationship with the children. For this process to be efficient, the teacher should be socially and personally competent on a high level.

Acknowledgement

This article was supported by the University of South Bohemia in České Budějovice (JU) under the grant entitled School – threat or a chance for vulnerable individuals?, number GAJU 117/2019/S and under the grant entitled Preparedness of students and graduates of the Faculty of Education of the South Bohemia University on solving behaviour issues of pupils, number GAJU 154/2016/S.

References

Barrientos, A., Sánchez, R. and Arigita, A. (2019) 'Formación emocional del profesorado y gestión del clima de suaula', *Praxis & Saber*, vol. 10, no. 24, pp. 119-141, https://doi.org/10.19053/22160159.v10.n25.2019.9894

Bendová, A. (2017) 'Jak přežít třídnictví aneb Inspirace pro začínající třídní učitele', *Komenský,* vol. 142, no. 1, pp. 11-16.

Bronfenbrenner, U. (1996) *The ecology of human development: experiments by nature and design.* 9th edition. Cambridge: Harvard University Press.
Čapek, R. (2010) *Třídní klima a školní klima*. Praha: Grada.
Eilam, E. (2019) 'Synchronization: a framework for examining emotional climate in classes', *Palgrave Communications*, vol. 5, no. 144. http://doi.org/10.1057/s41599-019-0356-0
Gutiérrez-Torres, A. M. and Buitrago-Velandia, S. J. (2019) 'Las Habilidades Socioemocionales de los Docentes, herramientas de paz en la escuela', *Praxis & Saber*, vol. 10, no. 24, pp. 167-192. https://doi.org/10.19053/22160159.v10.n25.2019.9819
Helus, Z. (2004) *Dítě v osobnostním pojetí: obrat k dítěti jako výzva a úkol pro učitele i rodiče*. Praha: Portál.
Jensen, M.T. and Solheim, O.J. (2020) 'Exploring associations between supervisory support, teacher burnout and classroom emotional climate: the moderating role of pupil teacher ratio', *Educational Psychology*, vol. 40, no. 3, pp. 367-388. https://doi.org/10.1080/01443410.2019.1673881
Karns, M. (1995) *Jak budovat dobrý vztah mezi učitelem a žákem: zásady a cvičení*. Praha: Portál.
Koštrnová, D. (2014) *Tvorba a rozvoj pozitívnej klímy v triede*. Bratislava: Metodicko-pedagogické centrum.
Králik, R. and Mahrik, T. (2019) 'Interpersonal relationships as the basis of student moral formation', *Proceedings of ICERI2019 Conference 11th-13th November 2019*, Seville, Spain, pp. 8896-8900.
Lašek, J. (2012). *Sociálně psychologické klima školních tříd a školy*. 3th edition. Hradec Králové: Gaudeamus.
Lašek, J. and Mareš, J. (1991) 'Jak změřit sociální klima třídy', *Pedagogická revue*, vol. 43, no. 6, pp. 401-410.
Mareš, J. (1998) *Sociální klima školní třídy*. Praha: Asociace školní psychologie ČR a SR, Institut pedagogicko-psychologického poradenství ČR.
Matějček, Z. (2003) *Co děti nejvíce potřebují.* Praha: Portál.
Moore, K.D. (2007) *Classroom teaching skills*. 6 th edition. Boston, MA: McGraw-Hill.
Olivar, R.R. (1992) *Etická výchova: Učeb. texty pre vyučovanie predmetu na zákl. a stred. školách*. Bratislava: Orbis pictus istropolitana.
Petlák, E. (2006) *Klíma školy a klíma triedy*. Bratislava: IRIS.
Průcha, J. (2002) 'Sociální klima ve třídách českých škol: porovnání nálezů z empirických šetření'*, Sborník prací Filozofické fakulty brněnské univerzity.*
Průcha, J. (2013). *Moderní pedagogika*. 5th edition. Praha: Portál.
Rohatgi, A. and Scherer, R. (2020) 'Identifying profiles of students' school climate perceptions using PISA 2015 data', *Large-scale Assess Educ*, vol. 8, no. 4. https://doi.org/10.1186/s40536-020-00083-0
Salend, S. J. (2008) *Creating inclusive classrooms: effective and reflective practices*. 6th edition. Upper Saddle River, N.J.: Pearson Merrill Prentice Hall.
Spilková, V. (2013) 'Klima školy je zásadním aspektem pro utváření osobnosti dítěte: mnohdy bohužel nedoceňujeme význam sociálně emocionálního klimatu školy a třídy pro socializaci dítěte', *Moderní vyučování: časopis na podporu rozvoje škol*, vol. 19, no. 3-4, pp. 4-6.
Strauss, A. and Corbin, J. (1999) *Základy kvalitativního výzkumu*. Boskovice: Albert.
Šeďová, K. (2007). 'Analýza kvalitativních dat', in Švaříček, R., Šeďová, K. et al. *Kvalitativní výzkum v pedagogických vědách.* Praha: Portál, pp. 207-247.
Walls, R.T. et al. (2002) 'The Characteristic of Effective and Ineffective teachers', *Teacher Education Quartely*, vol. 29, no. 1, pp. 39-48. https://www.jstor.org/stable/23478326

DIVERSITY OF STUDENTS' INFORMATION BEHAVIOUR WITHIN A DIGITAL LEARNING ENVIRONMENT

[1]Tatiana Noskova, [2]✉Tatiana Pavlova, [1]Olga Yakovleva

[1]Herzen State Pedagogical University of Russia, Russian Federation
[2]Herzen State Pedagogical University of Russia, Russian Federation, pavtatbor@gmail.com

Abstract

Students' information behaviour in the digital environment is considered as an indicator of their engagement in various educational activities that contribute to the personalisation of learning. The results of a survey on students' preferences of information resources in the digital environment show that learners use a variety of information sources, but they mainly use the methods of work in the "traditional" learning paradigm. They insufficiently use the digital environment potential of collaboration, knowledge exchange, and knowledge extraction from authentic sources. Obtained data indicates problems in students' information culture and shortcomings in the methodological support of students' autonomous work.

Keywords

Information behaviour, digital environment, personalisation of learning, information culture, higher education, student

Introduction

Modern education prepares students for effective activities in the knowledge society, based on the possession of knowledge and the ability to use it. P. Drucker emphasised the importance of "universal skills to use and systematically acquire knowledge as the basis for efficiency, qualifications and achievements…" (Drucker, 2017, p. 298).

Digital learning environment comprises social experience, scientific knowledge and educational resources that work efficiently due to the capabilities of multimedia, interactivity, customisation and productivity. Consequently, methods and technologies of "traditional" education should change in order to serve students' productivity in the digital learning environment.

One of the most important educational goals is shaping students' active learning position in relation to available information resources. Such position presumes perception of educational, cultural, and professional information sources not only from the sight of assimilation for solving particular learning problems, but also as a means of self-development that ensures success and competitiveness in the contemporary labour market. Particularly important become such learning skills as a self-directed information search and knowledge extraction, an acquisition of prospective ways to apply knowledge in various situations, creative and research activities in the extensive digital environment. In this context, students' autonomous learning plays an important role and ensures self-education and self-organisation, which are demanded for the lifelong learning.

In a complex, rapidly changing world, a comprehensive support of a person as a "full-fledged" author of his life is significant for education, because it helps to expand the range of learning outcomes (Wannemacher, 2016). We need a focused transition from a traditional reproductive students' interaction with educational resources, to the productive methods that provide the ability to construct knowledge in personal or joint activities and to produce new information

products. The implementation of such a paradigm is impossible without personalisation of learning activities.

Publications on e-learning and digital learning technologies often focus on the content and formats of learning resources (Lafuente, 2017; Lopez-Rosenfeld, 2017; Nau, 2017). However, internal psychological factors (attitudes, motivations, aspirations of a learner) also determine the effectiveness of a knowledge extraction. Accordingly, in the digital environment, not only a diversity of content, resource presentation modes and teaching methods should be considered by a teacher, but also a "cognising subject" (a learner) and his information behaviour (Noskova, Yakovleva, Pavlova, Smyrnova-Trybulska, 2018).

The main question of the paper is how diverse are students' information preferences in the digital learning environment. We hypothesise that students use a variety of information sources, but they mainly use the methods of work that they have mastered in the "traditional" (face-to-face) learning paradigm. To a lesser extent, they use the potential of the digital environment associated with collaboration, knowledge exchange, and knowledge extraction from non-adapted (authentic) sources. In other words, students do not use the entire potential of the digital learning environment, which may indicate problems in students' information culture and shortcomings in the methodological support of students' autonomous work.

The paper comprises several sections that describe a theoretical background of the study (what is information behaviour and which sources are available for students in the reach digital environment), methods and materials of the research (aims and structure of the questionnaire for bachelor students), analysis of the obtained results and further discussion of the main issues revealed.

Theoretical background

By student's information behaviour, we understand the entirety of human efforts and actions that ensure the search, assimilation, use and creation of new knowledge, together with its transmission and dissemination in the society (Spink and Cole, 2004; Wilson, 2000; Hayman, Smith & Storrs, 2018). Information behaviour is also considered as a reflection of a personal information culture.

Existing pedagogical practices in the digital environment need to be enriched with personality-oriented non-linear educational technologies, providing students a sufficient freedom of learning actions and a possibility of personally understood educational results with a satisfaction in the learning process (Laptev, Noskova, 2013). Digital environment instructional design should take into account students' information behaviour models, because the larger part of current learners are digital natives (Noskova, Pavlova, Yakovleva, 2016;. Hayman, Smith & Storrs, 2018; Smith, 2017). Such practices require both technological and methodological restructuring of a resource equipment for students' autonomous work. In order to promote a productive information behaviour of students within a particular learning task framework, a teacher can arrange various learning activities based on the choice of resources, learning methods and digital tools. At the same time, a teacher needs to reveal and analyse students' preferences in a wide range of their information activities.

Students' information behaviour analysis in the digital environment denotes new opportunities for interaction with information and people in the process of solving educational problems. Figure 1 shows a multilevel resource environment of a contemporary student, incorporating both didactically transformed and untransformed ("raw") information.

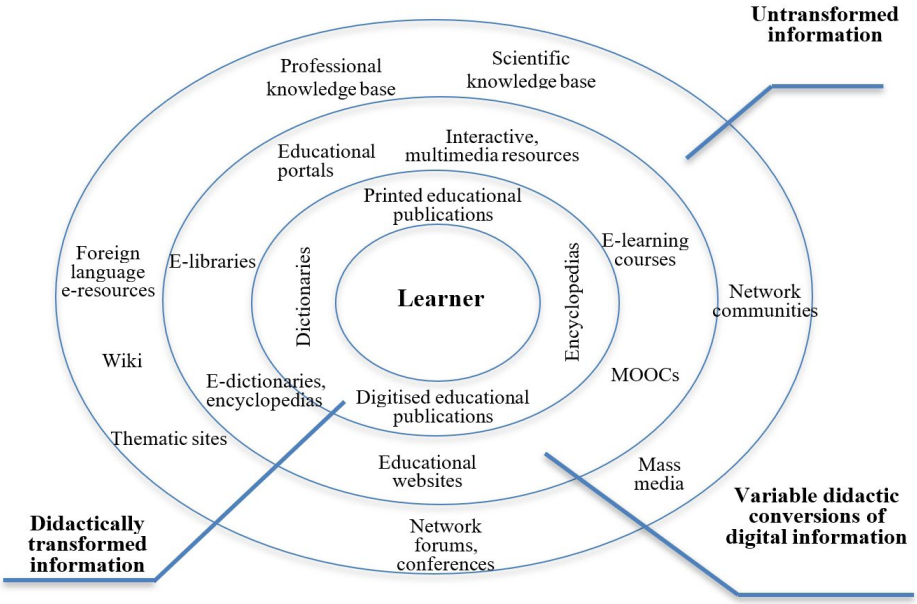


Figure 1: Resource environment of a modern student (source: own work)

Materials and Methods

In order to identify a diversity of students' information behaviour in the digital learning environment, a survey was conducted for the first-year bachelor students of the Herzen University. The sample was chosen for several reasons. Firstly, during the first year, students are adapting to the university (e.g., they understand the organisation of the learning process, requirements, rules and recommended sources of information). Secondly, in further learning, they will make use of an autonomous work with information sources even more; therefore, it is necessary to identify problematic aspects that should be analysed.

For this purpose, a questionnaire was elaborated. In total, 500 respondents were questioned to reveal their understanding of various strategies to interact with digital learning resources and to assess their preferences in digital tools. Respondents were asked to relate statements connected to their behaviour strategies and use of digital resources to a 5-point scale (1 point – never or almost never, 2 points – very rarely, 3 – rarely, 4 – quite often, 5 – very often or constantly).

The questionnaire consisted of several sections, combining questions related to the following aspects.

Knowledge acquisition:

- Students' preferences in terms of digital learning content (digitised printed publications, video lectures recorded by teachers, digital presentations and visualisations, interactive content, etc.)
- Selection of reliable, relevant information in various formats;
- Memorisation;
- Comprehension;

A sample question: “Evaluate your preferences in the ways of memorising the necessary terms and facts: tests for training and self-control, flash card applications, interactive timelines, traditional memorisation”.

Knowledge application:

- Processing of digital learning information;
- Analytical and synthetic processing of digital learning information extracted from multiple information sources;
- Attitude to gamification.

A sample question: “Evaluate your preferences in the ways of applying the acquired knowledge: traditional assignments; discussions; peer assessment; compilation of tests, crosswords, quizzes, games; scribing”.

Designing a personal information environment:

- Use of MOOCs, micro-learning, mobile resources;
- Personal learning resources data base;
- Demand to improve skills determining effective interaction with digital educational information.

A sample question: “Evaluate your preferences regarding the use of MOOCs in the process of study: tests, lecture fragments, MOOC for the purpose of obtaining a certificate, MOOC for self-education”.

Joint network activities with digital learning content:

- Collaborate learning;
- Discussions;
- Collaborate digital products;
- Virtual labs, gaming environments.

A sample question: “Evaluate your preferences regarding joint network activities with digital learning content: co-editing documents, online discussion, joint development of digital products, interaction in digital environments”.

Pedagogical support of learners’ information behavior:

- Assessment criteria;
- Deadlines;
- Reminders;
- Penalty points;
- Progress bar;
- Rating;
- Badges.

A sample question: “Evaluate your preferences in teachers’ management of your learning activities: clear assessment criteria, strict deadlines, reminders, penalty points, progress bar, rating, badges”.

Overall, the data on 42 variables was collected and analysed. The answers underwent statistical analysis: descriptive statistics for all questions, including distribution of answers to questions

for all respondents. The relationship between the survey questions was analysed with the Spearman's rank correlation coefficient. All results were considered significant at $p<0.05$. The analysis was performed with the statistical package STATISTICA v. 12.0 (StatSoft. Inc., Tulsa, Oklahoma, USA).

Results

The respondents rated all sources of information and strategies for working with them above the average level of significance (the median of none of the variables was lower than 3). However, the most interesting are the variables that students rated the highest (Me=5) and the lowest (Me=3). They are presented in Figure 2.

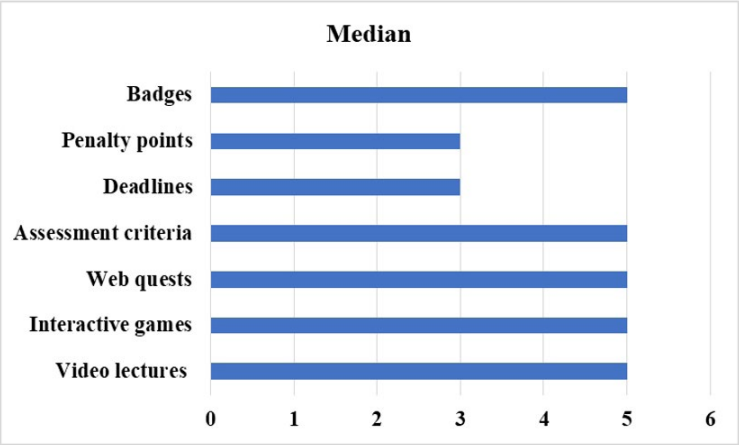


Figure 2: Students' preferences in the interactions with a digital educational content (source: own calculation)

The generalised histogram shows a relatively even distribution of students' attitudes to various techniques that organise interaction with a digital educational content. We see that the most highly rated are interactive, gaming, multimedia tools and methods. Consequently, students prefer high-quality educational videos and interactive training programmes. In addition, students gave a low evaluation to the "hard" methods of pedagogical support (ratings, strict deadlines, and penalty points), feeling that these methods are discrepant from the information behaviour freedom in the digital learning environment. The deeper analysis showed that students do not highly appreciate peer-to-peer evaluation in the process of interacting with digital educational content. This probably indicates a lack of experience and an inadequate understanding of the opportunities of such techniques.

The study particularly analysed data on students' preferences regarding sources of digital educational information (Table 1).

The data demonstrates that traditional digitised printed publications still occupy a leading position among the sources of educational information, but learners realise a variety of digital alternatives. However, at the same time, more troubling is that almost 48% of students noted they often use information from unreliable sources. These findings indicate both a low information culture of students and shortcomings in the methodological support of students' autonomous work.

Sources of information \ Scoring	1	2	3	4	5
Digitised educational publications within an e-course	14	21	20	33	16
E-libraries	3	7	21	32	41
Portals and data bases	1	9	21	34	39
Educational video channels and podcasts	6	6	22	23	47
Official scientific and educational sites	2	4	16	38	44
Mass media	3	10	31	29	31
Reputable professionals and scientists personal sites	7	13	25	39	30
Information sites of unspecified affiliation	28	24	8	25	19
Open digital educational resources	2	7	12	28	55
File hosting and torrent trackers	19	14	23	22	26

Table 1: A variety of digital educational information sources used by students, in % (source: own calculation)

The correlation analysis helped to find relations between the significance of the variables. In the first block of the questionnaire (knowledge acquisition), the closest correlation was found between the variables "tests for self-control" and "tests for training" (r=0.6). In the second block (knowledge application), the correlations between the variables "flashcards" and "interactive timelines" (r=0.7), "interactive games" and "mindmaps" (r=0.6), "infographics" and "quiz making" (r=0.4) were found. In the third block (designing a personal information environment), the correlation between the variables "MOOC lectures" and "MOOC tests" (r=0.7) was revealed. In the fourth block (joint network activities with digital learning content), the correlation between the variables "network discussions" and "virtual labs, gaming environments" was found (r=0.5), together with the correlation between "web quests" and "didactic games with a virtual agent" (r=0.8). In the last block (pedagogical support of learners' information behaviour), the correlations were found between the variables "progress bar" and "badges" (r=0.6), "deadlines" and "penalty points" (r=0.7).

We see that students perceive the digital learning environment as something created for them and objectively prepared for use. None of the variables that related to the design of a personal information environment and joint network activities with a digital learning content received the maximum scores.

The survey shows that students are familiar with a variety of capabilities that allow them to interact actively with digital educational content, process it, and create an individualised information product. Preferences regarding gamification are clearly expressed, and that indicates students' willingness to learn interactively. Students prefer educational video content, the source of which can be both open video channels and online courses (videos with a high level of static and dynamic visualisation, expert explanation, and emotional expressiveness). Nevertheless, encouraged to implement various computer practices, many still prefer traditional educational resources. Students demand an interactive learning content almost equally with traditional texts, and teachers should not ignore this. Respective to the modern educational process, methods of interaction with digital educational content assume a variety of learning activities, and at the same time require special efforts of teachers and students to minimise risks of the digital information environment redundancy.

Discussion

The information technology development demonstrates a proactive influence on educational environment design that enables new forms, methods and technologies of learning activities. The learning activity shifts toward interactivity, variability, and ambiguity of learning contexts. This

trend is reflected in the educational science research (Takev et al, 2019; Farrow, De los Arcos, Pitt, 2016).

The digital learning environment gives the ground for the personalisation of learning. It is important to review the indicators of an efficient information behavior and make efforts to support students' self-management, initiative in learning and personal productivity.

Personalisation of information behaviour in the digital learning environment as one of the problems of education (Han & Ellis, 2020). Personalisation requires a simultaneous consideration of many factors. Quantities and correlations of these factors are not constant and alter in the educational process. Personalisation of learning is ensured by both an active student's position and a quality of digital learning environment (information, communication, management conditions). If we strive to design a diverse digital environment and provide students with a choice of learning activities, we need to be aware that by the means of a "manual control", it is not feasible to support students' interaction with "redundant" learning resources. The digital learning environment has special tools for a dynamic data analysis (users' input and their so-called "digital footprints") to provide a deeper information on learners' decisions and activities.

Conclusion

The issues of students' information behavior, their capabilities, interests, aspirations and initiatives in the digital learning environment, need further reflection. This complex problem leads to a new pedagogical design of the digital learning environment, its methodological and technological transformation. Students' open learning position, innovative ways for productive interaction with information are of particular importance, because knowledge and technology change rapidly. The value of the ability to learn independently, to choose optimal resources, strategies and tools increases significantly. On the one hand, diverse activities with the digital content are highly demanded by students, but their expectations are not always justified by real educational practices. On the other hand, students sometimes prefer to act in traditional ways, having insufficient experience of an autonomous learning activity in an open digital environment.

Acknowledgement

The research was supported by the Russian Science Foundation (RSF), Project "Digitalisation of the high school professional training in the context of education foresight 2035", № 19-18-00108.

References

Takev, M., Rodriguez-Artacho, M. and Somova, E. (2019). Creating interactive and traceable epub learning content from Moodle courses, *Mathematics and Informatics*, vol. 62, no. 4, pp. 459-470.

Drucker, P. (2017) 'The Age of Discontinuity: Guidelines to Our Changing Society', *Routledge*, Taylor & Francis Group, p. 298.

Farrow, R., De los Arcos, B., Pitt, R. (2016) 'Who are the open learners? A Comparative study profiling non-formal users of open educational resources'*, European Journal of Open, Distance and E-Learning,* vol. 18, no. 2, pp. 49-731. https://doi.org/10.1515/eurodl-2015-0013

Han, F.F., Ellis, R. 'Personalised learning networks in the university blended learning context', *Comunicar,* vol. 28, no. 62, pp. 19-30.

Hayman, R., Smith, E.E. and Storrs, H. (2019) 'Information behavior of undergraduate students using Facebook Confessions for educational purposes'. *In Proceedings of RAILS - Research Applications Information and Library Studies*, *Faculty of Information Technology, Monash University, 28-30 November 2018. Information Research,* vol. 24, no. 3. [Online], Available: http://InformationR.net/ir/24-3/rails/rails1809.html

Lafuente, M. (2017) 'Getting looped in to the web: characterizing learning processes and educational responses', *Interactive Learning Environments*, vol. 25, no. 1, pp. 72-84. https://doi.org/10.1080/10494820.2015.1116014
Laptev, V., Noskova, T. (2013) 'Professional training in digital network environment', *Higher Education in Russia*, vol. 2. pp. 79-83.
Lopez-Rosenfeld, M. (2017) 'Tell me and I forget, teach me and I may remember, involve me and I learn: Changing the approach of teaching computer organization', *In Proceedings – 2017 IEEE/ACM 1st International Workshop on Software Engineering Curricula for Millennials, SECM 2017*, pp. 68– 71.
Nau, S. (2017) 'From Understanding Net Generation Expectation to Sustainable Student Engagement', *In: Issa T., Isaias P., Issa T. (Eds) Sustainability, Green IT and Education Strategies in the Twenty-first Century. Green Energy and Technology*. Springer, Cham, pp. 63–76. https://doi.org/10.1007/978-3-319-57070-9_4
Noskova, T., Pavlova, T., Yakovleva, O. (2016) 'Analysis of domestic and international approaches to the advanced educational practices in the electronic network environment', *Integratsiya obrazovaniya,* vol. 20, no. 85, pp. 456-467. https://doi.org/10.15507/1991-9468.085.020.201604.456-467
Noskova, T., Yakovleva, O., Pavlova, T., Smyrnova-Trybulska, E. (2018) 'Strategies of students' information behavior in the context of lifelong learning', *Open Education,* vol. 22, pp. 25-34. http://dx.doi.org/10.21686/1818-4243-2018-3-25-34
Smith, E. (2017). 'Social media in undergraduate learning: categories and characteristics', *International Journal of Educational Technology in Higher Education*, vol. 14, no. 1, pp. 2-24 https://doi.org/10.1186/s41239-017-0049-y
Spink, A., Cole, C. (2004) 'New Directions in Human Information Behavior', *Springer; 2006 edition*, pp. 256. https://doi.org/10.1007/1-4020-3670-1
Wang, V.X. (2016). Handbook of Research on Learning Outcomes and Opportunities in the Digital Age (pp. 1-851). Hershey, PA: IGI Global. https://doi.org/10.4018/978-1-4666-9577-1
Wannemacher, K. et al. (2016) 'Digitale Lernszenarien im Hochschulbereich', *Vorgelegt von HIS-Institut für Hochschulentwicklung (HIS-HE).* Arbeitspapier, no. 15, p.114, [Online], Available: https://www.uni-heidelberg.de/md/journal/2016/05/pub_hfd_digitale_lernszenarien.pdf
Wilson, T. (2000) 'Human Information Behavior', *Informing Science*, vol. 3, no. 2, pp. 49-55. https://doi.org/10.28945/57610.28945/576

HIDDEN TEACHER'S INCENTIVES IN TEACHING MATHEMATICS (A CASE STUDY)

[1]✉Jarmila Novotná, [2]Alena Hošpesová

[1]Faculty of Education, Charles University, Czech Republic, jarmila.novotna@pedf.cuni.cz
[2]Faculty of Education, University of South Bohemia in České Budějovice, Czech Republic

Abstract

The paper studies types of teacher's hidden incentives (in Brousseau's Theory of Didactical Situations called *Topaze effect*) in teaching mathematics. The method used is the method of multiple case study. Transcripts of communication between two teachers (from two schools) and their 14-15 year old pupils in ten consecutive lessons of mathematics are analysed. Several types of explicit (overt) and implicit (covert) teacher's prompting are detected. The study characterizes and illustrates these types of a teacher's behaviour (Topaze effect) using examples of classroom dialogue and makes conjectures about their reasons. The influence of Topaze effect on quality of pupils' understanding of mathematics and cultivation of (mathematical) thinking is discussed.

Keywords

14-15 old pupils, mathematics teaching, teacher's incentives, Theory of Didactical Situations, Topaze effect

Introduction

For a long time, research on mathematics education paid attention to social dimensions of pupils' learning as one of the factors affecting individual ways of acquiring and using knowledge and of cultivation of mathematical thinking (Gellert, Knipping and Straehler-Pohl, 2018; Yackel and Cobb, 1996; Forman, 1996). Brousseau (1997) explained the impact of the teaching/learning environment on pupils' thinking using the concept of *didactical contract.* The didactical contract includes a set of a teacher's behaviours (specific for the taught knowledge) expected by pupils, and a set of the pupil's behaviour anticipated by the teacher. This 'contract' has actually been 'contracted' neither explicitly nor implicitly between the teacher and their pupils and its regulation and criteria of satisfaction can never be really expressed precisely by either of the parties (Brousseau, 1997; Sarrazy, 2002; Brousseau and Sarrazy, 2002). Mutual interactions between the teacher and their pupils may produce unwanted effects and developments (e.g. the Topaze effect, the Jourdain effect, metacognitive shift, an improper use of analogy, Brousseau, 1997; Brousseau and Sarrazy, 2002). These effects and developments are not good for learning, especially from the metacognitive perspective, but are often inevitable (Binterová, Hošpesová and Novotná, 2006). Although they are not harmful individually, their systematic use is destructive.

In this text, we focus on the *Topaze effect*. The Topaze effect can be described as follows: When the teacher wants their pupils to be active (find an answer on their own) and they cannot, the teacher disguises the expected answer or performance by various behaviours or attitudes, without providing the answer explicitly. In order to help the pupil to give the expected answer, the teacher 'suggests' the answer, hiding it behind progressively more transparent didactical coding. During this process, the knowledge necessary to produce the answer changes (Brousseau, 1997). In most cases, the use of the Topaze effect is accompanied by lowering the level of intellectual demand of the task. We believe that its occurrence in a teaching episode influences significantly the quality of the anticipated learning process.

Characterisation of the Topaze effect given implies that its occurrence does not contribute to pupils' understanding of mathematics. However, this is not always true. In some cases, finding the correct answer (even using the Topaze effect) can help the pupil to reconsider the original task "through the eyes of the correct solution" and then to grasp mathematical ideas that would probably not be reached without getting the correct answer.
Our hypothesis is teachers have a unique repertoire of hints leading to didactical situations called the Topaze effect. We focus on the following research question: What types of hints leading to the Topaze effects appear in mathematics lessons and how can they be classified?
The text is divided in the following sections: Materials and Methods, Results, Discussion and Conclusion.

Materials and Methods

Data collection

Mathematics lesson data for this study were collected in two lower secondary schools in a county town with approximately 100,000 inhabitants in the 8th grade of compulsory school attendance (pupils aged 14-15). One of the schools (marked Sch1) is a school, the so called lower secondary grammar school, offers a more academic alternative to lower secondary education. The second school (Sch2) is a mainstream school. Both teachers are experienced and respected by parents, colleagues and educators. (Novotná and Hošpesová, 2007)
Ten consecutive lessons on the same topic (linear equations) in two 8th grade classrooms from Sch1 and Sch2 were recorded. The method of data collection was based on Learner's Perspective Study (LPS) framework (Clarke, Keitel and Shimizu, 2006). That means: three cameras were used, all pupils' and teacher's productions were documented. Immediately after the lesson, interviews with the teacher and a chosen pair of pupils were conducted. The interviews were video recorded. Later all video recordings were transcribed.

Data analysis

The study was a continuation of the authors' previous research (Novotná and Hošpesová, 2007) "mapping" the occurrence of hints leading to the Topaze effect in the Czech mathematics lessons. The qualitative methodology was used to distinguish different types of hints. In the first phase, both researchers (authors of this paper) analysed the transcripts and identified the places where they could observe the Topaze effect. In the following discussion, the researchers agreed that different forms of Topaze effect could be distinguished. These findings were confronted with data from post-lesson interviews. This confrontation revealed that the use of different forms of Topaze effect was related to the teacher's intentions.

Results

In our data, we classified the hints given by the teacher leading to the Topaze effect into nine types. The hints differ considerably in relations to being either explicitly stated or only implicitly suggested by the teacher. Let us recall here that the Topaze effect can only be considered when a previously explained subject matter is discussed. It is not connected to the process of explanation (Novotná and Hošpesová, 2007). We classified the following types of hints in the analysed lessons:
Explicit (overt) teacher's prompting can be of the following nature:

a) explanation of steps which pupils are expected to follow, although the procedure is obvious/ well known,
b) questions anticipating/prompting the subsequent solving procedure, pupils are not expected to answer,

c) warning on a possible mistake,
d) recollection of previous experience or knowledge e.g. by pointing out an analogy, either with a problem type or with a previously solved problem, although it is obvious/well known.

Implicit (covert) teacher's prompting can be of the following nature:
a) rephrasing of their own or pupils' statements,
b) use of signal words,
c) saying the beginning of words,
d) asking questions that lead to a simplification of the solving process,
e) doubting correctness in situations where the pupil's answer is not correct or suitable.

Let us illustrate the situations leading to the Topaze effect using examples from our data.
Explicit types of the Topaze effect seem to be connected with the teachers' anticipation of problems. In some moments, the teacher needs a specific pupil response that will result in achieving the teacher's plan. The purpose of "warning" the pupils is the teacher's aim to secure smooth course of the lesson. In our data we identified different types of warning.

Explanation of steps which pupils are expected to follow

Explanation of steps which pupils are expected to follow was used by both teachers whenever they wanted to ensure that each step of the solving process was clear to their pupils. This could be connected with the need to respect formal aspects. For example (in Sch1, L10, 37:54)[1] the teacher and her pupils solved the following problem together: *The sum of two consecutive natural numbers and their triples is 92. What are the numbers?* The teacher directed the communication – she put notes on the blackboard. The pupils followed this communication and wrote everything down in their exercise books. Steps numbered 7, 9, 10 are examples of this type of the Topaze effect.

1	Teacher:	Yes. What will the first number look like, Adam?
2	Adam:	x. [*T writes on the blackboard: 1st number…… x.*]
3	T:	Well done. And what will the second number look like, David?
4	David:	x + 1 [*T writes on the blackboard: 2nd number…… x + 1.*]
5	T:	Well done. So. And now, Lenka, make an equation from it, Lenka.
6	Lenka:	x + x + 1
7	T:	This is the sum of two consecutive natural numbers. [*T writes on the blackboard: x + x + 1…*]
8	Lenka:	3x
9	T:	And of their triples, yes. [*T continues:… + 3x + 3(x + 1)…*]
10	T:	You should say plus.
11	Lenka:	… 3x + 3(x + 1)
12	T:	Correct.
13	Lenka:	Equals 92. [*T finishes… = 92.*]
14	T:	Correct. Equals 92. Yes.

Questions anticipating/giving a hint on the subsequent solving procedure where no answer is expected

Often the teachers asked their pupils to state how the solving would proceed. We consider

1 The transcripts from the classroom are labelled as follows: Sch1 (1st school), L10 (Lesson 10), time of the beginning of the episode. In order to facilitate referring to the individual steps of the transcripts in the text, the steps are numbered sequentially.

a situation in which pupil does not respond or react correctly but the teacher continues following the original plan to be a manifestation of the Topaze effect. For example, in Sch1, L10, 41:18 the teacher invited her pupils to suggest how to carry on with solving of the word problem on common work of two mowers. Her pupils did not react. The teacher hinted the simple calculation.

15 T: So, and now. So what is the idea?
16 Pupils: …
17 T: In one hour, the first mower alone…?

Warning on a possible mistake

In some cases, teachers guided by their rich teaching experience and by their intention to avoid possible pupils' confusion warned their pupils straight away on mistakes that could be made. This teachers' behaviour suggests that mistakes are not taken as a useful part of the learning process. Occurrence of this type of the Topaze effect is very frequent, no matter if the warning is expressed implicitly or explicitly. We distinguish a lot of examples of this in different lessons (Sch1, L09, 2:25): "Some of you now feel you are really good, that you know it, and you start doing shortcuts by heart. Please, don't do that…". Or the teacher warns the pupil who forgot a step of solution (Sch1, L02, 28:59): "You forgot something.… How did I do it here?"

Pointing out an analogy

Pointing out analogies is of different forms. The most frequent types are recollection of a problem type, recollection of a previously solved similar problem. In case of linear equations, teachers in both schools pointed out that such equations had already been taught in lower grades, for example (Sch1, L03, 40:47): "So once more. How was it? How did we learn it? First sometimes in the 3rd grade or when, a long time ago, you learned it for the first time."

In addition to explicit prompting, a variety of ***implicit prompting*** was found in the lesson data.

Rephrasing

The question "How could you put this in different words?" was used whenever the pupils' explanations were essentially correct but inaccurately formulated. Rephrasing should help pupils understand what is and is not a sufficient explanation. It may be that these reformulations were not necessary for other pupils because they joined in the dialogue with the teacher easily. In transcript (Sch1, L10, 44:54) steps 20 and 22 are examples of this type of the Topaze effect:

18 T: What is it, 8 tenths from one hour?
19 S: It is about…
20 T: Not about. One tenth of one hour is…
21 S: 6 minutes.
22 T: 6 minutes and thus, 8 tenths is, Vítek?

Using signal words

Teachers often guided the solving process with the help of signal words used in their questions and instructions, e.g. in analysis of a word problem (Sch1, L10, 5:32) steps 23 and 25:

23 T: Problems about common work, we already know how to solve them. These are those that?
24 S: Equal 1.
25 T: With the 1, are they?

Saying the beginnings of words

In this type of the Topaze effect, teachers give the beginnings of words that they want to hear

from their pupils. Usually, it is used when the teacher is not able to formulate a suitable question. A typical example is the following excerpt from a discussion (Sch1, L10, 13:02) when naming geometrical shapes (step 28):

26 T: What is it, a tetrahedron? What does it look like?
27 S: It is a pyramid with a triangular base.
28 T: Triangular, and all the faces are what?… eeee eq eq eq…
29 S: equilateral.

Asking questions that lead to simplification of the solving process

Simplification of the situation by focusing on substeps often results in disintegration of the solving process and pupils' loss of insight. In the example (Sch2, L10, 27:50), the teacher does not react to the pupil's mistake; she formulates a question that requires only a simple calculation (step 32).

30 T: What time is 1/12 of an hour if an hour is 60 minutes?
31 Pupil: No, 1/5.
32 T: 60 divided by 12?
33 Pupil: 5.
34 T: 5 minutes.

Doubting correctness

When the pupil's answer was wrong, the teacher sometimes did not react to the incorrect statement but doubted its correctness indirectly (Sch1, L10, 13:57) (steps 37, 39):

35 T: What will it be, foot of a height?
36 S1: Centre
37 T: Centre, which centre?
38 S2: Orthocentre.
39 T: Will it be an orthocentre? It will be…
40 S3: … intersection of the axes of angles and sides.
41 T: Axes of sides as well as of angles. Just in view of the fact that the triangles are
42 S4: … equilateral.
43 T: Equilateral.

Discussion

We conclude from our observations that the frequent occurrence of the Topaze effect in mathematics lessons in our study was motivated by the teacher's belief that pupils must carry out a series of similar procedures and that their pupils need this type of teacher's support for successful solution of the given tasks. This was repeatedly confirmed in the post lesson interviews. For example, in the post lesson interview after Lesson 5 (Sch1, L05), the teacher expressed the following belief: "Even if we do it with older pupils, almost nobody is able to solve it on their own the second time. Well, as long as it is stereotypical, you see, the algorithm is always the same, there is no exception, then perhaps the pupils will be able to solve it on their own." This thought is consistent with the teacher's dominating teaching style in which the Topaze effect was frequently identified (Sarrazy and Novotná, 2005). In the observed sequences of lessons, we could see that teachers explained mathematical concepts and solving procedures to the whole class most of the time. In general, the lessons were conducted in an orderly manner and all pupils were disciplined. We are convinced that this classroom climate is the consequence of the teachers' teaching style.

With respect to pupils, a frequent occurrence of the Topaze effect often results in a decrease of pupils' responsibility for successful solution of the given mathematical problems. This conjecture was confirmed in post-lesson interviews (Sch1, L06): "… if it (the problem) was somehow

different, I would probably not solve it." Brousseau and Sarrazy (2002: 9) stated in this respect:

> The teacher begs for a sign that the student is following him, and steadily lowers the conditions under which the student will wind up producing the desired response. In the end the teacher has taken on everything important about the work. The answer that the student is supposed to give is determined at the outset, and the teacher chooses questions to which this answer can be given. Obviously the knowledge required to produce the answer changes its meaning as well.

We are fully aware of the shortcomings of our study. Firstly: we take this qualitative study important for gaining a deeper knowledge of what is happening in the mathematical class. It does not allow us to state how many teachers use help leading to the situations called the Topaze effect, how many times, in what subjects etc. Secondly: it is difficult to verify experimentally the impact (in our opinion negative) on pupils' learning/cognition because there is a number of variables affecting teaching experiments that are difficult to eliminate entirely. We have demonstrated that the Topaze effect formulated by Brousseau (1997) in the conditions of French schools also happens in some other cultures, namely in the Czech Republic. We believe that the Topaze effect occurs also in other countries.

Our study opens new questions that need further research. Is the teacher aware of this behaviour? Are pupils aware that the teacher is trying to "help"? Is it welcome? Are there patterns in teachers' behaviours having a significant influence on the amount and type of applications of the Topaze effect? Are the patterns of Topaze effect really linked to specific cultures and educational systems or do they depend more on the personality and individual teaching style of the teacher? Answers to these questions may become more found if, for example, an analysis of LPS data from more countries is conducted.

Conclusion

In this study, we tried to show different types of hints leading to the Topaze effect used by teachers quite naturally and equally naturally expected by pupils. These hints are built into the didactic contract (in the sense used by Brousseau, 1997). Teachers use them usually not quite consciously, as they are rooted in teachers' deeper pedagogical belief about the help that pupils need during lessons (not only) of mathematics. Unlike the so called 'good' questions (see e.g. Jančaříková and Novotná, 2019), overusing Topaze effect in the learning process fails to work with one of the key elements – mistake, its recognition and elimination; pupils' competence to solve the problems individually and to judge the correctness of a solution is not developed.

Acknowledgements

This research was partially supported by the grant GA JU 121/2019/S Educational content for the development of mathematical thinking and informatics.

References

Binterová, H., Hošpesová, A. and Novotná, J. (2006) 'Constitution of the Classroom Environment: A Case Study', *Mathematics Classrooms in Twelve Countries. The Insider's Perspective*, Rotterdam/Taipei: Sense Publishers, pp. 275-288.

Brousseau, G. (1997) *Theory of Didactical situations in mathematics 1970-1990*. Kluwer Academic Publishers.

Brousseau, G. and Sarrazy, B. (2002) *Glossaire de quelques concepts de la théorie des situations didactiques en mathématiques*, Bordeaux: DAEST, Université Bordeaux 2.

Clarke, D., Keitel, C. and Shimizu, Y. (2006) *Mathematics classrooms in twelve countries*. *The Insider's Perspective*, Rotterdam/Taipei: Sense publ. http://dx.doi.org/10.1163/9789087901622

Forman, E. (1996) 'Learning mathematics as participation in classroom practice: Implications of sociocultural theory for educational reform', *Theories of mathematical learning*, Mahwah, NJ: Lawrence Erlbaum Associates, pp. 115-130.
Gellert, U., Knipping, C. and Straehler-Pohl, H. (2018) *Inside the Mathematics Class: Sociological Perspectives on Participation, Inclusion, and Enhancement*, Springer International Publishing. http://dx.doi.org/10.1007/978-3-319-79045-9
Jančaříková, K. and Novotná, J. (2019) 'Posing good questions – Why are good questions posed not always good?', Proceedings of ERIE 2019, Prague: CULS, pp. 105-112.
Novotná, J. and Hošpesová, A. (2007) 'What is the Price of Topaze?', *Proceedings of the 31st Conference of the International Group for the PME*, Seoul: PME, vol. 4, pp. 25-32.
Sarrazy, B. (2002) 'Effects of variability on responsiveness to the didactic contract in problem-solving among students of 9-10 years', *European Journal of Psychology of Education*, vol. XVII, no. 4, pp. 321-341. http://dx.doi.org/10.1007/BF03173589
Sarrazy, B. and Novotná, J. (2005) 'Didactical contract: Theoretical frame for the analysis of phenomena of teaching mathematics', *Proceedings of SEMT 05*. Prague: Univerzita Karlova v Praze, Pedagogická fakulta, pp. 33-45.
Yackel, E. and Cobb, P. (1996) 'Sociomathematical norms, argumentation, and autonomy in mathematics', *Journal for Research in Mathematics Education*, vol. 22, pp. 390-408.

USE OF GAMIFICATION IN LECTURES USING THE KAHOOT! TOOL

[1]✉Ladislav Pilař, [2]Lucie Kvasničková Stanislavská, [2]Kateřina Kuralová

[1]Department of Management, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, pilarl@pef.czu.cz

[2]Department of Management, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

Technological development and social changes bring new gamification tools to teaching to increase the motivation of students and to facilitate the learning process. One such tool is Kahoot!, a formative evaluation tool. The aim of this article is to identify the attitudes of students to the use of gamification in lectures using the Kahoot! tool. The data were obtained through a questionnaire survey using the Likert scale and modus, mean and Mann-Whitney test was used to describe results. The results show that students consider using the Kahoot! tool in the lectures to be objective, entertaining and encouraging the motivation of students, including the positive impact on the learning process. A partial result is the finding that students would like to expand the use of the Kahoot! tool for other lectures too. The possibilities of further research are discussed in the article.

Keywords

Assessment tool, gamification, Kahoot!, learning motivation, Mann-Whitney test

Introduction

At the present, we can see a growing interest in research into how the motivation and engagement of students affect their learning (Koivisto and Hamari, 2019; Rodrigues, Oliveira and Rodrigues, 2019). It is assumed that technology can help the learning process and that is why educational institutions are introducing these technologies to encourage the motivation and engagement of students (Zainuddin et al., 2020). It has been found that the responses of students to games support their involvement, increase group dynamics and improve the overall learning experience of students. In particular, educational games and gamification are used to support the development of the cognitive, motivational, emotional and social perspectives of students (Licorish et al., 2017). Gamification is a technique that influences motivation and players engagements, mainly in the field of education, by creating more interesting forms of learning activities (Pilař et al., 2016, 2017; Kusuma et al., 2018). According to (Pilar et al., 2019), education is the most communicated topic on the Twitter social network in connection with gamification. The progress in technical infrastructure and teaching technology (Wang, 2015; Chaiyo and Nokham, 2017) and change in courses, such as reducing the volume of contact teaching in full-time study to half and the course content to be not so much theoretical, but more interesting for students, and more practically focused. (Kučera, Kvasnička and Krejčí, 2012) on the side of school, as well as the fact that students today commonly bring their own digital devices into the classroom (Subhash and Cudney, 2018), enable the use of new teaching tools as the Kahoot! tool. “Kahoot! is a game-based learning platform used to review students’ knowledge, for formative assessment or as a break from traditional classroom activities” (Wang and Tahir, 2020). Using gamification tools like Kahoot! enables teachers to engage their students in creative learning skills and attractive competition in an innovative way (Zainuddin et al., 2020). The implementation of Kahoot!

does not require prior training in teaching and therefore its use by teachers is easy (Plump and LaRosa, 2017). When using Kahoot! In the classroom, teachers log on to the Kahoot! website (https://getkahoot.com) to create questions for students. Then they automatically receive a generated code that they tell the students. Then they enter the code in the Kahoot! on their digital devices and register their name there. While playing Kahoot! those students who score correctly and faster than the others earn points (Chiang, 2020). The on-screen display of points motivates the students to reach the top of the rank. The quizzes can be enhanced with pictures and videos and the teacher is able to control the pace of the game (Plump and LaRosa, 2017).

Based on a literature review of 93 studies, (Wang and Tahir, 2020) identified a positive impact on learning, the dynamics of the study group, student and teacher attitudes and student anxiety through the Kahoot! tool. However, these findings cannot be generalized because there is study (Moutinho and Sa, 2018) where the positive effect of gamification is not conclusive. The main barriers in the research area may be a problem there, such as technical problems (e.g. internet connection, difficult questions and answers on the screen, inability to change the response after submission), stressful factor of the time to answer, fear of loss or of failure to respond correctly.

The aim of the article is to identify the attitudes of students to the use of gamification in the lectures using the Kahoot! tool.

Materials and Methods

The data were obtained through an online questionnaire survey which was sent to the students in the course via mass notification in the Moodle system in two waves. The participants were the students of the elective course Online Marketing. They were the students of the 1st year of a follow-up master study program Business Administration, Economics and Management Public Administration and Regional Development at the Faculty of Economics and Management, Czech University of Life Sciences Prague. In total, 201 students attended the course, 104 students participated in the questionnaire survey, which represents an 51.7% return.

The Kahoot! tool was incorporated into the lectures of the course Online Marketing. Its use was included at the end of each lecture where it was used to verify the knowledge that the students were presented during the lecture. At the end of each lecture, one game was launched that contained three questions. There were 3 quiz-type questions in each round. During the first 5 lectures the best 10 students received 3 points for the exam and during the subsequent 5 lectures the best 15 students received 5 points for the exam. In total, one student could get a maximum of 40 points for the exam. The exam was evaluated by a maximum of 100 points with subsequent evaluation (100-90 points - excellent; 89-75 points - very good; 74-60 points - good; 59-0 points - failed). The exam took place in the test module in the Moodle system where students could get a maximum of 70 points from the exam test. The average score was 52 points. In the exercises the students could get a maximum of 30 points for processing the seminar papers where the average value was 21 points. The average student thus gained 73 points, which corresponds to the grade “good”. At the end of each round, the best 3 students were announced and a table of the best 10 (15) students was put on the screen. The ID (student e-mail) was used to identify the students and to add the points.

The online questionnaire survey was conducted in January 2020. A total of 14 statements were formulated in the record sheet, with which the participants should have expressed their agreement or disagreement expressed on the Likert scale from 1 (strong disagreement) to 5 (strong agreement).

Median, Mean was used for statistical evaluation. 65% of women and 35% of men participated in the questionnaire survey. To compare the difference between men and women, the non-parametric test (Mann-Whitney U test) was used to compare response levels, since the data are ordinal (scale 1-5). *P*-values less than 0.05 are marked in bold (see table 1).
The research hypotheses were as follows:

- Hypothesis H_0: The respondent's gender does not influence his or her opinion on the tested issue.
- Hypothesis H_a: The respondent's gender influences his or her opinion on the tested issue.

Results and Discussion

The results of the study show that the students strongly agree that the lecture is more fun when using the Kahoot! tool. This confirms the conclusions of the study performed by Chiang (Chiang, 2020) and (Bicen and Kocakoyun, 2018) according to which learning using the Kahoot! tool is more fun for students, or by (Iwamoto et al., 2017) where students evaluated the Kahoot! tool to be attractive and entertaining. Students would also like to expand the use of the Kahoot! tool for the other lectures; especially women who preferred this option more often than men (see Table 1). They also strongly agreed that the evaluation of the results using the Kahoot! tool in the Online Marketing lectures is objective and they especially appreciated the immediate feedback. Thanks to the fact that the Kahoot! tool gives students immediate feedback, it allows them to immediately compare their knowledge with other students and they can see their ranking in a group of their classmates (Iwamoto et al., 2017; Basuki and Hidayati, 2019; Orhan Göksün and Gürsoy, 2019). The students also agreed with the statement that the use of the Kahoot! tool in the Online Marketing lectures is useful; thanks to the Kahoot! tool they had to be more attentive in the lecture to know the answers to the test questions, and they are convinced that attending the lectures positively influenced the successful passing of the exam. As in many studies (Licorish et al., 2017; Bicen and Kocakoyun, 2018; Lee et al., 2019; Orhan Göksün and Gürsoy, 2019), also the results of this study confirmed that the Kahoot! tool increased the motivation of students as well as their participation in the lectures. In this field women agreed more than men (see table 1). The students also confirmed that the Kahoot! tool increased their ambition to be among the best. This is also stated by (Orhan Göksün and Gürsoy, 2019), according to whom students consider the competitive environment to be entertaining and it motivates them to achieve better results. It is also possible to find a statistically significant difference in this area, namely that men agreed more than women. The students also agreed with the statement that they liked to show their achievements through the Kahoot! tool at the end of the lectures.
The students expressed their neutral attitude that they would feel bad when they were not successful using the Kahoot! tool. Despite neutral expression, a statistically significant difference can be found in this area. Men felt worse when they was unsuccessful using the Kahoot! Also, this study did not confirm that the Kahoot! tool would allow students to practice time management skills. Overall, it is important in future studies to focus on gender impact in the context of gamification, as there are studies that confirm gender differences in gamification, for example Tondello et al. (2019) and studies confirming that the effect of gamification is independent of age and gender, for example Putz, Hofbauer and Treiblmaier (2020). As confirmed by our study, there are certain elements of gamification where it is possible to find gender diversity and certain elements where it is not (see table 1).

	Men (n = 36)				Women (n = 68)				Mann-Whitney test	
	Med	Mea	S.E.M	S.D.	Med	Mea	S.E.M	S.D.	U value	p-value
I found the Kahoot! tool to be useful in the Online Marketing lecture.	5.00	4.08	0.227	1.360	4.00	3.99	0.145	1.187	1083	0.361
Thanks to the Kahoot! tool the lecture is more fun.	5.00	4.03	0.216	1.298	5.00	4.18	0.144	1.180	1131	0.565
I would like to expand the use of the Kahoot! tool for other lectures too.	5.00	3.94	0.255	1.530	4.00	3.82	0.174	1.424	1097	0.416
I considered the evaluation in the OM lectures using the Kahoot! tool to be objective.	4.00	3.64	0.208	1.246	5.00	4.12	0.150	1.225	927	**0.039**
I would like to expand the use of the Kahoot! tool without the factor of time.	3.00	3.42	0.220	1.317	3.00	3.34	0.140	1.149	1176	0.829
Using the Kahoot! tool increased my visits to the lecture.	4.00	3.28	0.224	1.344	3.00	3.16	0.170	1.399	1170	0.704
I think that participation in the OM lecture positively influenced the success of the exam.	3.50	3.47	0.216	1.298	4.00	3.49	0.181	1.481	1173	0.816
I appreciate the immediate feedback on the Kahoot! tool.	5.00	4.17	0.213	1.276	5.00	4.36	0.142	1.164	1105	0.406
The fact that I could compete with other students in the OM lecture using the Kahoot! tool increased my motivation.	4.00	3.61	0.230	1.379	4.00	3.60	0.155	1.268	1175	0.825
I felt bad when I was unsuccessful using the Kahoot! tool.	2.00	2.42	0.197	1.180	3.00	3.01	0.164	1.343	906	**0.034**
The Kahoot! tool allows me to practice time management skills.	4.00	3.81	0.173	1.037	3.00	2.88	0.132	1.080	672	**<.001**
Thanks to the Kahoot! tool I had to be more attentive in the OM lecture to know the answers to the test questions.	4.00	3.89	0.168	1.008	4.00	3.73	0.157	1.286	1171	0.802
The scoring system of the Kahoot! tool increased my ambition to be among the best.	5.00	3.97	0.233	1.359	4.00	3.57	0.157	1.282	892	0.065
I like to show to my achievements through the Kahoot! tool at the end of the lecture.	4.00	3.56	0.247	1.482	3.00	2.93	0.161	1.318	866	**0.016**
How many percent should the Kahoot! test results affect the test result?	20.00%	25.83%	2.59%	15.56%	30.00%	32.79%	2.43%	20.06%	939	**0.044**

**Med: Median; Mea: Mean; S.E.M.: Standard error of mean; S.D.: Standard Deviation; OM - Online Marketing*

Table 1: Perception of the using of Kahoot! (Source: own calculation)

Conclusion

The results of the survey also confirm the positive impact of the Kahoot! tool in the teaching process from the perspective of students. The implementation of the Kahoot! tool or other forms of gamification in higher education are perceived by students as objective, entertaining and encouraging student motivation, including a positive impact on the learning process. From the teacher's point of view, an important factor is the increased attention of students in the lectures and the higher degree of participation in the lectures. The teachers can take advantage of the innovative nature of gaming platforms to increase the engagement and performance of their students in the learning process. And in this way, they can transform their teaching practice from a conventional teacher-centred approach to a student-centred approach with innovative teaching and skills of the 21st century (Zainuddin et al., 2020). The analysis of the difference between men and women has brought two important factors that need to be further investigated as it can be assumed that they may have a significant impact on the implementation of gamification. The results show that both men and women positively evaluate the possibility of competition provided by Kahoot!. But for men, the Kahoot! scoring system is more important. Men probably appreciate more explicit expression of their own result in the form of points, so for them the number of points which at the end of the lecture was more important than competing with classmates.

In the area of group dynamics, there is still space for empirical investigations into the context of group dynamics and student anxiety, perceptions of students or teachers (Wang and Tahir, 2020). Following the results of this study, it would be useful to extend the results in the follow-up research by correlations between the total number of points achieved by students in the exam and the number of points they gained in lectures regardless of ranking. It would also be useful to determine the interest of teachers in the use of this method in other lectures, together with their opinion on the degree of influence of this result on the final grade of the exam.

References

Basuki, Y. and Hidayati, Y. (2019) 'Kahoot! or Quizizz: the Students' Perspectives', In *Proceedings of the 3rd English Language and Literature International Conference, ELLiC, 27th April 2019, Semarang, Indonesia*, EAI. http://dx.doi.org/10.4108/eai.27-4-2019.2285331

Bicen, H. and Kocakoyun, S. (2018) 'Perceptions of Students for Gamification Approach: Kahoot as a Case Study', *International Journal of Emerging Technologies in Learning (iJET)*, vol. 13, no. 02, p. 72-93. http://dx.doi.org/10.3991/ijet.v13i02.7467

Chaiyo, Y. and Nokham, R. (2017) 'The effect of Kahoot, Quizizz and Google Forms on the student's perception in the classrooms response system', In *2017 International Conference on Digital Arts, Media and Technology (ICDAMT)*. IEEE, pp. 178–182. http://dx.doi.org/10.1109/ICDAMT.2017.7904957

Chiang, H.-H. (2020) 'Kahoot! In an EFL Reading Class', *Journal of Language Teaching and Research*, vol. 11, no. 1, pp. 33-44. http://dx.doi.org/10.17507/jltr.1101.05

Iwamoto, D. H. *et al.* (2017) 'Analyzing The Efficacy of The Testing Effect Using Kahoottm on Student Performance', *Turkish Online Journal of Distance Education*, pp. 80–80. http://dx.doi.org/10.17718/tojde.306561

Koivisto, J. and Hamari, J. (2019) 'The rise of motivational information systems: A review of gamification research', *International Journal of Information Management*, vol. 45, pp. 191–210. http://dx.doi.org/10.1016/j.ijinfomgt.2018.10.013

Kučera, P., Kvasnička, R. and Krejčí, I. (2012) 'Impact of The Contact Teaching Reduction on Study Results in The Course of Mathematical Methods in Economics II', *Proceedings of* the *9th International Conference on Efficiency and Responsibility in Education*, Prague, pp. 287–293.

Kusuma, G.P. *et al.* (2018) 'Analysis of Gamification Models in Education Using MDA Framework', *Procedia Computer Science*, 135, pp. 385–392. http://dx.doi.org/10.1016/j.procs.2018.08.187
Lee, C.-C. *et al.* (2019) 'Investigation of the effects of an online instant response system on students in a middle school of a rural area', *Computers in Human Behavior*, vol. 95, pp. 217–223. http://dx.doi.org/10.1016/j.chb.2018.11.034
Licorish, S.A. *et al.* (2017) '"Go kahoot!" Enriching classroom engagement, motivation and learning experience with games', in *Proceedings of the 25th International Conference on Computers in Education, ICCE 2017 - Main Conference Proceedings*.
Moutinho, A. and Sa, S. (2018) 'Implementing active learning through pedagogical coaching in Control Systems lectures', in *2018 3rd International Conference of the Portuguese Society for Engineering Education (CISPEE)*. IEEE, pp. 1–6. http://dx.doi.org/10.1109/CISPEE.2018.8593470
Orhan G.D. and Gürsoy, G. (2019) 'Comparing success and engagement in gamified learning experiences via Kahoot and Quizizz', *Computers & Education*, 135, pp. 15–29. http://dx.doi.org/10.1016/j.compedu.2019.02.015
Pilar, L. *et al.* (2019) 'Education and Business as a key topics at the Instagram posts in the area of Gamification', *Journal on Efficiency and Responsibility in Education and Science*, vol. 12, no. 1, pp. 26–33. http://dx.doi.org/10.7160/eriesj.2019.120103
Pilař, L. et al. (2016) 'GAMIFICATION IN EDUCATION: CURRENT STATE', *Proceedings of the 13th International Conference on Efficiency and Responsibility in Education (ERIE 2016)*, Prague, pp. 436–471.
Pilař, L. et al. (2017) 'GAMIFICATION IN EDUCATION: SOCIAL NETWORK ANALYSIS', *Proceedings of the 14th International Conference on Efficiency and Responsibility in Education (ERIE 2017)*, Prague, pp. 319–324.
Plump, C.M. and LaRosa, J. (2017) 'Using Kahoot! in the Classroom to Create Engagement and Active Learning: A Game-Based Technology Solution for eLearning Novices', *Management Teaching Review*, vol. 2, no. 2, pp. 151–158. http://dx.doi.org/10.1177/2379298116689783
Putz, L.-M., Hofbauer, F. and Treiblmaier, H. (2020) "Can gamification help to improve education? Findings from a longitudinal study," Computers in Human Behavior. Elsevier BV, 110, p. 106392. http://dx.doi.org/10.1016/j.chb.2020.106392
Rodrigues, L.F., Oliveira, A. and Rodrigues, H. (2019) 'Main gamification concepts: A systematic mapping study', *Heliyon*, vol. 5, no. 7, p. e01993. http://dx.doi.org/10.1016/j.heliyon.2019.e01993
Subhash, S. and Cudney, E.A. (2018) 'Gamified learning in higher education: A systematic review of the literature', *Computers in Human Behavior*, vol. 87, pp. 192–206. http://dx.doi.org/10.1016/j.chb.2018.05.028
Tondello, G.F., Mora, A., Marczewski, A. and Nacke, L.E. (2019) 'Empirical validation of the Gamification User Types Hexad scale in English and Spanish', *International Journal of Human-Computer Studies*, vol. 127, pp. 95–111. http://dx.doi.org/10.1016/j.ijhcs.2018.10.002
Wang, A.I. (2015) 'The wear out effect of a game-based student response system', *Computers & Education*, vol. 82, pp. 217–227. http://dx.doi.org/10.1016/j.compedu.2014.11.004
Wang, A.I. and Tahir, R. (2020) 'The effect of using Kahoot! for learning – A literature review', *Computers & Education*, vol. 149, p. 103818. http://dx.doi.org/10.1016/j.compedu.2020.103818
Zainuddin, Z. *et al.* (2020) 'The role of gamified e-quizzes on student learning and engagement: An interactive gamification solution for a formative assessment system', *Computers & Education*, 145, p. 103729. http://dx.doi.org/10.1016/j.compedu.2019.103729

ASSESSMENT OF MANAGERIAL DECISION-MAKING SKILLS USING THE FACTOREASY®

[1]✉Michal Prokop, [2]Václav Švec, [2]Michaela Nováková

[1]Department of Management, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, mprokop@pef.czu.cz

[2]Department of Management, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

The paper deals with the FactOrEasy® simulation game. The main objective is to propose a way of assessing managers' decision-making skills based on their error behaviour in this simulation. For this purpose, we conducted an experiment in which decision-making of 15 managers in a particular situation was examined. Based on the findings, we developed a scale for categorizing managers from the least skilled to the most skilled as follows: managers who constantly repeat a systematic error that reflects a lack of knowledge and experience; managers who make occasional errors caused by unawareness as a result of inattention or by slips when they know the right solution but fail in its execution; faultless managers who always make the right rational decisions. This categorization is conducted by analysing data files, which contain records and results of the game attempts and can be exported from the game administration.

Keywords

Decision-making, error, FactOrEasy®, manager, simulation

Introduction

Managers are key employees in companies as they are responsible for carrying out activities that contribute to reaching company goals (Weihrich, Dolanský and Koontz, 1998). Success often requires quick, effective and efficient decisions (Trevis Certo, Connelly and Tihanyi, 2008). Any error may cause trouble (Reason, 1990). However, assessing decision-making skills is not easy. The tasks that managers face in practice are complex and require not only the necessary knowledge and experience but also the skill to use them appropriately. Therefore, case studies are often used to assess this ability. But Hawrylyshyn (1967) found that with case studies, the abilities used to diagnose problems and formulate solutions are those which improve the most. On the other hand, decision-taking is best developed by decision simulations (Hawrylyshyn, 1967). Moreover, modern technologies nowadays bring the almost limitless possibility of replacing case studies with computer simulation games. Simulations serve as a simplification of reality (Keys and Wolfe, 1990) and are the art and science of creating a representation of a process or a system for experimenting and evaluation (Gogg and Mott, 1993). Recent research has shown good results of their use in testing and evaluation of decision-making (Lee et al., 2019). Their use in assessment is based on the idea that users reflect their skills, knowledge, and experience during play (Ritterfeld, Cody and Vorderer, 2009). Constructs, which people use in a decision, are a function of their perception of the current situation and their experience with similar situations (Brosch et al., 2013).

The present study deals with the simulation game FactOrEasy®, which is an online simulation of decision-making in financial, operational and strategic management. This simulation was developed mainly for educational purposes (Švec et al., 2016). Nevertheless, in the pilot study

(Prokop and Švec, 2018) presented two years ago at the ERIE conference, we also started to deal with the use of this game in the field of decision-making research. We investigated how managers make errors and whether they can be conscious of them, learn from them and not repeat them. Based on the assumption that people work cognitively with what they see (Just and Carpenter, 1980), we used eye-tracking (ET) for this purpose. This was also the main limitation of our findings as ET cannot reveal all aspects of decision-making (Al-Moteri et al., 2017). Thus, we have not been able to identify so far all the causes of the monitored errors. In addition, the previous study (Prokop and Švec, 2018) was also limited by the small research sample. Nevertheless, the pilot study suggested that if we focused on managers' errors, the game could reveal significant differences in their decision-making skills. As Stanton and Salmon (2009) state, errors can indicate weaknesses because they are affected by skills, experience, and knowledge.

However, due to the above-mentioned limitations, the findings of the pilot study (Prokop and Švec, 2018) did not allow us to make sufficiently valid conclusions on how to divide managers into skilled and less skilled according to their error behaviour in the simulation. Therefore, we decided to improve the previous experimental procedure and conduct it with a higher number of respondents. This paper summarizes our new findings. Nevertheless, the aim is not only to verify and extend our previous findings of the error behaviour. The main objective is to propose a way of assessing managers' decision-making skills based on their error behaviour in the FactOrEasy® simulation game.

The paper is divided as follows: material and methods, where the methods used and the course of the experiment are described; summarization of results; the discussion, in which we propose a way of assessment based on the discussion of our results and findings of other authors; and conclusions with recommendations for further research.

Materials and Methods

Research sample and experimental task

The research sample consisted of 15 participants (10 men, 5 women, at the average age of 36). The condition of participation was that the participant must be a manager or business owner who has an active managerial role. Their task was to play FactOrEasy®, in which they run a virtual enterprise and make three mandatory decisions (Material Purchase, Production, Product Sale), and two optional decisions (Production Expansion, Taking Loan) in each round. The game consists of 12 rounds unless it ends earlier due to bankruptcy. The goal is to achieve maximum 'cash' at the end of the game and beat three virtual competitors (Švec et al., 2016).

Course of experiment

The individual testing was performed in Human behaviour research unit (HUBRU), which is a specialized lab at CZU Prague. Each participant received an e-mail with links to a video tutorial and demo version of the simulation before the official start. They had three attempts to try out the game on their own. When they arrived, the researcher firstly verified their understanding of the game and provided clarification when necessary. The instructions included only information about rules and control elements, but no advice on the procedures or strategies in the game. As in the previous study (Prokop and Švec, 2018), ET was recorded. We used Tobii eye-tracker and the Tobii Pro Studio software (Tobii Pro, 2018). The main difference from the previous study (Prokop and Švec, 2018) was that the participants were asked to continuously describe their thoughts and actions during play. This qualitative method is known as concurrent think-aloud (CTA) and serves to study behavioural and cognitive processes during problem-solving. (Ericsson and Simon, 1993). The researcher explained the requirements for CTA to the participants in line with the method standards. After explaining all procedures and setting up ET, the researcher left

the experimental room. This reduced the potential disturbing impacts. The researcher observed the participants from the control room. Mutual communication was possible using loudspeakers and microphones but was limited only to situations when the participant asked for a rule to be repeated; when the verbalization stopped (researcher's reminder) or in moments between two games (request for a break). The number of game attempts was not limited but the length of one session (including welcome, initial briefing, calibration of ET and breaks) was limited to a maximum of two hours. Video, ET and audio records were recorded from all sessions.

Data processing

For the purpose of this study, we examined the same specific game situation, when the player may make an error in decision-making, as in the previous study (Prokop and Švec, 2018) - the situation of excess demand that may occur during the selling phase (Product Sale). The player should be able to identify this situation as the game provides all the necessary information. In such a moment, the player gains the opportunity (hereinafter referred to as the 'opportunity') to sell all products at a maximum price. Any other decision means an error (Prokop and Švec, 2018). The data analysis focused on the detection of the described decision-making errors and their causes and circumstances. It consisted of three steps. At first, we examined the.csv data files that can be exported from the administration background of FactOrEasy®. The export from each game attempt provides data records from all rounds in the form of figures. The data processing can be done using MS Excel. The occurrence of each opportunity can be identified in the.csv export as follows: The sum of the player's products and the products of competitors before the selling phase in a given round is lower than the number of products demanded on the market. So, a properly utilized opportunity means that the selling price entered by the player is equal to the maximum market price, and the entered number of products is equal to the number of all products that the player had in stock before the selling phase. If the export contains different values in such moments, it is an evidence of an error. Second, we used ET with the aim to detect whether the participant follows the figures necessary for making the right decision. There are three areas needed to be monitored: Market window stating the demand; Competition window providing figures about competitors' stock (overall supply); and Decision window, where the player writes their decision. The ET analysis was performed using heat maps. Third, we examined comments gathered by CTA. Here we focused on all opportunities and we looked at explanations of both the right and wrong decisions. We were also interested in whether participants were able to realize their errors as data on-screen allows players to post-analyse their decisions. Some participants did not provide clear and understandable comments in some of the cases when they made the error. Therefore, we also reviewed the circumstances of their decisions in the other rounds (under the usual selling condition). There, we looked for other explanations that can imply monitored error behaviour.

Results

The analysis of data exports – occurrences of the opportunities and errors

Table 1 shows the classification of participants according to decision-making error occurrences. Seven participants did not make any errors (Faultless), six made an error in some cases (Occasionally Faulting), and two made an error every time the opportunity occurred (Always Faulting). Identification numbers are assigned to participants in the last column of Table 1. This was done for clarity of the following text. The numbers in parentheses represent the number of errors which the managers made, and the number of situations they faced.

Classification	Number of managers	Individual managers (errors/opportunities)
Faultless	7	No.1 (0/6), No.2 (0/10), No.3 (0/4), No.4 (0/9), No.5 (0/9), No.6 (0/8), No.7 (0/3)
Occasionally Faulting	6	No.8 (2/10), No.9 (1/11), No.10 (2/7), No.11 (2/7), No.12 (1/8), No.13 (1/14)
Always Faulting	2	No.14 (2/2), No.15 (5/5)

Table 1: Classification of managers by the error occurrences, 2019 (source: own compilation)

Evidence from ET and CTA - circumstances of the opportunities and errors

Faultless

All these participants (No.1 – No.7) realized the opportunity from the first moment. In all cases, they watched all the necessary figures and their comments proved that they calculated well, considered the opportunity and used it properly.

Occasionally faulting

Participant No.8 always found the right solution. However, she wrote the right decision into the wrong input boxes twice (4th and 5th opportunity) - she confused the product count with the price. She realized her error only in the 2nd case. From that moment on, she was careful not to repeat it.
Participant No.9 was aware of the opportunity at all moments. Her only error (5th opportunity) resulted from a typing error (typo). She realized it and she was more watchful afterwards.
Participant No.10 made two errors and did not realize either of them. In the 1st case, he did not watch Competition and the decision was based on experience from the previous rounds. He was too fixed on the auction rule and tried to keep the price as low as possible. He identified the opportunity at the 2nd occurrence, yet he failed again in the 3rd. Without watching Competition and rational judgment, he made an intuitive decision based on market conditions and the auction rule. In all the following opportunities, he was more focused and made the right decisions.
Participant No.11 wasted the last two opportunities. He acted under time pressure as the end of the session approached. He did not watch Competition and made fast intuitive decisions without a deeper post-analysis. All previous occurrences were properly utilized.
Participant No.12 missed only the 1st opportunity which arose right in her 1st round. She evaluated a lot of data from the screen (not only necessary ones) because she considered her strategy for the whole game. Stocks of competitors were monitored little and not considered. She focused on auction rule, feared competitors' low prices and tried to make a 'safe' decision. She realized the error immediately. It led to better attention in all the following rounds.
Participant No.13 failed during the 1st opportunity. He summed up the supply but did not compare it with demand. He paid little attention to Market and set a low price with the aim to cover the costs. He did not realize this error. All further opportunities were identified.

Always faulting

Participant No.14 wasted all opportunities due to a lack of attention to competitors' stock. She noticed that competitors sold at a high price, but she was not able to analyse why. She also did not consider stocks in any of the other rounds. Decisions were rather intuitive than based on an analysis. She most often considered the cost coverage, or she estimated the offers according to the current market situation and the bidding strategy of competitors in previous rounds.
Participant No.15 set his strategy according to the development of prices and competitors' offers. He noted the history data and tried to estimate the current bid based on them. Sometimes, if the

price seemed low, he considered the costs. He almost did not consider the supply at all. In two cases he found that all competitors sold for the maximum price, but he was unable to identify why.

Discussion

In the previous study (Prokop and Švec, 2018), we divided managers into four quadrants based on whether they made errors and whether they were conscious of them. However, the present research suggests the necessity for corrections in the original schema of error behaviour as well as a better specification of some terms. The essential point in presenting the new findings is to point out the difference between consciousness and awareness, i.e. to define their meaning for the purpose of the study - the description of error behaviour. In the previous study (Prokop and Švec, 2018), we used only the former term, but new findings oblige us to distinguish between them, although they are both frequently used interchangeably (Bunge and Ardila, 1987). Tulving (1993) defines consciousness as a general capacity that one possesses for particular kinds of subjective experience, whereas awareness is the particular manifestation of this capacity. It follows that awareness is subordinate to consciousness. In addition, to remember something means to be consciously aware of something that happened in the past (Tulving, 1993). Therefore, we assume that consciousness uses awareness to take hold of the experience, which is then stored in the memory. In this way, knowledge is created at the level of consciousness. Contrary to this, if there is knowledge, awareness serves to activate it at a time when it is needed. As a result, we use the term consciousness in a more general sense. It means that one has a skill (based on experience which created sufficient knowledge) that he/she may use whenever during the game. Awareness, in this case, is the actual utilization of this skill when the opportunity occurs.

Based on the above mentioned, we decided on several changes in our scheme (Figure 1). The changed parts are highlighted in grey. Firstly, we changed the name of the 2nd dimension from 'Consciousness of the error' to '*Consciousness of the opportunity*'. We assumed in the previous study that if players made an error in one opportunity and not in the next, it was because they had learned from the error. However, through CTA, we found that participants No.8, No.10, and No.13 made an error they did not realize and yet discovered the next opportunity when they were consciously aware of the next occurrence. This means that consciousness of the opportunity and/or error are different concepts. An error is only a consequence, and it can arise both as a result of unconsciousness and as a result of unawareness.

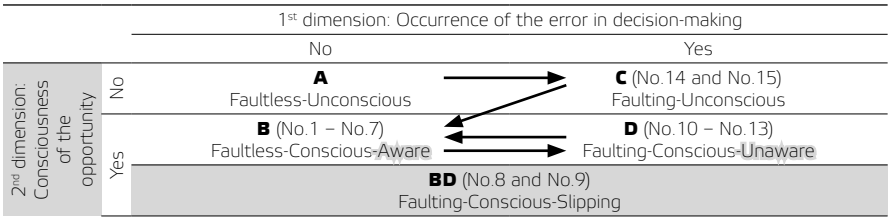


Figure 1: Scheme of error behaviour, 2019 (source: own compilation)

The unconsciousness of the opportunity arises when managers repeatedly make the decision-making error during all occurrences. Such was the behaviour of participants No.14 and No.15 placed in quadrant C. Their eye-movements and comments throughout the game did not indicate the likelihood of being conscious of the opportunity. We consider this to be an error that may indicate a lack of knowledge or previous experience that reduces the overall ability to properly resolve a particular situation. Given that the error keeps repeating even though the game

environment provides all information, this decision-making error can be described as systematic (Reason, 1990). However, there is still a possibility that even unconscious managers can make the right decision (quadrant A). This would mean that even without observing the necessary data or rationally interpreting it, they would make the corresponding decision during each opportunity. This situation has never occurred, not even in our previous study (Prokop and Švec, 2018). Therefore, it remains only theoretical. Nevertheless, we can say that even if the manager made the right decisions in this way, it would not prove his decision-making skills. Systematic decision-making error continues to exist although it has not been revealed.

We consider unawareness to be a short-term failure, not a proof of overall lack of skills, knowledge, and/or experience. Only conscious managers can express such behaviour. All participants (No.1 - No.13) who have been able to utilize at least one opportunity can be considered conscious. The presence of the error (1st dimension) subsequently divides them into aware (quadrant B) and unaware (quadrant D). The quadrant B includes those (No.1 - No.7) who have never made an error and have always justified the right decision. Their behaviour can be described as fully rational in the line with March and Heath (1994). In quadrant D we include conscious managers (No.10 - No.13) who have made errors occasionally. They were not aware of the opportunity at that particular moment. We assume that these errors are due to heuristic decision-making (Tversky and Kahneman, 1981) at a given moment when the player did not pay enough attention to the game and acted intuitively. There may be several causes for this. Participants No.10 and No.13 made errors in the later rounds. Their comments suggest that after they repeated the decision under normal conditions several times, it became a routine, which reduced their attention. Participant No.11 acted under time pressure and therefore simplified the decision-making process. Participant No. 12 made an error in the 1st round of the 1st game when she thought a lot about the whole game strategy. The human cognitive capacity is limited; therefore, a short-term overload may happen.

A specific issue is the classification of participants No.8 and No.9. They are conscious, aware and faultless from the perspective of the right appraisal of the opportunity. Nevertheless, they made an error that was not connected with the result of decision-making. They made a writing error. These errors, defined as slips, mean that the intention was correct, but the execution was wrong (Reason, 1990). As a result, we created a special field (BD quadrant) for such results.

Based on the previous discussion, we can rearrange the scheme from Figure 1 and use it as a scale for assessment of managers' decision-making skills. We found three main presumptions to do this. First, *errors are indicators of decision-making skills as they are affected by skills, experience, and knowledge.* Second, *a constantly repeated error caused by the unconsciousness (systematic) is more serious than the occasional error caused by unawareness (heuristic).* Thirdly, *we consider slips to be similar to the unaware error as they are also occasional and with similar consequences.* As a result of these presumptions, we propose the 'decision-making skills scale' - Figure 2.

<table>
<tr><th>Systematic error</th><th>Occasional error</th><th>No error</th></tr>
<tr><td>A Faultless-Unconscious</td><td>D (No.10 – No.13)
Faulting-Conscious-Unaware</td><td rowspan="2">B (No.1 – No.7)
Faultless-Conscious-Aware</td></tr>
<tr><td>C (No.14 and No.15)
Faulting-Unconscious</td><td>BD (No.8 and No.9)
Faulting-Conscious-Slipping</td></tr>
<tr><td colspan="3">Low → Decision-making skills → High</td></tr>
</table>

Figure 2: Decision-making skills scale, 2020 (source: own compilation)

The remaining question is how to apply our findings for further use of FactOrEasy® in practice. In the laboratory, participants may behave differently than under normal conditions (Lazar, Feng and Hochheiser, 2017), CTA may influence their performance (Ericsson and Simon, 1993), and eye-tracking is still quite expensive and sophisticated equipment (Su et al., 2019). Moreover,

the analysis of data outputs from these methods is time-consuming. Therefore, it is clear that such testing is not relevant in practice. Nevertheless, all these methods served primarily for the identification of causes and circumstances of participants' error behaviour and they helped us to develop and verify the defined scale.

However, the detection of occurrences of monitored errors itself is possible only with the use of.csv exports. The possibility of data export is a standard feature of FactOrEasy® and error detection can be easily performed in MS Excel in the way mentioned in the paper's methodology. Therefore, based on the findings of the present study, future assessment of the decision-making skills of players can be based only on this analysis.

It is true that distinguishing between quadrant A and other quadrants is not possible only on the basis of data exports. The figures themselves never say if the right decisions are conscious or not. However, we did not find any right unconscious decision in the present study nor in the previous one (Prokop and Švec, 2018). It is very unlikely that players would input the right values without being consciously aware of the opportunity. In addition, each player usually faces the opportunity several times in the game. Therefore, it cannot be assumed that he/she would be able to repeat such a decision in this way. As a result, we consider the categorization into quadrant A in practice to be unreal.

The categorization into quadrant B and C depends on whether the player utilizes (or misses) all opportunities. If he/she utilizes only part of them, then he/she belongs to quadrant D or BD. However, data exports themselves do not allow entirely accurate categorization into one of these two quadrants. The identification of a slip is possible only in cases when the player enters the right values in the wrong input boxes. The values of the offered quantity of products and their price are significantly different. Therefore, the interchange of both values is clearly evident in the results. However, for other types of writing errors, it is difficult to clearly identify whether it is a typo (BD quadrant) or a decision-making error (D quadrant). On the other hand, the presence of these slips (typos) in the present study was rare. Moreover, if we consider that the consequences of slips are similar to occasional errors in decision-making, then distinguishing between quadrants D and BD is not entirely essential for the assessment of decision-making skills.

Based on the above-mentioned, we suppose that the analysis of data exports provides the appropriate and sufficient way of identifying error behaviour in the FactOrEasy® simulation and hence also a way of assessing managers' decision-making skills. However, further work will be needed to put FactOrEasy® into practice for this purpose. It will be necessary to develop an adequate assessment methodology, which should clearly describe all testing means, conditions and procedures. In addition, identification and adding a higher number of different game situations should be considered. With decision-making being a complex process, an overall assessment of an individual's decision-making skills should not be based only on error behaviour in one particular situation.

Conclusion

In this paper, we proposed a way of assessing managers' decision-making skills based on their error behaviour in the FactOrEasy® simulation game. To do this, we proceeded from our previous study of error behaviour in this simulation (Prokop and Švec, 2018) and from the assumption that the players' decisions are based on their skills, experience, and knowledge. Using the improved experiment, we found some new insights that led to the modification of our original scheme of error behaviour (Figure 1). Subsequently, we transformed this scheme into the form of scale that can be used for assessing decision-making skills (Figure 2). *Managers who* unconsciously and *constantly repeat* the same error in a particular situation are considered the least skilled. We called their error *a systematic decision-making error* and we believe *that* it *reflects a lack of*

knowledge and experience. More skilled *managers* are those *who make occasional errors*. They have appropriate knowledge and experience and they can use them. Nevertheless, they make errors *caused by unawareness as a result of short-term inattention or by slips when they know the right solution but fail in its execution. Faultless managers* are considered the most skilled. They *are always aware of the situation and know how to rationally utilize it*. Our findings also suggest that we are able to detect the majority of the above-mentioned types of error behaviour with the use of FactOrEasy®. This is possible through the analysis of data files that contain records and results of each game attempt. This analysis can be easily performed in MS Excel. Therefore, we can state that if we use errors as indicators of decision-making skills, then FactOrEasy® has significant potential to be the tool for their assessment.

Although we assume that we have identified most of the possible causes and circumstances of the error behaviour in the simulation, the results of this study are still limited by the methods we used to detect them and by the relatively low number of participants.

Acknowledgement

This article was created with the support of the IGA PEF CZU (CULS) Prague, number 2019A0001 - Analysis of the managers´ error behaviour in the decision-making process using the business simulation game FactOrEasy®

References

Al-Moteri, M.O., Symmons, M., Plummer, V. and Cooper, S. (2017) 'Eye tracking to investigate cue processing in medical decision-making: A scoping review', *Computers in Human Behavior*, vol. 66, pp. 52–66. https://doi.org/10.1016/j.chb.2016.09.022

Brosch, T., Scherer, K., Grandjean, D. and Sander, D. (2013) 'The impact of emotion on perception, attention, memory, and decision-making', *Swiss Medical Weekly*, pp. 1–10. https://doi.org/10.4414/smw.2013.13786

Bunge, M. and Ardila, R. (1987) *Philosophy of psychology*, New York: Springer-Verlag.

Ericsson, K.A. and Simon, H.A. (1993) *Protocol analysis: verbal reports as data*, Cambridge, Mass: MIT Press.

Certo, T.S., Connelly, B.L., Tihanyi, L. (2008) 'Managers and their not-so rational decisions', *Business Horizons*, vol. 51, no. 2, pp. 113–119. https://doi.org/10.1016/j.bushor.2007.11.002

Gogg, T.J. and Mott, J.R.A. (1993) 'Introduction to Simulation', In *Proceedings of the 25th Conference on Winter Simulation*, New York, pp. 9–17. https://doi.org/10.1145/256563.256571

Hawrylyshyn, B.B. (1967) 'Preparing Managers for International Operations: Role of Management Development', *Business Quarterly*, vol. 32, no. 3, pp. 28–36.

Just, M.A. and Carpenter, P.A. (1980) 'A theory of reading: From eye fixations to comprehension', *Psychological Review*, vol. 87, no. 4, pp. 329–354. https://doi.org/10.1037/0033-295X.87.4.329

Keys, B. and Wolfe, J. (1990) 'The Role of Management Games and Simulations in Education and Research', *Journal of Management*, vol. 16, no. 2, pp. 307–336. https://doi.org/10.1177/014920639001600205

Lazar, J., Feng, J.H. and Hochheiser, H. (2017) *Research Methods in Human-Computer Interaction*, United States: Morgan Kaufmann.

Lee, J.Y., Donkers, J., Jarodzka, H. and van Merriënboer, J.J.G. (2019) 'How prior knowledge affects problem-solving performance in a medical simulation game: Using game-logs and eye-tracking', *Computers in Human Behavior*, vol. 99, pp. 268–277. https://doi.org/10.1016/j.chb.2019.05.035

March, J.G. and Heath, C. (1994) *A primer on decision making: how decisions happen*, New York: Free Press.

Prokop, M. and Švec, V. (2018) 'Flawless Managers: Myth or Reality?' In *Proceedings of the 15th International Conference on Efficiency and Responsibility in Education (ERIE 2018)*, Prague, pp. 281–289.
Prokop, M., Vrábelová, T., Nováková, M. and Šímová, T. (2019) 'Evaluation of managerial and decision-making skills of small-scale farmers' In *Agrarian Perspectives XXVIII. Business Scale in Relation to Economics. Proceedings of the 28th International Scientific Conference*, Prague, pp. 218–225.
Reason, J.T. (1990) *Human error*, New York: Cambridge University Press.
Ritterfeld, U., Cody, M.J. and Vorderer, P. (2009) *Serious games: mechanisms and effects*, New York: Routledge.
Stanton, N.A. and Salmon, P.M. (2009) 'Human error taxonomies applied to driving: A generic driver error taxonomy and its implications for intelligent transport systems', *Safety Science*, vol. 47, no. 2, pp. 227–237. https://doi.org/10.1016/j.ssci.2008.03.006
Su, M.-C., U, T.-M., Hsieh, Y.-Z., Yeh, Z.-F., Lee, S.-F. and Lin, S.-S. (2019) 'An Eye-Tracking System based on Inner Corner-Pupil Center Vector and Deep Neural Network', *Sensors*, vol. 20, no. 1, pp. 25. https://doi.org/10.3390/s20010025
Švec, V., Pavlíček, J., Tichá, I. and Křečková, J. (2016) 'FactOrEasy®: Art and Craft of Management?' In *Proceedings of the 13th International Conference on Efficiency and Responsibility in Education (ERIE 2016)*, Prague, pp. 567-577.
Tobii Pro (2018) *Tobii Pro Studio,* [Online], Available: https://www.tobiipro.com/learn-and-support/learn/tobii-pro-studio/ [3 April 2020].
Tulving, E. (1993) 'Varieties of consciousness and levels of awareness in memory', In Baddeley, A. and Weiskrantz L. (ed.) *Attention: Selection, Awareness, and Control: A Tribute to Donald Broadbent*, Oxford: Clarendon Press.
Tversky, A. and Kahneman, D. (1981) 'The framing of decisions and the psychology of choice', *Science*, vol. 211, no. 4481, pp. 453–458. https://doi.org/10.1126/science.7455683
Weihrich, H., Dolanský, V. and Koontz, H. (1998) *Management*, Praha: East Publishing.

INFLUENCE OF ECONOMIC FACTORS ON SELECTION OF FIELD OF STUDY

[1]✉Alice Reissová, [2]Jana Šimsová, [3]Michala Pátková

[1]Department of Economics and Management, Faculty of Social and Economic Studies, Jan Evangelista Purkyně University in Ústí nad Labem, Czech Republic, alice.reissova@seznam.cz

[2]Department of Mathematics and Informatics, Faculty of Social and Economic Studies, Jan Evangelista Purkyně University in Ústí nad Labem, Czech Republic

[3]Department of Economics and Management, Faculty of Social and Economic Studies, Jan Evangelista Purkyně University in Ústí nad Labem, Czech Republic

Abstract

At present, the supply of free places at universities in the Czech Republic outstrips the demand of students in many fields of study. As a result, universities are trying to understand the circumstances that influence a student's decision-making. The aim of this study is to identify these factors. Using a Friedman ANOVA and Wilcoxon test it was discovered that the most important role is played by the institutional factors, i.e. ones that the university can itself influence. In statistical terms, they are significantly more important than economic or social factors. Out of the institutional factors, the entry requirements, structure of mandatory subjects and quality of teachers have a significant influence. A regressive analysis showed that whereas students find out the first two mentioned items in advance, there is generally no verification of the quality of teachers.

Keywords

Choice of university, economic factors, entry requirements, institutional factors, quality of teachers, social factors, structure of subjects

Introduction

In view of the fact that in the Czech Republic the financing of universities is still partially dependent on the number of students who study at the relevant university, and the fact that the supply of free places exceeds demand, there is an evident attempt on the part of individual universities to appeal to and gain the greatest number of students. Many studies examine the influence of the individual tools that universities use as part of their marketing on students' decision-making (Chase, Geringer and Stratemeyer, 2019; Songan et. al, 2010; Simoes and Soares, 2010; Moogan and Baron, 2003; Obermeit, 2012; Rutter, Roper and Lettice, 2016; Le, Robinson and Dobele, 2019).

Rather than the individual marketing tools, some authors focus on the student's actual decision-making process. In her study Navrátilová (2013) proceeds on the basis of the Ajzen theory of planned behaviour. She works with three latent variables, which are the attitude of the student, his subjective standard and the perceived control of behaviour. For subsequent measurement she created a model in which she compared students of economic and technical fields. She discovered that the values of standardised regressive coefficients are highly similar for both types of schools. She identified differences only in the area of motivation during the selection of field, where students of technical fields displayed a greater interest in the chosen field of study, whereas students of economic fields tended to choose study with regard to the promised career and working successes. Maniu and Maniu (2014) state that it is not easy to understand the process by which a student chooses a university because it is a complex decision influenced by many factors. The authors include the reputation of the institution, economic demands, influence of

parents, possibility of finding work and many other things amongst the important factors. Many similar studies have been written (Hemsley-Brown and Oplatka, 2015; Briggs, 2006; Haryanti, Wijayanto and Sumarwan, 2016; Echchabi and Al-Hajri, 2018; Kulcsár, Dobrean and Gati, 2020). Some of them point out the importance of economic factors, i.e. expenses, which are necessarily associated with university education (Dao and Thorpe, 2015). Joseph, Mullen and Spake (2012) looked at whether there are differences in preferences between students of private and public universities. They discovered that the costs associated with study tend to be important for students regardless of the type of university. But information about the country in which the research was performed is wholly fundamental because costs for study can differ diametrically. The aim of this study is to find out whether the economic factors are dominant in the choice of university for the Czech students living in a socially disadvantaged region with high unemployment, low average pay, the highest proportion of inhabitants with bankruptcy orders, and high proportion of inhabitants with low education.

Materials and Methods

In order to achieve the goal, i.e. to discover which factors play a role in decisions about the choice of university, three groups of factors were created: economic, social and institutional. These factors were also operationalized on the basis of specialist literature. An overview of the individual groups of factors is given in Table1.

Social (personal) factors	Institutional factors
I have sufficient abilities for this university	Entry requirements (entrance exams, Scio tests)
and skills to complete it successfully	What are the mandatory subjects (math., statistics, languages)
The university is close to my home	Quality of teachers
My friends are applying to the same university	Difficulty of subjects
I am continuing in a family tradition	Opinion on teaching evaluation of current students
(for example, all the men in the family are firemen)	Reputation of university
Someone from my family studied	Life at university (atmosphere, people, lifestyle)
at this university	Possibility of fellowship/internship
Economic factors	Possibility to work during studies
Price per semester	Possibility to travel (Erasmus)
Price for halls of residence	Extra-curricular activities organised by university
Level of possible scholarships	(non-traditional lectures, breakfast with teachers, trade fairs)
Price for commute	Facilities of university
Price for extended study	Possibility of scholarships
Price for textbooks and study aids	Appearance of halls of residence
Price for lunches	Successes of scientific works of former students
	Possibility of combined study program
	Appearance of university complex

Table 1: Monitored groups of factors and their operationalization (source: own)

For each item students responded on a Likert scale of 1 to 5, according to how they consider it to be important for the choice of university (1 = not at all important to 5 = is definitely important). Based on previously performed research, the following hypotheses were formulated:

H1: Out of the monitored groups of factors the most important for choice of university are economic ones (Maniu and Maniu, 2014; Hemsley-Brown and Oplatka, 2015; Briggs, 2006).

H2: The students who are considering the study of economic fields will differ in the preferences of individual factors from the students who want to study other fields of study (Navratilova, 2013; Owusu, et al. 2018).

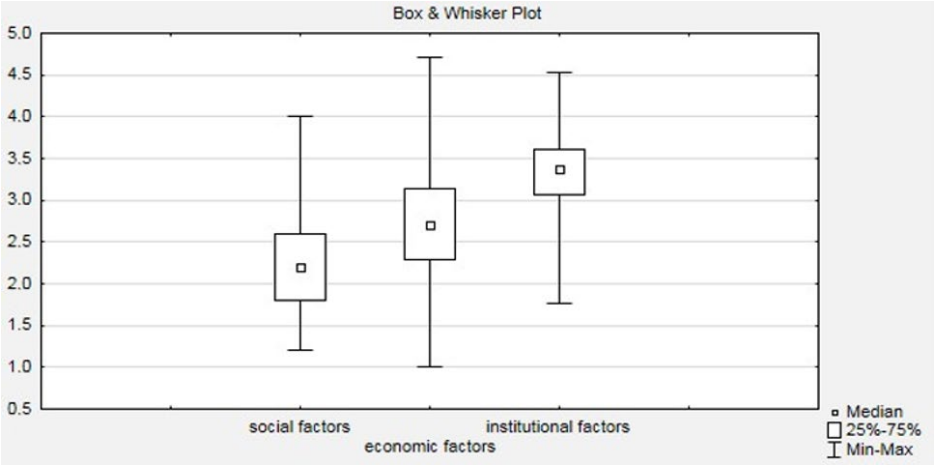
The selection data set consisted of students of the last years of grammar schools and specialist schools with economic focus in the Most area (N = 155), i.e. in one of the disadvantaged localities of the Czech Republic. After a check and processing of data some questionnaires were excluded. In 6 of the questionnaires not all of the meretricious questions had been answered, and 5 students stated that they would not go to university. 144 questionnaires remained in the data set. Most students stated that they wanted to study economic fields (57), the second largest group were social sciences (47) such as social work, psychology, philosophy, law etc. Other fields had lower representation. The students could indicate more than one field of study that they wanted to study. On average every student marked nearly 2 fields of study, which indicates that the interests of the students are not very well defined.

The method chosen was written questioning, students were asked to fill in a questionnaire as part of tuition.

The data were collected in the autumn of 2019 and developed using MS Excel and Software Statistica. The tests used: Friedman´s ANOVA (H_0: $\widetilde{\mu}_1 = \widetilde{\mu}_2 = \ldots \widetilde{\mu}_1 = \widetilde{\mu}_k$; H_1: non H_0) and Kendall Coeff. of Concordance, Wilcoxon test (H_0: $\widetilde{\mu}_1 = \widetilde{\mu}_2$;H_1: $\widetilde{\mu}_1 \neq \widetilde{\mu}_2$) (Hendl, 2015).

Results

In the context of responses to the first hypothesis it was discovered which factors have the greatest influence on students' decision-making. The values of the individual items in the context of each of the monitored factors were added together and the arithmetic average was calculated. From picture 1 it is evident that institutional factors have the most significant influence, followed by economic factors and then social factors in third place.



Picture 1: Importance of individual groups of factors - all students (source: own calculation)

From picture 1 it is evident what the most important institutional factors are for students. They are more important than economic and social factors. Freidman ANOVA (H_0: $\widetilde{\mu}_1 = \widetilde{\mu}_2 = \ldots \widetilde{\mu}_1 = \widetilde{\mu}_k$; H_1: non H_0): was then used to verify whether this difference in evaluation was statistically significant. The results are displayed in Table 2.

Variable	Average	Sum of Ranks	Mean	Std.Dev.
Social factors	1.253472	180.5	2.240278	0.482754
Economic factors	1.972222	284	2.734127	0.678233
Institutional fac.	2.774306	399.5	3.360703	0.472397

Friedman ANOVA and Kendall Coeff. of Concordance (ANOVA Chi Sqr. (N = 144, df = 2) = 167.2787 p =0.00000 Coeff. of Concordance =.58083 Aver. rank r =.57790

Table 2: Testing significance of difference of individual factors evaluation amongst students regardless of chosen field of study (source: own)

Based on the specified calculation the ascertained results are statistically significantly different. Institutional factors have a significantly greater importance than economic and social factors. The ascertained result is then verified using a Wilcoxon test of mutual comparison of medians (H_0: $\widetilde{\mu_1} = \widetilde{\mu_2}$; H_1: $\widetilde{\mu_1} \neq \widetilde{\mu_2}$), and the results are given in Table 3.

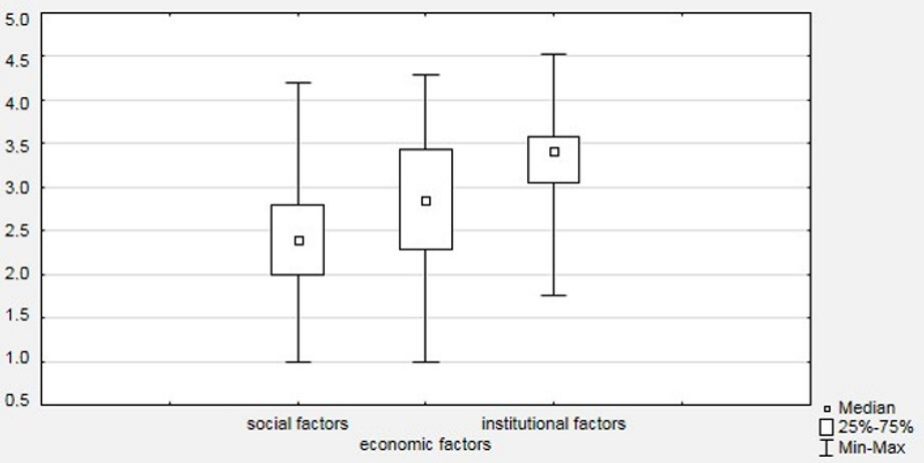
	Social factors	Economic factors
Social factors		
Economic factors	**0.000000**	
Institutional factors	**0.000000**	**0.000000**

Table 3: *P-values of Wilcoxon test of mutual comparison of medians for students regardless of chosen study field (source: own)*

The Wilcoxon test of mutual comparison of medians also confirmed the statistically significant differences between the individual factors for the students who want to study at university, regardless of the chosen field of study.

H_1, which assumes that out of the monitored groups of factors the economic factors are the most important for choice of university, was rejected.

In the context of the second hypothesis, it was discovered whether the students who are considering study at university with an economic focus will differ. H_2 was formulated: Students who are considering studying economic fields will in the preferences of individual factors differ from students who want to study other fields of study. But picture 2 indicates that this is not the case.



Picture 2: Importance of individual groups of factors - student of economic fields (source: own calculation)

It is interesting that for the data set of students who prefer economic fields the box plot is very similar to the picture where the values of preference (or importance) of individual factors were depicted, regardless of the field of study. Here too, it was evaluated using Friedman ANOVA (H_0: $\widetilde{\mu}_1 = \widetilde{\mu}_2 = \ldots \widetilde{\mu}_1 = \widetilde{\mu}_k$; H_1: non H_0) whether there was a statistically significant difference between the individual factors. The results are shown in Table 4.

Variable	Average	Sum of Ranks	Mean	Std.Dev.
Social factors	1.196429	67	2.325	0.490732
Economic factors	2.089286	117	2.854592	0.692655
Institutional factors	2.714286	152	3.358193	0.472892

Friedman ANOVA and Kendall Coeff. of Concordance ANOVA Chi Sqr. (N = 56, df = 2) = 65.17857 p =.00000 Coeff. of Concordance =.58195 Aver. rank r =.57435

Table 4: Testing significance of difference of individual factors evaluation - students of economic fields (source: own)

In this case, it was verified that institutional factors are statistically significantly different from economic and social factors. For the sake of completeness, a Wilcoxon test of mutual comparison of medians (H_0: $\widetilde{\mu}_1 = \widetilde{\mu}_2$; H_1: $\widetilde{\mu}_1 \neq \widetilde{\mu}_2$) was performed (see Table 5).

	Social factors	Economic factors
Social factors		
Economic factors	**0.000002**	
Institutional factors	**0.000000**	**0.000008**

Table 5: *P-values of Wilcoxon test of mutual comparison of medians for students regardless of chosen study field (source: own)*

The Wilcoxon test verified that the medians of the individual factors also differ statistically significantly. H_2, which assumed that students of economic fields will differ in terms of the evaluation of importance of individual factors, was also rejected.

In view of the fact that the ascertained results point to the importance of institutional factors, a deeper analysis was also performed using a pair Wilcoxon test. Out of the group described as "institutional factors", 7 items were selected that attained the highest average evaluation (they were thus considered the most important). Table 5 shows the ascertained *p*-values amongst these items.

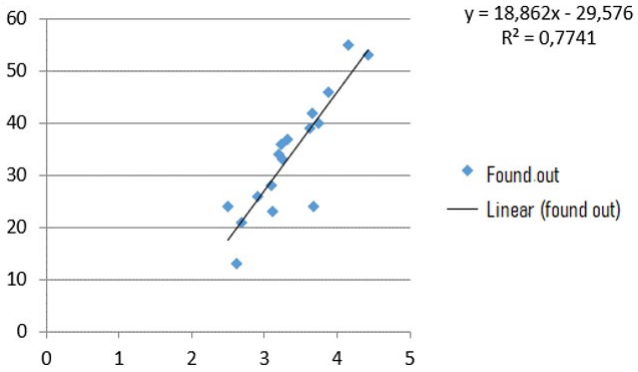
	mandatory subjects	opinion of students	difficulty of subjects	quality of teachers	entry requirements
mandatory subjects					
opinion of students	**0.004354**				
difficulty of subjects	**0.005993**	0.556974			
quality of teachers	**0.009152**	0.981946	0.646343		
entry requirements	0.052374	**0.000266**	**0.000200**	**0.000790**	
reputation of university	0.077601	0.099743	0.381435	0.103842	**0.003174**
life at university	**0.003426**	0.771326	0.489709	0.876347	**0.000167**

Table 6: *P-values of Wilcoxon test - comparison of most important items in the context of institutional factor (source: own)*

From table 6, it is evident that the evaluation of the item "mandatory subjects" and "entry requirements" differs from the evaluation of other items with the exception of the item "reputation of university". The evaluation of this item on a 5% significance level does not differ from the evaluation of the item "mandatory subjects". But the *p*-value is so close to 0.05 that on a 10% significance level these evaluations do not differ. The *p*-value of comparison of the items "mandatory subjects" and "entry

requirements" may be similarly debatable. These items do not differ on a 5% significance level, but they do differ on a 10% significance level. Here too a difference can be detected. Mandatory subjects and entry requirements are the most important institutional factors for students.

For the individual items, the students were also asked not only about whether they were important for them but also whether they found out about them in advance or not. For this reason, it could also be verified further whether there is a relationship between the declared importance of the given item and its ascertaining. Picture 3 shows the correlation between the arithmetical average of evaluation of importance of an item and number of people who ascertain this information. The coefficient of correlation is 0.879849. There is thus a strong direct dependency.



Picture 3: Correlation between importance of item and subsequent discovery of information (source: own calculation)

From the graph of the line of best fit it is evident that with each one-point increase of evaluation of importance there is an increase of almost 19 students who ascertain the information about the given item. An outlying value in the graph is the item "quality of teachers". This item reached an average value of 3.6, which makes it a value with great importance, but relatively few students ascertained the quality of teachers in advance.

Discussion

Another important item which influences decision-making is the reputation of the university. The results of some studies indicate that the reputation of a university plays a key role in students' decision-making (Simões and Soares, 2010).

Universities in the Czech Republic are facing many problems. They have to deal with the motivation of students when choosing fields of study (Navrátilová, 2013) as well as reasons for premature termination of studies (Berka, Vrabec and Marek, 2019). Analyses of study success of students in relation to the field of study are processed (Fajčíková et. al., 2019), there is a measurement of the productivity of academic staff (Flégl, Jiménez-Bandala, and Rosas, 2019) and relationships are sought between entrance exams and entry requirements (Měsíček, Petrus and Kovářová, 2019). The entry requirements play a very significant role from the aspect of students. It was seen that entry requirements, the structure of mandatory subjects and quality of teachers are amongst the three most important items that students evaluated in the context of the group of institutional factors. This group of factors was also seen to be statistically the most important.

In spite of the fact that the research data set was intentionally selected in a socially and economically disadvantaged locality, the economic factors were not the most important for choice of university. Social factors were identified as the least important. It is evident that there exist significant intercultural

differences because some studies pointed to the fact that in their country social factors played the dominant role (Lai, Gibson and Muthaly, 2014; Granitz, Chen and Kohli, 2014; Pappas and Kounenou, 2011).

In this study it was not proven that students of economic fields differed significantly in the evaluation of importance of individual factors from the students of other fields of study. But no analysis was performed that could show up differences in the evaluation of individual items, or differences in motivations for study. It is also necessary to take into account the fact that the selection data set was relatively small and the representation of students with regard to fields of study was not balanced. In view of the importance of the problem examined it would be appropriate to expand the study in the future.

Conclusion

In order for universities to gain new students successfully, they need to understand the students' decision-making process, which is not that simple and may be influenced by many variables. Within this study three groups of factors were created: economic, social and institutional. There are statistically significant differences between these factors. It was discovered that not even in a socially and economically disadvantaged locality are economic factors of the greatest importance. One piece of good news for universities may be the finding that factors described as institutional have the greatest importance, and these are factors which each institution can itself influence. Out of the 16 monitored items the most important are entry requirements (i.e. difficulty of entrance examinations), structure of mandatory subjects, quality of teachers and also the opinions of current students, difficulty of subjects, reputation of university and life at university (overall atmosphere, people, lifestyle). Using linear regression, it was shown that most of the aforementioned items which students consider important in the process of their decision-making consist of information which the students also ascertain.

References

Berka, P., Vrabec, M. and Marek L. (2019) 'Analyzing Bachelor Students Dropout at The University of Economics, Prague', *16th International Conference Efficiency and Responsibility in Education,* Prague, Czech Republic, pp. 21-26.

Briggs, S. (2006) 'An Exploratory study of the Factors influencing Undergraduate student Choice: The Case of Higher Education in Scotland', *Studies in Higher Education*, vol. 31, no. 6, pp. 705-722. https://doi.org/10.1080/03075070601004333

Dao, M.T.N. and Thorpe, A. (2015) 'What factors influence Vietnamese students' choice of university?', *International Journal of Educational Management*, vol. 29, no. 5, pp. 666-681. https://doi.org/10.1108/IJEM-08-2014-0110

Fajčíková, A, Fejfarová, M., Hlavsa, T. and Fejfar J. (2019) 'Success Rate in Examinations: Does the Degree Programme Matter', *16th International Conference Efficiency and Responsibility in Education,* Prague, Czech Republic, pp. 43-49.

Echchabi, A. and Al-Hajri, S. (2018) 'Factors Influencing Students' Selection of Universities: The Case of Oman'. *Journal of Education Research and Evaluation*, vol. 2, no. 2, pp. 83-88. http://dx.doi.org/10.23887/jere.v2i2.13694

Flégl, M., Jiménez-Bandala, C.A. and Rosas, L.A.A. (2019) 'Can We Measure Professors' Productivity over Longer Period? An Introductory Analysis', *16th International Conference Efficiency and Responsibility in Education,* Prague, Czech Republic, pp. 50-56.

Granitz, N., Chen, S. and Kohli, K.K. (2014) 'Choosing Business as a College Major: A Survey of High School Students', *Journal of the Academy of Business Education*, vol. 15, pp. 1-22.

Haryanti, Wijayanto, H. and Sumarwan, U. (2016) 'Analysis of the Factors Influencing Bogor Senior

High School Student Choice in Choosing Bogor Agricultural University (Indonesia) for Further Study', *Journal of Education and e-Learning Research*, vol. 3, no. 3, pp. 87–97.
Hemsley-Brown, J. and Oplatka, I. (2015) 'University choice: What do we know, what don't we know and what do we still need to find out?', *International Journal of Educational Management,* vol. 29, no. 3, pp. 254–274. https://doi.org/10.1108/IJEM-10-2013-0150
Hendl, J. (2015) *Přehled statistických metod*, Praha: Portál.
Chase, C., Geringer, S. and Stratemeyer, A. (2019) 'The Effect of University Marketing Efforts on Students' Academic Decision-Making: An Empirical Study', *Journal of Higher Education Theory and Practice*, vol. 19, no. 6, pp. 40-48.
Joseph, M., Mullen, E.W. and Spake, D. (2012) 'University branding: Understanding students choice of an educational institution', *Journal of Brand Management*, vol. 20, no.1, pp. 1–12. https://doi.org/10.1057/bm.2012.13
Kulcsár, V., Dobrean, A. and Gati, I. (2020) 'Challenges and Difficulties in Career Decision Making: Their Causes, and Their Effects on the Process and the Decision', *Journal of Vocational Behavior*, vol. 116(Part A), pp. 1-39. https://doi.org/10.1016/j.jvb.2019.103346
Lai, A.P.C., Gibson, P. and Muthaly, S. (2014) 'Becoming an education provider of choice in Hong Kong: An inquiry into student decision making', *International Journal of Educational Management*, vol. 28, no. 5, pp. 590–609. https://doi.org/10.1108/IJEM-05-2013-0082
Le, T.D., Robinson, L.J. and Dobele, A.R. (2019) 'Understanding high school students use of choice factors and word-of-mouth information sources in university selection', *Studies in Higher Education*, vol. 45, pp. 808-818. https://doi.org/10.1080/03075079.2018.1564259
Maniu, I. and Maniu, G.C. (2014) 'Educational Marketing: Factors Influencing the Selection of a University', *SEA: Practical Application of Science*, vol. 2, no. 3, pp. 37-41.
Měsíček, L., Petrus, P. and Kovářová, K. (2019) 'Do Admission Procedure Scores Correlate with University Study Results?', *16th International Conference Efficiency and Responsibility in Education,* Prague, Czech Republic, pp. 190-196.
Moogan, Y.J. and Baron, S. (2003) 'An Analysis of Student Characteristics within the Student Decision Making Process', *Journal of Further and Higher Education*, vol. 27, no. 3, p. 271-288. https://doi.org/10.1080/0309877032000098699
Navratilova, T. (2013) 'Analysis and Comparison of Factors Influencing University Choice', *Journal of Competitiveness*, vol. 5, no.3, pp. 90-100. https://doi.org/10.7441/joc.2013.03.07
Obermeit, K. (2012) 'Students' choice of universities in Germany: structure, factors and information sources used', *Journal of Marketing for Higher Education*, vol. 22, no.2, pp. 206–230. https://doi.org/10.1080/08841241.2012.737870
Owusu, G.M.Y. et al. (2018) 'Factors Influencing Career Choice of Tertiary Students in Ghana: A Comparison of Science and Business Majors', *Education and Training*, vol. 60, no. 9, pp. 992–1008. http://dx.doi.org/10.1108/ET-04-2017-0050
Pappas, T.S. and Kounenou, K. (2011) 'Career decision making of Greek post secondary vocational students: The impact of parents and career decision making selfefficacy', *Procedia - Social and Behavioral Sciences*, 15, pp. 3410–3414. http://dx.doi.org/10.1016/j.sbspro.2011.04.310
Rutter, R., Roper, S. and Lettice, F. (2016) 'Social media interaction, the university brand and recruitment performance', *Journal of Business Research*, vol. 69, no. 8, pp. 3096–3104. https://doi.org/10.1016/j.jbusres.2016.01.025
Simões, C. and Soares, A. (2010) 'Applying to higher education: information sources and choice factors', *Studies in Higher Education*, vol. 35, no. 4, pp. 371–389. https://doi.org/10.1080/03075070903096490
Songan, P., Hong Kian Sam, Tonga, G., Rahman, M.A. and Wah T.K. (2010) 'Factors Influencing Student Choice: A Study of a Malaysian Public University', *Asian Journal of University Education*, vol. 6, no. 1, pp. 75-89. https://doaj.org/article/821e783c88fe442a8a5cab4f8f7889e4

UNDERSTANDING OF BASIC CONCEPTS IN NOVICE PROGRAMMING COURSES

[1]Radim Remeš, [2]✉Ladislav Beránek

[1]Department of Applied Mathematics and Informatics, Faculty of Economics, University of South Bohemia in České Budějovice, Czech Republic

[2]Department of Applied Mathematics and Informatics, Faculty of Economics, University of South Bohemia in České Budějovice, Czech Republic, beranek@jcu.cz

Abstract

This paper deals with the problem how students understand the basic concepts of computer programming including the object design and the use of design patterns. It turns out that students have great difficulty in understanding some basic programming concepts including basic concepts of the object objective programming (OOP). This is also reflected in the problems that students often have when they are given a task to design some computer program. This paper is intended to contribute to a knowledge about education of programming in tertiary education. We present some results of our qualitative research of how the understanding of basic concepts of object oriented programming relates to study results of students in computer programming courses. Data obtained from interviews and observations was analysed from several different perspectives to provide an overview of students' learning of concepts and their learning of practice. Results are briefly discussed and evaluated.

Keywords

Learning programming, object oriented programming, programming concepts, teaching programming, tertiary education

Introduction

Object oriented programming is focused on creating complex systems with high efficiency and possibility of their easy maintenance and reuse. In most cases, the assignments to be solved by students are relatively simple. The scope of these assignments is not broad due to the limited ability of students to design and create structures that are more complex. The reason is the limited number of available syntactic elements known to students, and the fact that the number of lines of code should not be too big. However, if the assignment or example does not point to the basic concepts and concepts of object oriented programming, then students may conclude that object oriented approach is not too useful at problem solving.

The cognitive processes that lead to learning computer programming have been the subject of many information education researchers for many years. Many empirical researches have been conducted to find out what problems students encounter when learning different programming concepts (variables, cycles, classes, inheritance, encapsulation etc.) (Corney, Teague, Ahadi, & Lister, 2012; Beranek & Remes, 2013, Beranek & Remes, 2015; Izu, Weerasinghe, & Pop, 2016, Remes & Beranek, 2019). Many studies point to the need for a good understanding of the central concepts of object oriented programming. Ragonis and Ben-Ari (2005a, 2005b) present a long-term study on the understanding of concepts in object oriented programming of high school students. Fleury (2000) found out in his study that students developed their own understanding of OOP, however, their understanding were not always complete and correct. This also prevents students from achieving the right results in programming and discourages them

from doing programming. Some tools and approaches as the use of Unified Modelling Language (UML) diagrams, pictorial representations, visualizations, and interactive animations might also help students to understand better different basic concepts including object oriented programming concepts (Biju, 2013) at the teaching programming. In addition, the use of software tools, which can support the teaching and learning process of programming concepts, can be useful, as well. Such tools for understanding object oriented programming concepts are for example Alice (Hsu, 2018), Greenfoot (Kolling & Rosenberg, 2001), or BlueJ (Yan, 2009). Berglund and Lister (2007) examined the understanding of programming concepts by students in advanced courses. Usually authors in these studies used qualitative research including a phenomenographic approach (Akerlind, 2008). In addition, for example, Boustedt et al. (2007) studied the understanding of advanced objects by students. Eckerdal and Thune (2005), Chen et al. (2012) emphasizes that a good understanding of programming requires both practical skills and conceptual understanding and interconnection between them.

In his study, Biju (2013) found that although beginners knew the syntax and semantics of individual commands, they did not always know how to use these constructs to create valid programming code. The authors concluded in their research that teachers should be able to improve the performance of their students through education of learning strategies, i.e., how to assemble parts of the code into the resulting functional program, and help them learn the syntactic and semantic constructs of programming.

The authors of this study pointed out that the ability of beginners to solve problems and to write proper programming code requires the mastering of other skills besides knowledge of the syntax and semantics of the programming language. Most of the mistakes, students make in their programs, are related to the lack of organizational knowledge and problem-solving strategies. For example, it may be the inability to see the internal context between problems or the transmission of a good idea to solve similar problems in different contexts (Brown et al., 2018; Muller, 2005).

The aim of our work is to gain a deeper understanding of how beginners can learn to program with an emphasis on cognitive development processes, especially when they are to understand programming concepts. Based on these findings, it is possible to understand students' cognitive schemes and the ways students apply them in designing and programming assignments. This understanding helps in designing tasks that help with learning while maintaining object oriented quality.

The motivation of our research was to strengthen our students' competencies in design and programming of computer applications. The research questions we have defined at the beginning of our research can be formulated as follows:

- How do students understand the concepts of object oriented programming?
- What strategies do use the students in programming courses when they have problems in learning of OOP concepts?

Materials and Methods

Methodology

Our research is based on a qualitative interview approach. We used a theoretical framework based on Threshold Concept Theory (Meyer and Land, 2006) with the focus on the first two characteristics of this framework – troublesome and transformative. It means that the research questions were designed with respect to the programming aspects that the participants faced with, and possibly gave them a paradigmatic shift in understanding the subject (Meyer and Land, 2006). Therefore, research questions concerned some aspects of programming that participants had struggled with as well as which had potentially provided them with a certain shift in understanding of the programming problems solving. In an attempt to achieve some consensus

regarding the Threshold Concepts for novice student programmers, data was gathered from first year undergraduate students three time during the year. The rationale was to capture a sense of which respective OOP concepts were identified at the beginning, in the middle and end of the course. The questions concerned conceptual understanding: abstract or theoretical understanding of the concept; concrete understanding of the concept supported by practical programming; ability to move from abstract to concrete understanding; understanding why the concept is used and taught, and understanding of its application in new situations.

Simultaneously to the dealing with programing concepts, our analysis is focused on student programming strategies. Starting from Trigwell et al. (1994), where it was stated that approaches to the learning could be discussed in terms of intention and strategy. The intention is what the student is trying to do, while strategy is what the student is doing to fulfill the intentions. In the field of programming teaching, Robins et al. (2003) stated that the lack of programming strategies causes problems for novice students. We investigated the strategies of how students handle the problems they face in their learning of the programing. Especially when they are stuck in their learning. This builds on the issues of our research on the problems students have when learning programming concepts.

Method

Within the framework of the proposed research described in previous section, a group of 28 students were monitored during the first year of programming at the Faculty of Economics.

1. Could you tell me about something where you were stuck at first but then became clearer? (Subject answers <X>.)
The rest of this session will now focus on <X>
2. Tell me your thoughts, your reactions, before, during and after the process of dealing with <X>
3. Please tell me what other things you need to understand in order to gain a good understanding of <X>
4. Can you tell me how your understanding of <X> has affected your understanding of other things?
5. To finish the interview, can you tell me whether there are any other things where you were stuck at first but then became clearer?

Table 1: Script excerpt for students' interviews

Our research followed the approach we described in our paper (Remes, Beranek, 2019). This approach was subsequently used to design a set of tasks that will induce situations that require some form of adaptation or knowledge acquisition. Appropriate programming tasks were identified, and the participants were individually observed during their attempts to solve the assigned tasks. Data was gathered through direct tracking and interviews (see Table 1 with examples of questions). At the end of each session, each student participated in a retrospective interview described the procedures he had used when he had tried to create programs when solved the set of given tasks. Student also should describe problems he or she encountered in trying to solve them and the way to overcome these problems.

Results and Discussion

Analysis of the results of interview

We chose to interview more advanced students (students in the second semester who we supposed they knew the basics of object oriented programming) at first, since we thought that they mastered relevant concepts on certain level, and have developed some picture. We started by addressing the troublesome criterion, asking students for concepts they found difficult (places

where they were initially "stuck"). From these, we selected one concept to be pursued in depth and addressed the transformative, integrative, and irreversible criteria in that context. We did not examine the boundary marker criterion, as it is related more to disciplinary boundaries and less to individual experience. We, interviewers agreed in advance on a list of some problematic concepts, i.e. control structures, thinking sequentially, parameters, objects, memory model that had come up repeatedly in interviews. The aim of this deeper investigation was twofold. It enabled us to gather evidence as to whether specific concepts met the requirements for Threshold Concepts. In addition, it gave us data for an analysis. These transcripts of the interviews were thematically coded. The aim was to identify possible threshold concepts. Finally, we used only two threshold concepts: transformative (once understood, a threshold concept changes the way in which the student views the discipline) and troublesome (threshold concepts are likely to be troublesome for the student. Perkins (1999, 2006) has suggested that knowledge can be troublesome, e.g., when it is counter-intuitive, or seemingly incoherent). Other threshold concept are irreversible, integrative, bounded, discursive or liminality. We have chosen only the two aforementioned for our purposes. The programming concepts, that were mentioned in several interviews, were analyzed. The ones identified as troublesome or transformative were selected, see Table 2 and Table 3.

Programming Concept	Dimension of Threshold Concept Theory	Data Examples
Numeral systems	Troublesome	When I understood how it was transforming into a binary system and a sixteen system, I realized that it was still the same thing, just changing the base there. At least I will not forget any combination when we look again for all numbers for 4 bits." *Student 1 semester.*
Boolean expressions	*Troublesome*	I never know if I have to combine those conditions with the *or* or the *and* function, I always do it wrong, I always put the other one there. As there are more conditions, so I'm lost." *Student 1 semester.*
Arrays	*Troublesome* and *transformative*	The fields are quite simple. If I do not forget to allocate memory, it all works for me. Finally, I can also store more values and do not have to make a separate variable for each. It's just stupid that I can't have different values (*understand data types*) in individual values (*understand elements*)." *Student 1 semester.*
Loops	*Troublesome*	I like Loops. When I want something to be repeated multiple times, so I put it in a loop. I just have to be careful not to loop it on again, it happened to me once. So I prefer to use only for loop, which is clearer for me." *Student 1 semester.*
Conditions	*Troublesome* and *transformative*	When I need to find out or separate something, I use the condition. I practically use it all the time." *Student 1 semester.*
Functions and parameters	*Troublesome*	I never know what to put the output type from a function. If it was up to me, I would always put a void there and have it printed on the console." *Student 1 semester.*

Table 2: The Basic Programming Concepts, (source: own research)

While many of the basic programming concepts discussed by interviewed students were identified as troublesome, only few were also considered as transformative (see Table 2). However, the concepts of object oriented programming are more abstract. Some students also have noted that it is more difficult to understand such abstract concepts in OOP programming than in subjects such as mathematics and others. Table 3 shows that more OOP concepts were described as troublesome and as transformative. We consider these results as evidence to consider the five concepts as suitable candidates for Threshold Concepts in programming. Of particular interest are *Object Design*, *Abstract Class*, *Object Interaction*, *Polymorphism* and *Delegates and Events*, all of which fall under the area of object oriented programming

(see Table 3). In the literature, the whole object orientation approach has been suggested as a prospective Threshold Concept in programming, but it has also been criticized as being far too large an area to be of significant use (Rountree and Rountree, 2009). We believe that our findings can contribute to find more specific sub-concepts of object oriented approach that may be of more help in identifying particular points in the curriculum where students may require additional support.

As part of our research, we have also identified strategies that students use when they were stuck with some programming tasks. None of approaches, which were mentioned by the students (Table 4), was surprising in itself. Students used mostly three approaches: the approach to ask their friends or their instructor for help, the approach to find resources on the Internet (and to find similar solutions they could use), and the approach to programming by trial and error. We have assigned appropriate strategies to these approaches of interviewed students: *Discuss and learn from other people*, *Learn from tools or written materials* or *Gain experience*.

The students mentioned in the interviews that they like systematic instructions when they learn something new. For teaching, this implies giving students the opportunity to discuss their work with their peers, giving them good examples that relate to what they already know detailed instructions. This approach is already used that by experienced teachers. However, our study provides a deeper understanding of students' experiences and a list of possible ways to overcome the difficult parts of programming.

Programming Concept	Dimension of Threshold Concept Theory	Data Examples
Object design	*Troublesome* and *transformative*	I will finally figure out what all the objects will be there. When I create a class, I know what it is all about there. But, sometimes, I get confused about properties and abilities. Then I don't know if it's supposed to be a property or ability." *Student 1 semester.*
Inheritance	*Transformative*	The inheritance of classes was not difficult for me. I basically understood it right from the start. Only later, when the association was added, I sometimes hesitated whether to link the classes through inheritance or association." *Student 1 semester.*
Abstract class	*Troublesome* and *transformative*	I understand what an abstract class is, and that I can't make an instance of it. I just don't know what it's good for if it can't have an instance." *Student 1 semester.*
Object interaction	*Troublesome* and *transformative*	All this connecting objects is pretty clear and simple. But, the terms are pretty confusing, especially aggregation and composition. Fortunately, it is similar in the databases where we learned a lot about it, so I probably understand everything." *Student 1 semester.*
Polymorphism	*Troublesome* and *transformative*	I already understand polymorphism, I've always forgotten to put that virtual in there, so it didn't work, but when I put it everywhere, it works for me. I just don't know why don't I create that instance directly as a child, why do I put that parent there?" *Student 2 semester.*
Encapsulation	*Troublesome*	It makes sense now. I was wondering why the variable was defined twice, but I get it now. It is quite handy that I can shield it like this so that someone there does not do anything with the data under my hand." *Student 1 semester.*
Delegates and events	*Troublesome* and *transformative*	When I finally understood how it worked and how to use it, it all made sense to me. I didn't know a lot of things, but now I can solve it or make my program much simpler." *Student 2 semester.*

Table 3: The object programming concepts, (source: own research)

Students' approach	Used strategy
Learn from peers	Discuss and learn from other people
Get help (from a tutor)	Discuss and learn from other people
Read instructions form textbook	Learn from tools or written materials
Read instructions form on Internet	Learn from tools or written materials
Write programs	Gain experience
Learn by trial and error	Gain experience

Table 4: Identified strategies and their description

Conclusion

In this research, we have used Threshold Concepts Theory framework in the research of learning of programming especially object oriented programming. The results of this paper are concepts that may be candidates for thresholds in learning of programming. We have also presented strategies the students used when they had problems with solving of some programming assignments. We have presented some preliminary results of our research.

Based on our research findings, we have gained a deeper understanding of how beginners can learn to program with emphasis on their cognitive development processes. The research and analysis of student interviews enabled us better to understand the students' cognitive patterns and the ways students use to solve their assigned tasks. Our further task is to suggest some procedures and suggestions for appropriate metrics to evaluate the quality of students' object oriented design. This reflects our finding that abstract concepts are the biggest problem for students. We will further test and optimize suggested procedures and task in our further research.

References

Akerlind, Gerlese (2008) A phenomenographic approach to developing academics' understanding of the nature of teaching and learning', *Teaching in Higher Education*., vol 13, no. 6, pp. 633-644. https://doi.org/10.1080/13562510802452350

Beranek, L. (2015) 'The Attitude of the College Students to Entrepreneurial Skills Development in the Subject E-commerce', *Informatics in education*, vol. 14, no. 1, pp. 1–12.

Beranek, L. and Remes, R. (2013) 'Evaluation of the support of entrepreneurial competences of students in the subject e-commerce', *Proceedings from the 10th International Conference Efficiency and Responsibility in Education* (*ERIE 2013*), Prague, pp. 32 – 38.

Berglund, A. and Lister, R. (2007) 'Debating the OO debate: where is the problem?', In *Proceedings of the 7th Baltic Sea Conference on Computing Education Research* (Koli Calling'07). Australian Computer Society, pp. 171–174.

Biju, S.M. (2013) 'Difficulties in understanding object oriented programming concepts, Innovations and Advances in Computer', In: *Information, Systems Sciences, and Engineering*, Springers, Netherlands, pp. 319-326.

Boustedt, J., Eckerdal, A., McCaetney, R., Mostrom, J.E., Ratcliffe, M. Sanders, K., and Zander, C. (2007) 'Threshhold concepts in computer science: do they exist and are they useful?', *SIGCSE Bulletin*, vol. 39, no. 1, pp. 504–508.

Brown, Neil C.C. and Wilson, Greg (2018) 'Ten quick tips for teaching programming', *PLOS Computational Biology*, vol. 14, no. 4. https://doi.org/10.1371/journal.pcbi. 1006023

Chen, C.L., Cheng, S.Y. and Lin, J.M.C. (2012) 'A study of misconceptions and missing conceptions of novice Java programmers', In *Proceedings of the International Conference on Frontiers in Education: Computer Science and Computer Engineering* (FECS'12).

Corney, M., Teague, D., Ahadi, A., and Lister, R. (2012) 'Some empirical results for Neo-Piagetian reasoning in novice programmers and the relationship to code explanation questions',

In *Proceedings of the 14th Australasian Computing Education Conference (ACE'12)*, vol. 123, pp. 77–86. Melbourne, Australia: Australian Computer Society Inc.
Eckerdal, A, and Thuné, M. (2005) 'Novice Java programers' concepts of "objects" and "class", and variation theory', *SIGCSE Bulletin*, vol. 37, no. 3, pp. 89–93.
Fleury, A. E. 2000. Programming in Java: student-constructed rules', *SIGCSE Bull*., vol. 32, no. 1, pp. 197–201.
Hsu, T.-Ch., Chang, S.-Ch., Hung, Yu-Ting (2018) 'How to learn and how to teach computational thinking: Suggestions based on a review of the literature', *Computers and Education*, vol. 126, pp. 296–310.
Meyer, J.H.F. and Land, R. (2006) *Overcoming Barriers to Student Understanding: Threshold Concepts and Troublesome Knowledge*. London: Routledge and CRC Press.
Muller, O. (2005) 'Pattern oriented instruction and the enhancement of analogical reasoning', In *Proceedings of the 5th International workshop on Computing Education Research* (ICER'05), pp. 57–67. Seattle, WA, USA: ACM.
Perkins, D. (1999) 'The many faces of constructivism', *Educational Leadership*, vol. 57, no. 3, pp. 6-11.
Perkins, D. (2008) 'Beyond Understanding', In: *Threshold Concepts within the Disciplines*, Land, R., Meyer, J.H.F. and Smith, J., (eds), Sense Publishers, Rotterdam, pp. 3-19.
Ragonis, N. and Ben-Ari, M. (2005a) 'A long-term investigation of the comprehension of OOP concepts by novices', *Comput. Sci. Educ, vol. 15, no. 3, pp. 203–221.*
Ragonis, N. and Ben-Ari, M. (2005b) 'On understanding the statics and dynamics of object-oriented programs', *SIGCSE Bull*, vol. 37, no. 1, pp. 226–330.
Remes, R. and Beranek, L. (2019) 'Object design in the novice programming programing course in the tertiary education', In: *Proceedings from the 16th International Conference Efficiency and Responsibility in Education* (*ERIE 2019*), Prague, pp. 81 – 88.
Yan, L. (2009) Teaching Object Oriented Programming with Games', *Sixth International Conference on Information Technology: New Generations* 2009, IEEE, Las Vegas, NV, USA, pp. 969–974.

USE OF THE CLIL METHOD IN TEACHING MATHEMATICS AT LOWER SECONDARY SCHOOL LEVEL

Hana Reslová

Department of Mathematics and Mathematical Education, Faculty of Education, Charles University, Czech Republic, hanreslova@gmail.com

Abstract

The paper focuses on Content and Language Integrated Learning (CLIL). The term stands for the teaching of a non-language subject through the medium of a second or foreign language. The teaching has content-oriented and language-oriented goals. The aim of the presented research study was to plan, conduct and evaluate a two-month-long process of using CLIL in mathematics lessons at lower secondary school level. In the teaching experiment, the impact of the connection of mathematics and English language on pupils' motivation and mathematics knowledge was explored. The experimental lessons focused on the topics of ratio, direct and inverse proportion. The main method used in the experiment was action research. Other applied methods were quantitative methods (questionnaires) and qualitative methods (interview and mediated observation). The experiment proved that the implementation did not have any negative impact on pupils' motivation, knowledge and activity in the lessons.

Keywords

CLIL, English, integrated learning, mathematics

Introduction

One of the priorities of European politics is to educate its population in mother tongue and two other foreign languages. One tool that helps to achieve the goal is integration of content and language in education. Content and Language Integrated Learning (CLIL) is a method of learning content (non-linguistic) subject through a non-native language. Objectives of lessons where the method is used are two: content and language (Coyle, Hood and Marsh, 2010).

There are schools providing education using the CLIL method in all European countries (European Commission, 2017). At the same time the European Commission (2017) claims that there is no evidence at the level of European Union that would show the number of existing CLIL programmes in European schools.

This research paper focuses on the CLIL used in mathematics. Nikula et al. (2016) claim there is a close connection between mathematics and language. Language is the primary means through which mathematical content and knowledge are expressed. Traditionally, mathematics has been regarded as in some ways analogous to a language as a system of communication used by a particular community. More recent approaches to the relation between language and mathematics have emphasised that mathematical content or understanding are inconceivable without flexibility of everyday language. Use of natural language is prerequisite to learning of mathematical knowledge. Mathematical content is expressed and developed through language (Nikula et al., 2016).

Relevant research in field of the CLIL method used in lessons of mathematics could be classified into three categories. The first group of studies focuses on pedagogical aspects of learning by the CLIL method (Novotná, Hadj-Moussová and Hofmannová, 2001). The second group of studies focuses on discourse in bilingual classrooms (Moschkovich, 2007). The third group of research studies focuses on cognitive aspects of how a non-native language influences mathematical thinking and problem-solving processes (Barwell, 2005).

The research presented in this paper belongs to the third category. Its main objectives were to plan, conduct, describe and evaluate the process of implementation of the CLIL method in mathematics at lower secondary school level. The priority when planning the implementation was long-term sustainably of this kind of teaching and maximum advantage to pupils in language and mathematical learning. The main research question was: *Is the CLIL method suitable for long time implementation in lessons of mathematics?* The question is very complex and thus was divided into three areas: mathematical knowledge, motivation of pupils and activities of pupils in CLIL lessons.

The paper starts with general information about the CLIL method, with a brief presentation of some experiments and researches exploring the impact of the connection between mathematics and non-native language instruction. The paper then introduces the research study (teaching experiment) conducted at a lower secondary school in Prague by the author of this paper. In the following part methods used for data collection are described and results of the study presented.

Materials and Methods

The main method used in the research was action research in which the author of this paper was the researcher and the teacher at the same time. The phase of implementation was based on action, reflection, action enriched with experience from previous lessons. To guarantee a higher level of objectivity of findings, all lessons were recorded and these audio recordings were transcribed. Having transcriptions from the lessons made it possible to analyse the lessons in a different perspective, in a different time and space frame. The method of indirect observations (audio recordings) of lessons makes the action research more objective.

To ensure validity of the research, triangulation of data was used (Gavora, 2000). Data were collected by several methods (observation, interview and questionnaire) thanks to which data triangulation was possible. The methods used were qualitative – direct and indirect observation (audio recordings), interview and action research and quantitative – questionnaire.

In the experiment, two groups were involved: one experimental group and one control group of pupils from the 7th grade of a lower secondary school (ISCAD 2). Both groups had had no prior experience with the CLIL method in any subject before the experiment. Pupils from both groups filled in a questionnaire that tested and compared their knowledge before the experiment. Evaluation of this questionnaire proved that the groups had comparable knowledge of mathematics, at least in the topic that followed.

Seven lessons of mathematics conducted by the CLIL method in the experimental group were implemented and reflected on. At the same time the control group was taught mathematics without the CLIL method. The whole teaching experiment lasted two months. The experimental group was given one lesson of CLIL a week. The lessons taught by the CLIL method focused on revision. The emphasis in the CLIL lessons was on solution of real-world problems, cooperation, experience of pupils and on more kinds of representation of the same thing.

At the beginning of the experiment, the pupils from the experimental group were asked to fill in a scaled questionnaire with several open questions about their motivation in mathematics. The same document was filled in at the end of the two-month experiment in which they were taught by the CLIL method. The goal of the questionnaire was to detect pupils' level of motivation in mathematics lessons at school. Pupils' answers before and after implementation of the CLIL method were compared and analysed. The questionnaire was constructed on the basis of Hrabal and Pavelková (2010). All the mentioned sources focus on the main factors that influence the motivation. The factors are – self-evaluation, teacher, usefulness of the knowledge in the future, parents and their relationship to mathematics. In the questionnaire, only three of these factors were studied. Relationship of parents to the mathematics could not change thanks to the use of the CLIL method and thus was not tested.

Each pupil got an index of relationship to mathematics based on their answers in the questionnaire. Each answer was on scale from 1 (disagreement) to 4 (agreement). From the answers, the average number was calculated (index of relationship to mathematics) and the pupils were grouped as shown in Table 1.

high index	$(3;4\rangle$
average index	$(2;3\rangle$
low index	$\langle 0;2\rangle$

Table 1: Index of motivation

The number of pupils in each group was compared before and after the experiment. The process of evaluation of motivation was described in Karhanová (2010) were used as model.
At the end of the experiment, pupils sat a test which assessed the knowledge acquired in the topics – ratio, direct and inverse proportion – over the period of time when the CLIL method was used. The results of both groups were compared. The comparison was made not only between the experimental and control groups but also with the requirements defined by framework education programme.

Results

Firstly, conclusions resulting from the final test of the knowledge of pupils from experimental and control group on the topic ratio, direct and inverse proportion are presented. The final test consisted of nine problems.
Figure 1 shows the percentage of gained points per group. One group is experimental – 7.C and the other is the control group – 7.A.

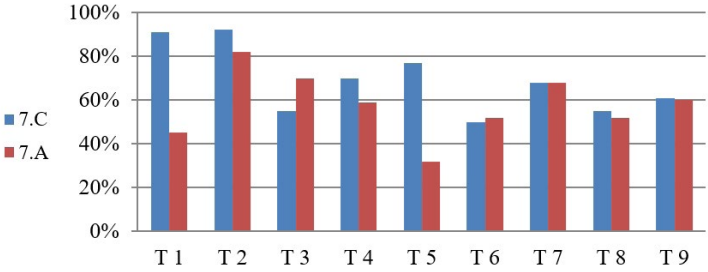


Figure 1: Graph of the results (source: own calculation)[1]

The results of the final test presented by Figure 1 show better results of the experimental group in seven problems and of the control group in two problems. If the average scored gained by the experimental and control groups in the pre-test and post-test are compared, it is the experimental group that gets better results. After the experiment, the difference between the scores is more distinct. Table 2 shows the results.

	Average point gain per pupil	
	Pre-test	Post-test
Control group	6.8 points	12.7 points
Experimental group	7 points	13.8 points

Table 2: Average score gained (source: own calculation)

1 T stands for Task which was in the final test.

The results presented by Table 2 confirm the first conclusion – *Long-term use of the CLIL method in school lessons does not have negative impact on the amount of the knowledge acquired.*
In the following part, conclusions resulting from the questionnaire on motivation and changes in motivation before and after the experiment are presented. Table 3 shows the share of pupils in the groups divided according their motivation to the mathematics.

high motivation			average motivation			low motivation		
before	after	difference	before	after	difference	before	after	difference
36 %	45 %	9 %	45 %	45 %	0 %	18 %	9 %	9 %

Table 3: Motivation to mathematics (source: own calculation)

Table 3 clearly shows that there are more pupils in the group with high index of motivation to mathematics after the experiment. The results of the questionnaire on motivation thus confirm the second conclusion – *Long-term use of the CLIL method in school lessons does not decrease pupils' motivation in mathematics.*
Indirect observations and analysis of audio recordings from all lessons confirm the last conclusion. The use of the CLIL method is not an obstacle to pupils' engagement in activities in lessons. A necessary condition for pupils' active participation in activities in the lessons was use of scaffolding (support from the teacher on the language and content).
The goal of the experiment was accomplish. The experiment shows successful model of implementation of the CLIL method in lessons of mathematics. Action research made by Reslová (2019) shows that the successful implementation of the CLIL method to the lessons of mathematics is possible when the following points are provided:

- to get experience with the CLIL method gradually,
- lessons of CLIL focuses on revision,
- careful preparation of lessons,
- scaffolding of language and mathematics,
- interesting topics of lessons from the life of pupils,
- motivating activities at the beginning of the lesson,
- discussion in foreign language.

Discussion

The main findings from the reported study are connected to pupils' motivation in lessons of mathematics conducted by the CLIL method. A research study from the Spain conducted with 46 pupils indicates that the CLIL method has positive impact on lowering gender differences in motivation; the motivation of the less motivated group was increased (Heras and Lasagabaster, 2015). The same research confirms that the CLIL method has positive impact on learning technical vocabulary. A longitudinal study conducted by Doiz, Lasagabaster and Sierra (2014) with 393 pupils shows similar results. Doiz, Lasagabaster and Sierra (2014) highlight that their results should be analysed and interpreted cautiously because there are the series of individual and contextual variables. The research of Surá (2012) confirms positive impact of the CLIL method on motivation and creativity of pupils and on positive social climate in the class.
In contrast to the positive results of the here reported and other mentioned research, there are studies that are more sceptical. For example Falk´s study (2015) investigates Swedish students´ ability to produce the discourse of the subject history in a situation where they had to demonstrate historical knowledge in written explanations, and where both English and Swedish are involved. The results confirm the importance of paying attention to both languages in CLIL education. Gabasová (2006) based on the psycholinguistic studies and her own research states that knowledge is not linguistically neutral and is connected with the language in which it is

acquired. Gabasová (2006) writes about the evidences that the information stays closed in the language (either mother tongue or foreign language). The knowledge based on exact fact are not saved in the mind in the universal format. Her experiment realized in mathematics with 16 students of bilingual grammar school partly confirms her assumption.

The mentioned experiments show that integration of language and content could have both positive and negative impact. Navés (2002 in Hanušová and Vojtková, 2011) based on the researches in Spain created 10 conditions which must be fulfiled to provide effective and successful learning by the CLIL method. The conditions are: the respect and support of native language and culture of the student, the bilingual teachers, the generally accessible subjects, the long term programs and teachers, the parental support, the cooperation of all parts of educational system, the teachers with double qualification, the high standards, the quality learning materials, the correct use of the CLIL method. The high demands for effective application of the CLIL method which are presented by Navés (2002) are really difficult to achieve. Hanušová and Vojtková (2011) describe the conditions as the goals where the teachers and schools should tend.

Conclusion

In the reported research, the CLIL method was used in lessons of mathematics for two months. The non-mother tongue used in the lessons was English. In the paper, implementation of the CLIL method into lessons as well as the methodology, objectives and results of the research study on the implementation are presented.

In the two-month-long teaching experiment, seven CLIL lessons were conducted in the experimental group. These lessons were included once a week and their nature was revision lessons. After the lessons, audio recordings of the lessons, questionnaires and tests were analysed. The results from this analysis were compared to results of the control group. The results of the cooperation show that the selected way of implementation had no negative impact on mathematical knowledge, motivation of pupils and pupils' activity in individual and group work.

The findings from the study contribute to and enrich the field of CLIL with results from long-term implementation of the CLIL method in mathematics. The described results of the experiment indicate a positive impact on language and content.

The study could be further developed by experiments with larger experimental groups, by studies conducted over a longer period of time or by changing the observed aspects.

References

Barwell, R. (2005) 'Integrationg language and content: Issues from the mathematics classroom', *Linguistics and Education*, vol. 16, no. 2, pp. 205-218. https://doi.org/10.1016/j.linged.2006.01.002

Coyle, D., Hood, P. and Marsh, D. (2010) *CLIL: Content and Language Integrated Learning,* New York: Cambridge University Press.

Doiz, A., Lasagabaster, D. and Sierra, J.M. (2014) 'CLIL and Motivation: The Effect of Individual and Contextual Variables', *Language Learning Journal,* vol. 42, no. 2, pp. 209-224. https://doi.org/10.1080/09571736.2014.889508

European Commission (2017) *Eurydice Brief: Key Data on Teaching Languages at School in Europe*, Audiovisual and Culture Executive Agency.

Falk, L. (2015) 'English and Swedish in CLIL Student Texts', *Language Learning Journal*, vol. 43, no. 3, pp. 304-318. https://doi.org/10.1080/09571736.2015.1053280

Gabasová, D. (2006) *CLIL in Theory and Practice*, Prague: Charles University.

Gavora, P. (2000) Úvod *do pedagogického výzkumu* [The introduction to pedagogical research], Brno: Paido.
Hanušová, S. and Vojtková, N. (2011) *CLIL v české školní praxi* [CLIL in Czech school practise], Brno: Studio Arx.
Heras, A. and Lasagabaster, D. (2015) 'The impact of CLIL on affective factors and vocabulary learning', *Language Teaching Research,* vol. 19, no. 1, pp. 70-88. https://doi.org/10.1177/1362168814541736
Hrabal, V. and Pavelková, I. (2010) *Jaký jsem učitel* [What kind of teacher I am], Prague: Portal.
Karhanová, J. (2010) *Faktory ovlivňující oblibu matematiky u žáků základní školy*, Praha: Charles University.
Moschkovich, J. (2007) 'Examining mathematical discourse practices', *For the learning of Mathematics,* vol. 27, no. 1, pp. 24-30.
Navés, T. (2002) *Successful CLIL programmes*, Milan: Universita e della Ricerca.
Nikula, T., Dafouz, E., Moore, P. and Smith, U. (2016) *Conceptualising integration in CLIL and multilingual education*, Multilingual Matters.
Novotná, J., Hadj-Moussová, Z. and Hofmannová, M. (2001) *Teacher training for CLIL – Competences of a CLIL teacher*. Proceedings SEMT 01. Prague: Charles University, pp. 122-126.
Reslová, H. (2019) *Využití metody CLIL ve vyučování matematice na 2. stupni* ZŠ [Use of the CLIL method in teaching mathematics for lower secondary pupils], Prague: Charles University.
Surá, M. (2012) *CLIL – Methode im DaF – Unterricht.* Brno: Masaryk University.

UNIVERSITY STUDENTS' EXPERIENCE WITH PROFESSIONAL SOCIAL NETWORKS

[1]Daniela Šálková, [1]Petra Šánová, [2]✉Olga Regnerová

[1]Department of Trade and Accounting, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

[2]Department of Trade and Accounting, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, oregnerova@pef.czu.cz

Abstract

Professional social networks are becoming a part of preparing students for future employment. The usual standard is to use personal social networks. Students do not have much experience with professional networks which is an important tool in building professional contacts. The article deals some university student´s experience with professional social networks by selected dependencies between study, gaining practical experience of students in employment or internship and using professional social networks. The research addressed a total of 1,383 university students in economics of the 3rd year of Bachelor's programs and the 2nd year of Master's programs. By addressing these students, their increased interest in establishing professional contacts could be expected.

Keywords

Employment, experience, professional social networks, study, theoretical preparation

Introduction

Universities represent the highest level of the education system. They are top centers of scholarship, independent knowledge and creative activities (Svatosova and Pelikan, 2017). Social networks have become a de facto tool of communication and social networking in the 21st century in terms of both services and places, and also enhance social relations (Boyd and Ellison, 2007). Universities provide a platform for employee selection. In addition to communicating on strengthening social relationships, social networks can be considered as one of the main sources of entertainment, a means of self-realization, or a helper in building a career and a career (Kadushin, 2012).

Most of the available social networking studies are focused on Facebook, Twitter and Youtube (Pilar et al., 2019). Less attention is paid to professional social networks. The interconnection of professional social networks and university studies brings benefits in the form of establishing contacts with practice. These can be used to acquire practical skills and experience of students, for example through internships or cooperation in writing the final thesis. Especially at the end of their studies, the use of professional networks can bring benefits in the form of employment.

There are several studies on the effects of technologically advanced feedback on learning outcomes (Tanes et al., 2011), interest in learning analytics is growing (Tempelaar, Rienties, and Giesbers, 2015) and social networking (Benson, Morgan and Filippaios, 2014). There are now countless types of social networks with the same or different focus. Currently, professional social networking LinkedIn has the greatest success (Pavlicek, 2010).

The aim of the article is to identify the behaviour and experience of university students in economics with the use of professional networks. Given the possibilities offered by professional networks to students (internships, theses, getting a job or employment), attention is focused on students in business-oriented courses in the last year of study.

The research questions are as follows: the first research question concerns the potential difference in attitudes and use of professional networks by students. The second research question is about the dependence of the use of professional networks on the level of study. The third research question targets on potential dependence between using of professional network and inviting to a job interview. The final research question is, whether using a professional network increases the likelihood of getting a job through this channel.

Materials and Methods

The theoretical background of this paper has been based on an analysis of secondary sources gained from scholarly papers, specialized literature, and official web portals. Primary data have been obtained through an own conducted survey by electronic questionnaires. The target group of respondents was students of FEM CZU in Prague, who finished the study of some "trade" subject and during the education process, they were informed about the possibilities of using professional social networking. The following survey included students of full-time (present form) and distance form of study and in master and bachelor degree (always in the ending year). Each student completed the questionnaire only once.

The research data were collected from 1st February 2018 to 30th November 2019 (i.e. 3 ended semesters, each student filled the questionnaire only once) and contains answers from full-time and distance students. The questionnaire consisted of a total of 24 questions, 22 closed, 2 open. The first part was focused on the demographic characteristics of respondents (gender, age, study program and form of study). Issues related to the current job while studying, a form of employment, and the reasons have been identified in other parts of the questionnaire. Furthermore, the knowledge of professional social networks, the extent, and reasons for their use and a possible link to current or future employment were investigated.

Primary descriptive statistics are used to analyse the basic characteristics of respondents. The multi-dimensional analysis is used for finding the answers to the above question. There is an analysis of the dependence of two variables written into contingency tables. The contingency tables are the basis for testing the previously formulated hypotheses. The chi-square test for independence of attributes was used for testing in contingency tables. The precondition for using this test was met. It means is that expected frequencies in individual cells must not be lower than 5 at least in 80% of cells, and in the remaining cells, theoretical frequencies must not be lower than 1 (Pecakova, 2008). For the test of statistical hypotheses and the following analysis the significance level $\alpha = 0.05$ was used. Only answers without missing values were taken into account in the calculation. The calculations were made with the statistical software SPSS version 25.

Results

1383 respondents (students of FEM CZU in Prague) participated in data collection. According to the student structure on the faculty, 378 men and 1005 women were asked to fill in an online questionnaire. The most frequent age group (80%), in agreement with the structure of FEM students, was the 21-25 age group (1107 respondents). The survey was determinate for students at the end of the study of "trade subject" (and study program), namely 778 students in the Bachelor's program (56.3%) and 605 students in the Master's program (43.7%). 75% of the interviewed students were in full-time study (presently form of study). According to the results, 90.2% of the total of 1,383 students (1248) already work in some form (student job, part-time, full-time). Taking into account distance learning, there is a large volume of full-time students who are already working in some form of study (see table 1).

Count		Study form		Total
		full time study	distance study	
The student is employed	no	124	11	135
	yes	913	335	1248
Total		1037	346	1383

Table 1: Cross tabulation about count of employed students (source: own research)

The structure of the form of employment is shown in Table 2 below. The relatively high number of full-time jobs is due to the involvement of distance learning students. Nevertheless, the proportion of students working part-time and full-time remains relatively high.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	student job	640	46.3	51.4	51.4
	part-time job	259	18.7	20.8	72.3
	full-time job	345	24.9	27.7	100.0
	Total	1244	89.9	100.0	
Missing	System	139	10.1		
Total		1383	100.0		

Table 2: Type of jobs (source: own research)

A total of 711 students commented on the issue of professional networks, of which 416 students use a professional network. Out of the 1,383 students addressed, only 30% of respondents using the professional network are involved. This is different from the social networks used, such as Facebook and Instagram. 87.4% of students (i.e. 1209 out of 1383 respondents) use these networks. The most frequently used network is LinkedIn (more than 90%).Of those using the professional network, only 35% use the network actively. The remaining 65% of respondents stated that they had only a profile. The average number of contacts is 2 per profile.

The next part of the paper focuses on a more detailed two-dimensional analysis of relations between selected aspects. The first research question concerns the potential difference in attitudes and use of professional networks by students. It is likely that students who already have practical experience in the labour market will benefit more from professional networks.

Formulation of null hypothesis:

H_0: There is no statistically significant difference in the use of professional networks between full-time and part-time students.

H_A: non H_0.

	Value	*df*	Asymptotic Significance (2-sided)
Pearson Chi-Square	65.454[a]	1	.000
Likelihood Ratio	62.434	1	.000
Linear-by-Linear Association	65.407	1	.000
N of Valid Cases	1383		

0 cells (0.0%) have expected count less than 5. The minimum expected count is 105.08.

Table 3: Chi-square test (source: own calculation)

Using the Pearson´s chi-square test for independence (see Table 3) on *p*-value = 65.454, so there is dependence between using of professional networks between full-time and part-time students at the significance level 0.05. *Therefore, the null hypothesis was rejected.*

The second research question is about the dependence of the use of professional networks on the level of study. It is assumed that the higher the degree of study the student will be more likely to use a professional network.
Formulation of null hypothesis: H_0: There is no statistically significant difference in using of professional network on the level of study. H_A: non H_0.

	Value	*df*	Asymptotic Significance (2-sided)
Pearson Chi-Square	62.876[a]	1	.000
Likelihood Ratio	62.751	1	.000
Linear-by-Linear Association	62.831	1	.000
***N* of Valid Cases**	**1383**		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 183.73.
b. Computed only for a 2x2 table

Table 4: Chi-square test (source: own calculation)

Pearson´s chi-square test for independence is 62.876, so there is dependence between using of professional network on the level of study at the significance level 0.05. *Therefore, the null hypothesis was rejected.*
The third research question targets on potential dependence between using of professional network and inviting to a job interview. One of the most commonly reported reasons for using a professional network was that students expect increased working contacts and an increased chance to get (better) jobs. It can, therefore, be expected that active use of the network will lead to possible incentives and invitations to job interviews.
Formulation of null hypothesis: H_0: There is no statistically significant difference between using of professional network and inviting to a job interview. H_A: non H_0

	no yes		invited to a job interview		Total
Count	Student uses professional network	no	259	21	280
		yes	278	139	417
	Total		537	160	697
Expected Count	Student uses professional network	no	215.7	64.3	280.0
		yes	321.3	95.7	417.0
	Total		537.0	160.0	697.0
Residual	Student uses professional network	no	43.3	-43.3	
		yes	-43.3	43.3	
Sign Scheme	Student uses professional network	no	+++	---	
		yes	---	+++	

Table 5: Cross tabulation Student uses professional network * invited to a job interview (source: own calculation)

The result of Pearson's chi-square is 63.211, for 1 *df* and condition, that 0 cells (0.0%) have expected count less than 5. The minimum expected count is 64.28. There is dependence between using of professional network and inviting to a job interview at the significance level 0.05. Therefore, the null hypothesis was rejected. The exploratory sign scheme was used to display the relationship. From this scheme, it is clear that 99.5% of reliability has more frequently become getting of job in case of using a professional network. Next, the risk was estimate. Odds (chance, risk) gives the ratio of the probability of occurrence of a phenomenon to the probability of its occurrence. The odds Ratio for students use the professional networks (no/yes) is 6.6167. For

cohort "invited to a job interview = no" is 1.388. It means, that the situation „student doesn´t use professional network and isn´t invited to a job interview" is 1.388 more time probably.

The final research question is, whether active using a professional network increases the likelihood of getting a job through this channel.

Formulation of null hypothesis: H0: There is no statistically significant correlation between active using a professional network and getting a job through this network. HA: non H0.

			job offers through the professional network no yes		Total
Count	How to use the network	actively	46	163	209
		only profile	236	119	355
	Total		282	282	564
Expected Count	How to use the network	actively	104.5	104,5	209.0
		only profile	177.5	177.5	355.0
	Total		282.0	282.0	564.0
Residual	How to use the network	actively	-58.5	58.5	
		only profile	58.5	-58.5	
Sign Scheme	How to use the network	actively	---	+++	
		only profile	+++	---	

Table 6: How to use the network * job offers through the professional network Cross tabulation (source: own calculation)

Using the Pearson´s chi-square test for independence (p-value = 104.058), there is dependence between active using professional network and getting job by this way at the significance level 0.05. Therefore, the null hypothesis was rejected. There was counted with expect values. The exploratory sign scheme was used to display the relationship. From this scheme, it is clear that 99.5% reliability has more frequently become getting of job in case of active using a professional network.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	104.058[a]	1	.000
Likelihood Ratio	108.728	1	.000
Linear-by-Linear Association	103.874	1	.000
***N* of Valid Cases**	**564**		

Table 7: Chi-square test (source: own calculation)

Next, the risk estimate was identify. Odds Ratio for How to use the network (actively / only profile) is 0.142. For cohort job offers through the professional network = yes is this value 2.327 part time.

Discussion

The interconnection of professional social networks and university studies brings benefits in the form of establishing contacts with practice. This enables to gain practical skills and experience not only in the form of internships or cooperation in writing the final thesis. According to Fischer and Musil (2015), the outcomes of education institutions are skills and knowledge that students get, which can be very different among graduates. Research shows that there is some concern among students about the lack of practical skills and the possibility of their acquisition in the Czech Republic and abroad (Chalupova, Cerna and Prokop, 2016). The researchers Bennis and

O'Toole (2005) have stated that there have long been discussions regarding the development of comprehensive management skills, including leadership. Havlicek et al. (2010) stated generally that information technologies are an effective tool to enhance the efficiency of collaboration. Professional networks can very well serve as a tool for building professional links and gaining experience during their studies. Similarly, lifelong education as such leads to the development of individual social, cultural and economic capital (Varvazovska and Jarkovska, 2016).

In our research, 87.4% of students use social networks (as Facebook, Instagram, etc.), but only 30% of respondents using the professional network. The most famous professional network is LinkedIn (more than 90%). It corresponds with other authors e.g. Pavlicek (2010). This network is widely used by so-called head hunters and managers to discover talents and suitable candidates for various jobs (Pinola, 2013).

Professional networks are actively used by 35% of students surveyed. 65% had only a profile on these networks. This indicates an inefficient use of this network. Also Slone and Haffney (2016) say, that a descriptive analysis of student LinkedIn profiles revealed that students included some basic requirements, but many students still neglected to fully complete the profile, thereby leaving out some important information that would boost their credibility.

Relationships in social networks, including professional ties, constitute an important facet of social capital (Bozionelos, 2003; Seibert, Kraimer and Liden, 2001; Kezar, 2014). Respondents in distance form use the professional network more than students in full-time form. Similarly, students in master's programs use this network more than undergraduate students. The use of professional networks is likely to increase with age or with expected job opportunities. Also Wrzrus et al. (2013) state, those age-related social network changes are due to normative, age-related life events. However, this may also be related to the ambitions that may appear more in the Master's program or in students who are demandingly combining job and study (distance students). Ryan and Xenos (2011) have similar opinion, because argue that users with higher leadership scores tend to provide more active social contributions and use the network for self-promotion.

While the density of the social network of connections is another determinant of career success (Bozionelos, 2003; Seibert, Kraimer and Liden, 2001), the average number of contacts in the professional network is two for the sample of respondents. Hypothesis testing has shown that the active use of a profile in a professional social network increases the possibility of inviting for a job interview or even getting a job. According to Benson, Morgan and Filippaios (2014) clearly UK business postgraduate students are strongly aware that LinkedIn is a professional social network and is unlikely be used to make informal friends and it is evident that postgraduate students join professional networks to search for and explore new opportunities.

Conclusion

Professional social networks are significant to the gradual building of links within professional structures not only for absolvents but also for university students. It can be said that the current utilization rate of professional social networks is particularly low among students of the 3rd year of the Bachelor's program in full-time form. The reason for this may be that students do not realize the fundamental contribution of this type of networking to their future career prospects. Educators should be brought students more to the attention of the importance of professional networks and the possibilities of their use. In addition, attention should be paid to deeper research into obstacles and opportunities for the use of professional networks in academia sphere.

References

Al-Mukhaini, E.M., Al-Qayoudhi, W.S. and Al-Badi, A.H. (2014) 'Adoption Of Social Networking In Education: A Study Of The Use Of Social Networks By Higher Education Students In Oman', *Journal of International Education Research (JIER)*, vol. 10, no. 2, pp. 143-154. https://doi.org/10.19030/jier.v10i2.8516

Bennis, W.G. and O'Toole, J. (2005) 'How business schools lost their way', *Harvard Business Review*, vol. 83, no. 5, pp. 96-104.

Benson, V., Morgan, S. and Filippaios, F. (2014) 'Social career management: Social media and employability skills gap', *Computers in Human Behavior*, vol. 30, January, pp. 519–525. https://doi.org/10.1016/j.chb.2013.06.015

Boyd, D.M. and Ellison, N.B. (2007) 'Social Network Sites', *Journal of Computer-Mediated Communication*, vol. 13, no. 1, pp. 210-230. https://doi.org/10.1109/EMR.2010.5559139

Bozionelos, N. (2003) 'Intra-organizational network resources: Relation to career success and personality'. *International Journal of Organizational Analysis*, vol. 11, no. 1, pp. 41–66. https://doi.org/10.1108/eb028962

Chalupova M., Cerna M. and Prokop M. (2016) 'International Business Weeks - From Challenge to Opportunity', *Journal on Efficiency and Responsibility in Education and Science*, Vol. 9, No. 2, pp. 31-36. https://doi.org/10.7160/eriesj.2016.090201

Fischer, J. and Musil, P. (2015) 'Measurement of education services'. *Proceedings of the 12th International Conference on Efficiency and Responsibility in Education (ERIE 2015)*, Prague, pp. 385-392.

Havlicek, Z., Vanek, J., Lohr, V. and Cerna, E. (2010) 'IT for more effective team collaboration', *AGRIS on-line Papers in Economics and Informatics*, vol. 2, no. 1, pp. 31-40.

Kadushin, C. (2012) *Understanding Social Networks: Theories, Concepts and Findings*, New York: Oxford University Press.

Kezar, A. (2014) 'Higher Education Change and Social Networks: A Review of Research', *The Journal of Higher Education*, vol. 85, no. 1, pp. 91-125. https://doi.org/10.1080/00221546.2014.11777320

Pavlicek, A. (2010) *Nová média a sociální sítě*, Prague: Oeconomica.

Pecakova, I. (2008) Statistika v terénních průzkumech, Prague: Professional Publishing.

Pilar L., Moulis P., Pitrova J., Bouda P., Gresham G., Balcarová T. and Rojik S. (2019) 'Education and Business as a key topics at the Instagram posts in the area of Gamification', *Journal on Efficiency and Responsibility in Education and Science*, vol. 12, no. 1, pp. 26-33. http://dx.doi.org/10.7160/eriesj.2019.120103

Pinola, M. (2013) *LinkedIn in 30 minutes: how to create a rock-solid profile and build connections that matter*, Peterborough: i30Media Corporation.

Ryan, T. and Xenos, S. (2011) 'Who uses Facebook? An investigation into the relationship between the Big Five, shyness, narcissism, loneliness, and Facebook usage', *Computers in Human Behavior*, vol. 27, no. 5, pp. 1658–1664. http://dx.doi.org/10.1016/j.chb.2011.02.004

Seibert, S.E., Kraimer, M.L. and Liden, R.C. (2001) 'A social capital theory of career success', *Academy of Management Journal*, vol. 44, no. 2, pp. 219–237. https://doi.org/10.2307/3069452

Slone A.R. and Gaffney, A.L.H (2016) 'Assessing students' use of LinkedIn in a business and professional communication course', *Communication Teacher*, vol. 30, no. 4, pp. 206-214. http://doi.org/10.1080/17404622.2016.1219043

Svatosova, L. and Pelikan, M. (2017) 'Analysis of Entrance Examinations', *Proceedings of the 14th International Conference Efficiency and Responsibility in Education (ERIE 2017)*, Prague, pp. 408-412.
Tanes, Z., Arnold, K.E., King, A.S. and Remnet, M.A. (2011) 'Using Signals for appropriate feedback: Perceptions and practices', *Computers & Education*, vol. 57, no. 4, pp. 2414–2422. https://doi.org/10.1016/j.compedu.2011.05.016
Tempelaar, D.T., Rienties, B. and Giesbers, B. (2015) 'Stability and sensitivity of Learning Analytics based prediction models', *Proceedings of 7th International conference on Computer Supported Education*, Lisbon, pp. 156–166.
Varvazovska, P. and Jarkovska, M. (2016) 'The Need For Lifelong Learning In The Non-State Nonprofit Sector', *Proceedings of the 13th International Conference Efficiency and Responsibility in Education (ERIE 2016)*, Prague, pp. 610-616.
Wrzus, C., Hänel, M., Wagner, J., and Neyer, F.J. (2013) 'Social network changes and life events across the life span: A meta-analysis', *Psychological Bulletin*, vol. 139, no. 1, pp. 53–80. https://doi.org/10.1037/a0028601

OBSERVING HOW FUTURE PRIMARY SCHOOL TEACHERS REASON ABOUT GENERAL STATEMENTS

Libuše Samková

Department of Mathematics, Faculty of Education, University of South Bohemia in České Budějovice, Czech Republic, lsamkova@pf.jcu.cz

Abstract

The contribution belongs to a larger empirical qualitative study that focuses on various possible ways of using an educational tool called Concept Cartoons in professional preparation of primary school teachers. In this particular case, we use the tool for observing future teachers' modes of reasoning about general mathematical statements. We created a new Concept Cartoon with four general statements about the properties of results of multiplication, and assigned it to future teachers to respond in the written form. Collected data enable us to connect the responses to various modes of reasoning belonging to various levels of proof schemes (inductive, deductive) and various types of examples (counter-examples, generic examples).

Keywords

Argumentation, Concept Cartoons, future primary school teachers, general statements

Introduction

As mathematics consists not only of calculations to compute or equations to solve but also of statements to express, asses or reason about, also teachers have to be prepared to deal with various types of mathematical statements in their teaching practice. They have to understand properly the meaning of logical conjunctions, quantifiers and negations – not only in the environment of formal mathematical logic but most importantly in the more or less formal environment of school mathematics. In that area, a specific approach pertains to teachers being prepared to teach mathematics at the primary school level. These teachers do not usually receive any education on formal mathematical logic, nor are they supposed to teach it to their pupils. But as classroom teachers they would become the main source of pupils' first experience with this part of mathematics – in the form of verification and justification of various types of statements.

In recent years, we have been analysing an educational tool called Concept Cartoons and its possible use in professional preparation of future teachers, especially in assessing various aspects of teachers' knowledge. The issues presented at previous ERIE conferences and in the ERIES journal focused on Concept Cartoons assessing reasoning about calculation tasks and word problems solved by calculations (Samková and Tichá, 2016; Samková, 2018a). And so, naturally, questions arose whether and how it would be possible to use Concept Cartoons also for assessing reasoning about mathematical statements. To hold the line of the mathematical content, the mathematical statements discussed in this contribution relate again to calculations but from a broader general perspective. We discuss properties of the operation of multiplication within the sets of natural numbers, fractions and integers. From the perspective of mathematical statements, we focus on general statements. Our research question is "What kinds of reasoning about general statements can be observed in future primary school teachers when using Concept Cartoons as a diagnostic instrument?"

This contribution belongs to an international educational project supported by the European Commission as an Erasmus+ strategic project *Digital Support for Teachers' Collaborative Reflection on Mathematics Classroom Situations (coreflect@maths)*. The goal of the project is to

bring together and exchange good practices of vignette-based professional preparation of teachers, and then develop a multilingual digital tool to provide an environment for such a preparation. In that sense, Concept Cartoons are considered vignettes (cf. Skilling and Stylianides, 2019).
The text is organized as follows: at the beginning it presents the background of argumentation and general statements considering the perspective of future primary school teachers. Then it describes the participants of the empirical qualitative study and the diagnostic instrument, the course of data collection and data analysis, the findings and their discussion.

Argumentation and general statements

When pupils develop, their view of a proper response to questions whether and why a mathematical statement is true develops as well. The first attempts of such a response usually have the form of a *reference to an authority* (e.g. "It is true because it was on TV yesterday."), later on to one or more *confirming examples* – particular cases in which the statement holds. The confirming examples are welcome when the statement is existential (because they confirm the desired existence) but not so welcome when the statement is general. In the latter case, the disadvantage of confirming examples is that sometimes they can be easily used to mistakenly show the veracity of a false statement. For instance, the general statement that multiplying one positive number by another positive number always produces a bigger number looks true when you multiply 2 by 3, or 5 by 2. Quite a different role in argumentation is played by *counter-examples* – particular cases in which the statement does not hold despite the fact that they meet all the prerequisites of the statement. Such counter-examples are welcome when the statement is general since one counter-example is enough to disprove the statement. For instance, the general statement that multiplying one positive number by another positive number always produces a bigger number may be disproved by a counter-example consisting in multiplying 2 by 1.
Various types of argumentation in assessing and proving mathematical statements were systematized by Harel and Sowder (1998) under the name of *proof schemes*. In their interpretation, "a person's proof scheme consists of what constitutes ascertaining and persuading for that person" (ibid: 244). Their multi-level classification of proof schemes includes:

- *external conviction proof schemes* (doubts are removed by the ritual of the argument presentation, by the word of an authority, or by the symbolic form of an argument);
- *empirical proof schemes* (doubts are removed by quantitatively evaluating the conjecture by one or more specific cases – *inductive proof scheme*, or by reasoning from an illustration or a geometric figure, regardless of possible transformations – *perceptual proof scheme*);
- *analytical proof schemes* (doubts are removed by means of logical deductions: *transformational proof schemes* are based on operations on objects and anticipations of results of the operations, *axiomatic proof schemes* are based on some prior results, axioms and definitions).

In some later sources (e.g. in Harel and Sowder, 2007), the name of *deductive proof schemes* is used instead of analytical proof schemes, to highlight the role that deductive reasoning plays in this type of proof schemes: "Deductive reasoning is a mode of thought commonly characterized as a sequence of propositions where one must accept any of the propositions to be true if he or she has accepted the truth of those that preceded it in the sequence." (ibid: 811). Harel and Sowder (2007) also relate their proof schemes to other taxonomies, e.g. the taxonomy given by Balacheff (1988), and refer to a *generic example* as a sample of a transformational proof scheme. In their interpretation, a generic example is a „justification by an example representing salient characteristics of a whole class of cases" (Harel and Sowder, 2007: 810). Although Harel and Sowder's research leading to the typology was conducted generally, with college students as respondents and with special attention paid to mathematics major students, the typology might

be applied to any stage of mathematical education, including the primary school level. Axiomatic proof schemes might be too formal for the primary school, but all the other types of proof schemes might naturally appear there (Komatsu, 2010).

As reported repeatedly by educational research studies, future primary school teachers have often deeply rooted misconceptions about argumentation and proving: they tend to rely on an external authority as the basis of their conviction (Simon and Blume, 1996), believe that it is possible to affirm the validity of a generalization through a few examples, randomly selected or big-number examples (Martin and Harel, 1989; Goulding and Suggate, 2001). Some of them do not understand the role of counter-examples in refuting general statements and consider one counter-example not being enough (Barkai et al, 2002; Zazkis and Chernoff, 2008). To prevent and remedy such misconceptions, we might present future teachers some false mathematical statements and ask them to determine whether or not they are true or under what conditions (Durand-Gierrier et al., 2012), or challenge their appreciation of proving and need for proving by assigning sets of tasks that aim to enhance the understanding of logical connections between various types of examples and their status in proving and refuting general and existential statements (Buchbinder and Zaslavsky, 2011).

Materials and Methods

Participants

Participants of the study were 28 future primary school teachers – students of the third year of a five-year master degree program at the Faculty of Education. The future primary school teachers are not math specialists; in their teaching practice, they would teach all school subjects of the primary school curriculum (for pupils of 6 to 11 years of age). For our study we choose completely all students who attended the particular compulsory seminar where data were collected.

Diagnostic instrument

As mentioned in the introduction and indicated by the research question, we used an educational tool called *Concept Cartoons* (Keogh and Naylor, 1999; Samková, 2018b) as a diagnostic instrument in the study. Concept Cartoons are pictures showing several children in a bubble dialog and in this particular case we employed a dialog comprising of four general statements on multiplication based on four common misconceptions about the operation: “multiplication makes a bigger number”, “multiplication by a fraction makes a smaller number”, “multiplication by a negative number makes a smaller number” and “multiplication by zero makes a smaller number” (see Figure 1). The domain set of the numbers in focus is not specified, intentionally; it might be either natural numbers, integers, fractions, rational numbers or real numbers.

These misconceptions are partially related to critical moments in learning when an earlier way of thinking fails to account sufficiently for new ideas (cf. Confrey and Kazak, 2006). The earlier ways of thinking associated to the four misconceptions refer respectively

- to multiplication as a repeated addition of a positive integer (i.e. an addition of at least two same addends that are positive) which gives a result that is bigger than the repeated number;
- to multiplication of a positive integer by a positive proper fraction which gives a result that is smaller than the positive integer;
- to multiplication of a positive integer by a negative integer which gives a negative result that is smaller than the positive integer;
- to multiplication of a positive integer by zero which gives a zero result that is smaller than the positive integer.

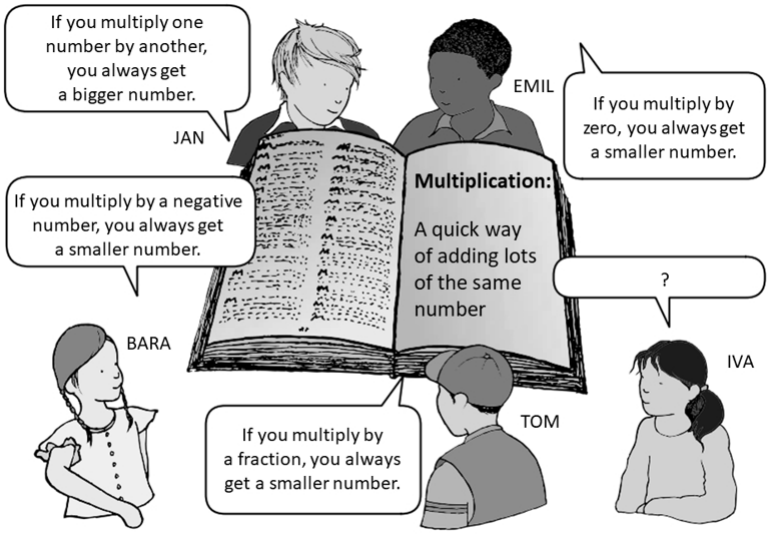


Figure 1: A Concept Cartoon on multiplication; (source of the template of the book and children with empty bubbles: Dabell, Keogh and Naylor, 2008: 3.2)

As for the veracity of the four statements in bubbles, none of them is correct since for each of them there exist counter-examples (numbers for which the statement is not valid). However, it is possible to specify under what conditions the statements are valid, and the conditions might be established in such a way that they apply regardless of the domain set of the numbers in focus:

- Jan – the statement is valid for all pairs of positive numbers bigger than 1, for all pairs of negative numbers, for positive numbers multiplied by positive numbers bigger than 1, for negative numbers multiplied by zero, for negative numbers multiplied by positive numbers smaller than 1;
- Emil – the statement is valid for all positive numbers;
- Bara – the statement is valid for all positive numbers;
- Tom – the statement is valid for positive numbers multiplied by positive fractions smaller than 1, for negative numbers multiplied by positive fractions bigger than 1, for positive numbers multiplied by negative fractions.

Data collection and data analysis

During data collection, we assigned the respondents a worksheet with the Concept Cartoon from Figure 1 and asked them to respond to it in a written form: make a decision which children in the picture are right and which are wrong, and then justify the decision. The participants worked on the worksheet individually, during a lesson, with a time allocation of 20 minutes.

In order to find an answer to the research question, collected data went through qualitative analysis using open coding and constant comparison (Miles, Huberman and Saldaña, 2014). During data analysis we first registered which bubbles were chosen by individual respondents as correct and under which additional conditions. Afterwards, we openly coded all the material, looking for various aspects related to mathematical reasoning, justification

and argumentation. Then we applied the method of constant comparison – from the overall perspective, from the perspective of individual bubbles across all participants and from the perspective of individual participants across all bubbles. At the end of the process, each of the participants was assigned exactly one code category for each of the bubbles (i.e. $28 \cdot 4 = 112$ assignments were made), with eight different code categories involved. The categories are specified below, accompanied by illustrative excerpts.

Results

According to the results of the analysis, majority of the participants based their reasoning just on one or more counter-examples, without any additional reasoning (code category CEX):

S16 Jan: He is not right since $0.002 \cdot 0.002 = 0.000004$ and $0.002 > 0.000004$.
S23 Jan: He is not true, because $0 \cdot 6 = 0$, $1 \cdot 6 = 6$, $12/10 \cdot 5 = 60/10 = 6$.
S32 Jan – no! $1 \cdot 358 = 358 \rightarrow$ stays the same.
Tom – he is also not true, for example $3/3 \cdot 3 = 3 \rightarrow$ the same number, $9/3 \cdot 3 = 27/3 = 9$.

Several of the counter-examples were accompanied by a commentary that linked them to a wider group of numbers with the same behaviour within the given context, i.e. these counter-examples might be considered as generic examples (code category GE):

S33 Bara: She considered neither zero, nor negative numbers
$(-8) \cdot 0 = 0$ is not smaller
$(-3) \cdot (-3) = 9$ is not smaller
S4 Tom: This is also not true. A fraction might be > 1 as well $(10/5 \cdot 1 = 2)$.

Other responses consisted in counter-examples that were generic examples accompanied by other deductive arguments (code category GED), more or less correct:

S23 Bara: She is not right, $-2 \cdot (-6) = 12$. Bara forgot that two negative numbers might appear → the result would be bigger (+).
Tom: It is not true. If you multiply by a fraction with numerator > denominator, the result is bigger, $12/10 \cdot 5 = 60/10 = 6$. If numerator < denominator, the result is smaller, $10/12 \cdot 5 = 50/12 = 25/6 = 4.166$.
S29 Bara: When I multiply a negative number by a negative number, I get a number that is positive, so bigger, $-3 \cdot (-3) = 9$. When I multiply zero by a negative number, I get zero – the same number.

Some participants did not apply counter-examples, instead they just indicated conditions under which the given statement holds or does not hold, with a proper deductive justification (code category COD) or without (code category COX). Some of them were able to cover properly the conditions for Emil and Bara, but none of them covered completely the conditions for Jan or Tom:

S32 Emil – not true. You might have one number zero and the other also zero, then the result stays the same. Otherwise it is true, when you multiply positive number by zero, then the result will be smaller than the positive number. But with a negative number, the result will be bigger (zero is more than -3).

S26 Jan: It would be true if we were working within the set of natural numbers.
Bara: It would be true if we completed the sentence as follows: If you multiply a positive number by a negative number…
Tom: It would be true if I multiplied by a fraction that is smaller than 1.

Eight of the 28 participants displayed erroneous considerations due to their over-fixation to a particular learning context (natural numbers) or a particular didactic model (e.g. a fraction as a part of a whole); they were assigned the code category OF:

S16 Emil – yes, because after multiplying by 0 the result is always $0 \rightarrow 0 \cdot 153245 = 0, 0 < 153245$.
S10 Tom – yes – a fraction is a part of a whole → the result will be always smaller.
S11 Tom – correct, because with a denominator, you divide the big number into a smaller one.

Twelve of the 28 participants provided vague or unclear responses to some or all of the bubbles (code category VR), these responses could not be considered as properly justified arguments:

S33 Emil: If you multiply by 0, you always get 0.
S7 Bara: You get smaller result but the number itself might be big.
S18 Jan: You can get also smaller number, or the same.
Tom: It is not true for all examples.

Summarized, some of the responses were erroneous (code category OF), too vague to be considered correct (code category VR) or provided no justification (code category COX). All the other responses spread from empirical proof schemes (code category CEX) to various types of deductive proof schemes (code categories GE, GED, COD).
From the perspective of individual participants across all bubbles, some of the participants employed different modes of argumentation for different bubbles (e.g. S23, S32) or used the same counter-example for different bubbles (S23). Two of the participants did not provide a response to one of the bubbles (code category XR). From the perspective of individual bubbles, the Jan's bubble seems to have been the most difficult for the participants since it provided the least number of respondents with deductive proof schemes (see Figure 2).

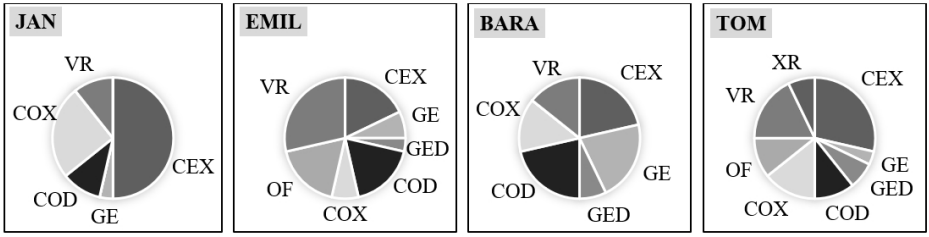


Figure 2: The diagrams of the relative frequency of the code categories for individual bubbles among the participants, *n*=28, 2016 (source: own calculation)

Discussion

The results of this study enrich the puzzle on "How can we meaningfully employ Concept Cartoons in future teacher education" by another piece of knowledge. To complement the previous contributions (Samková and Tichá, 2016; Samková, 2018a) that had focused on Concept Cartoons based on mathematical tasks related to particular calculations or

word problems solved by calculations, this time we turned our attention to the last type of tasks eligible to generate Concept Cartoons: to tasks that consist in assessing a validity of a mathematical statement. In that setting, three different types of statements might be employed: a statement about an individual case, an existential statement and a general statement. A Concept Cartoon with statements about an individual case had already appeared in (Samková and Tichá, 2017) and Concept Cartoons with existential statements had not provided much content-related data previously, so that we choose a Concept Cartoon with general statements for this study. As before, we worked with future primary school teachers as participants, so that the mathematical task was adjusted to the primary school mathematics content: all the number sets mentioned in the Concept Cartoon in Figure 1 (natural numbers, integers, fractions) are introduced at the primary school level. The results itself are promising both from the perspective of the mathematical knowledge of the participants and from the perspective of the applicability of Concept Cartoons with such specific content in bubbles.

As for the knowledge of participants displayed in responses to the Concept Cartoon, the findings are partially in accordance with previous research studies. Like in (Simon and Blume, 1996), many of the participants (12 of 28) provided responses that could not be considered as justifications since being vague or unclear (code category VR). But only 2 of these 12 participants provided such responses for all four bubbles. Also, unlike Simon and Blume (1996), none of the responses seemed to belong under external conviction proof schemes. Some of the participants (8 of 28) showed misconceptions related to critical moments in learning (Confrey and Kazak, 2006) as they provided erroneous considerations due to an over-fixation to earlier learning (code category OF). However, each of them provided it with just one of the bubbles. None of the participants confirmed the findings of Barkai et al (2002) or Zazkis and Chernoff (2008), since they widely used counter-examples but did not hesitate to refute the statements on their basis. Like in (Martin and Harel, 1989), some of the counter-examples were big-number examples (e.g. S16 Emil). But none of the respondents tried to affirm a validity of a general statement through several confirming examples. From the overall knowledge perspective, 32 of the 112 responses belonged to the code categories GE, GED, COD, i.e. fell under the highest level of proof schemes – deductive proof schemes. As for the Concept Cartoon itself, even with the specific type of bubbles containing general mathematical statements, the willingness to respond to the bubbles was high among participants. Only 2 from 112 responses were blank (code category XR), and a wide range of proof scheme types and subtypes appeared in data, densely filling the code categories that were content-related. Such findings seem to promise a big potential of Concept Cartoons for the context of knowledge related to proper reasoning and generalization (Medová, Bulková and Čeretková, 2019).

Conclusion

In this contribution we showed how Concept Cartoons might be employed in professional preparation of future primary school teachers in activities related to reasoning and argumentation, namely in activities related to reasoning about general mathematical statements. Our small empirical qualitative study confirmed the motivational and diagnostic role of Concept Cartoons since the tool provided us with enough relevant content-related data about argumentation knowledge and skills of the respondents. Moreover, we conducted a qualitative analysis of collected data which enabled us to connect the responses to various modes of reasoning belonging to various levels of proof schemes (inductive, deductive) and to various types of examples (counter-examples, generic examples).

Acknowledgement

This article was supported by the European Commission under Erasmus+ Programme Grant 'Digital Support for Teachers' Collaborative Reflection on Mathematics Classroom Situations', project No. 2019-1-DE01-KA203-004947.

References

Balacheff, N. (1988) 'Aspects of proof in pupils' practice of school mathematics', In *Mathematics, teachers and children*, London: Hodder & Stoughton, pp. 216-238.

Barkai, R., Tsamir, P., Tirosh, D., and Dreyfus, T. (2002) 'Proving or refuting arithmetic claims: The case of elementary school teachers', In *Proceedings of PME 26 (vol. 2)*, Norwich, pp. 57-64.

Buchbinder, O. and Zaslavsky, O. (2011) 'Is this a coincidence? The role of examples in fostering a need for proof', *ZDM Mathematics Education*, vol. 43, no. 2, pp. 269-281. http://doi.org/10.1007/s11858-011-0324-7

Confrey, J. and Kazak, S. (2006) 'A thirty-year reflection on constructivism in mathematics education in PME', In *Handbook of research on the psychology of mathematics education: past, present and future*, Rotterdam: Sense, pp. 305-345. http://doi.org/10.1163/9789087901127_012

Dabell, J., Keogh, B. and Naylor, S. (2008) *Concept Cartoons in mathematics education*, Sandbach: Millgate House Education.

Durand-Guerrier, V., Boero, P., Douek, N., Epp, S.S. and Tanguay, D. (2012) 'Argumentation and proof in the mathematics classroom', In *Proof and proving in mathematics education, New ICMI Study Series 15*, Dordrecht: Springer, pp. 349-367. http://doi.org/10.1007/978-94-007-2129-6_15

Goulding, M. and Suggate, J. (2001) 'Opening a can of worms: Investigating primary teachers' subject knowledge in mathematics', *Mathematics Education Review*, vol. 13, pp. 41-54.

Harel, G. and Sowder, L. (1998) 'Students' proof schemes: Results from exploratory studies', in *Issues in mathematics education (Research in collegiate mathematics education III, vol. 7)*, Providence: AMS, pp. 234-283. http://doi.org/10.1090/cbmath/007/07

Harel, G. and Sowder, L. (2007) 'Toward comprehensive perspectives on the learning and teaching of proof', in *Second handbook of research on mathematics teaching and learning*, Charlotte: NCTM, pp. 805-842.

Keogh, B. and Naylor, S. (1999) 'Concept cartoons, teaching and learning in science: an evaluation', *International Journal of Science Education*, vol. 21, pp. 431-446. http://doi.org/10.1080/095006999290642

Komatsu, K. (2010) 'Counter-examples for refinement of conjectures and proofs in primary school mathematics', *Journal of Mathematical Behavior*, vol. 29, pp. 1-10. http://doi.org/10.1016/j.jmathb.2010.01.003

Martin, W.G. and Harel, G. (1989) 'Proof frames of preservice elementary teachers', *Journal for Research in Mathematics Education*, vol. 20, pp. 41-51. http://doi.org/10.2307/749097

Medová, J., Bulková, K. and Čeretková, S. (2019) 'Relations between generalization and reasoning in solving mathematical problems', in *Proceedings of ERIE 2019,* Prague, pp. 183-189.

Miles, M.B., Huberman, A.M. and Saldaña, J. (2014) *Qualitative data analysis. A methods sourcebook*, Thousand Oaks: Sage.

Samková, L. (2018a) 'Assessing future teachers' knowledge on fractions: written tests vs Concept Cartoons', *Journal of Efficiency and Responsibility in Education and Science*, vol. 11, no. 3, pp. 45-52. http://doi.org/10.7160/eriesj.2018.110301

Samková, L. (2018b) 'Concept Cartoons as a representation of practice', in *Mathematics Teachers Engaging with Representations of Practice, ICME-13 Monograph*, New York: Springer, pp. 71-93. http://doi.org/10.1007/978-3-319-70594-1_5
Samková, L. and Tichá, M. (2016) 'On the way to develop open approach to mathematics in future primary school teachers', *Journal of Efficiency and Responsibility in Education and Science*, vol. 9, no. 2, pp. 37-44. http://doi.org/10.7160/eriesj.2016.090202
Samková, L. and Tichá, M. (2017) 'On the way to observe how future primary school teachers reason about fractions', *Journal of Efficiency and Responsibility in Education and Science*, vol. 10, no. 4, pp. 93-100. http://doi.org/10.7160/eriesj.2017.100401
Simon, M.A. and Blume, G.W. (1996) 'Justification in the mathematics classroom: A study of prospective elementary teachers', *Journal of Mathematical Behavior*, vol. 15, pp. 3-31. http://doi.org/10.1016/s0732-3123(96)90036-x
Skilling, K. and Stylianides, G.J. (2019) 'Using vignettes in educational research: a framework for vignette construction', *International Journal of Research and Method in Education*, advanced online publication. http://doi.org/10.1080/1743727X.2019.1704243
Zazkis, R. and Chernoff, E.J. (2008) 'What makes a counterexample exemplary?', *Educational Studies in Mathematics*, vol. 68, pp. 195-208. https://doi.org/10.1007/s10649-007-9110-4

ONLINE BEHAVIOUR AND PRIVACY DISCLOSURE

Tomáš Sigmund

Department of System Analysis, University of Economics, Prague, Czech Republic, sigmund@vse.cz

Abstract

The paper investigates the relationship between ethically defective online behaviour and privacy disclosure. The nothing to hide argument is also investigated in this research. We used statistical methods of descriptive statistics and cluster analysis in our research. The results show that respondents are not hiding and protecting their privacy to hide their defective behaviour and not to harm their reputation. The validity of the nothing to hide argument wasn't confirmed. Respondents have other reasons why they protect their privacy than fear of reputation harm, like acceptability of this behaviour by their social group, seeming anonymity or indifference of the audience. As for the unethical behaviour, we found out that pirating digital content is considered acceptable in the online environment. However, students are concerned about their privacy in the online environment.

Keywords

Nothing to hide argument, privacy, reputation, ethics

Introduction

There are many reasons why people protect their private information. Kang, Brown and Kiesler (2013) in their article researched reasons why people seek anonymity in their online activities. Their results show a big variability in reasons leading to anonymity seeking. The respondents were from all round the world. Most participants sought anonymity judiciously for special kinds of online activities, but some used it as a general practice. 53% of interviewers used anonymity for illegal or malicious activities or engaged in socially banned behaviour like surfing on pornographic or violent websites, illegal files downloading or searching for others' personal information. To sum up people seek anonymity not to seem disadvantaged and not to be exposed to personal threat.

People tend to present themselves as positively as possible. Many social stigmas including socially defective behaviour may threaten the positive self-presentation. Stigmatized community members try to manage their impression so that their stigma is not visible to others. However, attempts to be evaluated positively may undermine wellbeing (Ellemers and Barreto, 2006).

The deceit of one's identity, which can be either an omission or a falsehood, causes some harms to wellbeing (Frable, Blackstone and Scherbaum, 1990). Hiding one's true identity involves above all emotional costs: people hiding a stigmatised identity report worse physical health and other negative effects compared to people revealing it (Harris, 2001). Ellemrs and Baretto (2006) found out that 85% of people hiding their identity reported negative feelings of guilt, shame, insecurity and only 4% reported feeling good when hiding their identity. To sum up the expectations of higher social status may be fulfilled by hiding the identity, but it is often outweighed by decreased well-being. The negative feelings may lead to feeling inadequate, less self-confident and result in some kind of self-defeating behaviour.

In the area of privacy, the nothing to hide argument sometimes appears to justify the careless approach towards privacy. It states that any surveillance or private data collection or processing does not threaten privacy if the person is not involved in illegal or unethical activities. It can be applied both to the governmental surveillance and to the commercial data collectors. It assumes that if one doesn't do anything illegal one can't be harmed from the governmental information

collection and that the commercial data collection is done by reputable organizations with honest intentions to serve customers. The claim that if you have nothing to hide you have nothing to fear is commonly used in privacy discussions (Solove, 2011). There are some politicians (Trant Lott, Johann Hari or Richard Graham) or businessmen (Eric Schmidt from Google) who support this argument, but the majority of intellectuals is against it pointing out to the distorted image, harmed reputation or defamation. This argument is also used in politics (Milita, Ryan and Simas, 2013) or in research of man's relationship to institutions (Marwick and Hargittai, 2017).

From what has been said above it seems people behaving unethically in the online environment will be more careful with regard to their private identification as unethical behaviour may harm their reputation. On the other hand hiding the truth about oneself may cause psychological problems and harm one's wellbeing. Our objective is to investigate this relationship and possible theoretical gap. Our research question is: What is the relationship between student's behaviour and students' approach towards privacy? The tested hypotheses are the following: 1) At least two clusters can be found among the answers to our questions regarding the behaviour in the online environment. 2) There are no significant differences with regard to gender in the answers to our questions. 3) Students with higher levels of unethical behaviour will hide their privacy significantly more.

The Czech organization People in Need carried out a quantitative research in the whole Czech Republic in 2018 about secondary schools students' media literacy and students' approach towards media. According to this research, only 15% of students know how search engines work, only 43% of them know that the content showed by Facebook is governed by algorithms, only 52% is able to recognize commercial content (Jeden svět na školách, 2018).

Since 2010 the European Union has supported a research on technology use among children of 9-16 years. The authors found out a massive proliferation of smartphones, fast mobile internet and new services for children, like Instagram. Watching videos, listening to music, communicating with friends has become a daily routine. The differences in behaviour between boys and girls is decreasing. The proportion of children that faced negative online experience rises with age, but is unequally distributed among countries (7% Slovakia, 45% Malta). Most children however said they knew how to react in such circumstances. They also talk about different things online than offline (Šmahel et al., 2020).

That is why we investigated the influence of socially negative behaviour on privacy disclosure. The nothing to hide argument is part of the research as it forms one extreme - people think that only unethical or illegal behaviour is the reason for privacy protection.

Materials and Methods

We have carried out a research based on online questionnaires distributed via Google Forms investigating the nothing to hide argument. The respondents were from the University of Economics in Prague and they were recruited by means of email invitation. 144 students participated in our survey in the time period 1st November – 30th December 2019. Their demographic characteristics can be seen below.

We used the methods of descriptive statistics (mean, standard deviation, correlation) to describe the results of our research. Additionally, cluster analysis and internal consistency was used to test the first hypothesis, correlations were used to test the second hypothesis and correlations and methods of descriptive statistics were used to test the third one. As for the clustering, we used the Ward's method as it is a standard method of hierarchical clustering and does better than other methods when the cluster sizes are similar (Ferreira and Hitchcock, 2009). The statistical analysis was based on (Kaufman and Rousseeuw, 2005). The SPSS program was used for calculations. The methods are standard statistical procedures and their application for the purposes of testing

our hypotheses is our initiative. We used 6 point Likert scale with 1 meaning definitely no and 6 meaning definitely yes.

Gender		Age		Year of study		Average grade	
M.	68.1%	18-20	51.4%	1st bac	61.0%	1-1.99	33.3%
F.	31.9%	21-23	30.3%	2nd bac	5.6%	2-2.99	58.3%
		24-26	10.2%	3rd bac	19.4%	3-3.99	8.4%
		27-29	8.1%	4th bac	4.2%		
				1st master	5.1%		
				2nd master	4.2%		
				3rd master	0.5%		

Table 1: Demographic characteristics of the respondents

Employment		Orientation	
Full contract	1.4%	Output	12.5%
>half contract, but not full	37.5%	Social relations	25.0%
< half contract	11.1%	Balance	62.5%
Holiday jobs	29.2%		
No employment	20.8%		

Table 2: Demographic characteristics of the respondents (cont.)

Results

Students don't seem to have a clear opinion on whether the disclosed personal information will lead to harms in their reputation (M=3.26, SD=1.595). They tend to be concerned about their privacy in the online environment (M=4.1, SD=1.3)

As for the nothing to hide argument respondents don't seem to agree with this argument (M=2.17, SD=1.26).

We then asked respondents questions regarding their ethical behaviour online. The lowest results achieved behaviour that would harm a concrete person (breaking onto one's email or social network account) or passing someone else's work off as one's own. The highest consent was achieved by the question about downloading a pirated film or music without the copyright.

Question number	Question
1	If you knew how would you create a program that would allow you to play paid games or use paid software free of charge?
2	Would you return a product to an e-shop if you broke it yourself?
3	Would you break into someone's email in exchange for some profit?
4	Would you break into someone's social network profile in exchange for some profit?
5	Would you pass someone else's seminar work off as yours?
6	Would you use an access code to a paid account that you would find on the internet?
7	Would you use false information in the registration for an online service in exchange for some benefit?
8	Would you download a pirated film or music without copyright?

Table 3: Question numbers

Question number	1	2	3	4	5	6	7	8
Mean	4.43	2.76	2.17	1.93	1.85	2.97	3.94	5.25
Std. d.	1.567	1.758	1.622	1.508	1.142	1.921	1.696	1.191

Table 4: Questions' mean and standard deviation

Question number	1	2	3	4	5	6	7	8
1	1	0.289***	0.335***	0.245**	0.303***	0.153	0.331***	0.394***
2	0.289***	1	0.514***	0.439***	0.305***	0.156	0.464***	0.350***
3	0.335***	0.514***	1	0.841***	0.253**	0.271**	0.478***	0.275**
4	0.245**	0.439***	0.841***	1	0.282**	0.268**	0.315***	0.203*
5	0.303***	0.305***	0.253**	0.282**	1	0.236**	0.334***	0.341***
6	0.153	0.156	0.271**	0.268**	0.236**	1	0.450***	0.240**
7	0.331**	0.464**	0.478**	0.315**	0.334**	0.450**	1	0.432**
8	0.394**	0.350**	0.275**	0.203*	0.341**	0.240**	0.432**	1

** - Correlation is significant at the 0.05 level (2-tailed). ** - Correlation is significant at the 0.01 level (2-tailed). ***- Correlation is significant at the 0.001 level (2-tailed).*

Table 5: Spearman correlation coefficient between questions

The questions are all correlated with the highest correlation between questions 3 and 4 (r_s=0.84, p<0.001). The Cronbach's alpha of the questions achieved 0.8 for these 8 items which shows good internal consistency of the questions. The cluster analysis shows two clusters. One cluster is formed by questions 1, 8 and 7 and the second one by questions 2, 3, 4, 5, 6. The first cluster is characterized by relative high average of consent compared to the second cluster. The close relationship between questions 3 and 4 is worth noticing. Both concern breaking into someone's social network profile and email account are evaluated negatively. We can conclude that the first hypothesis was confirmed.

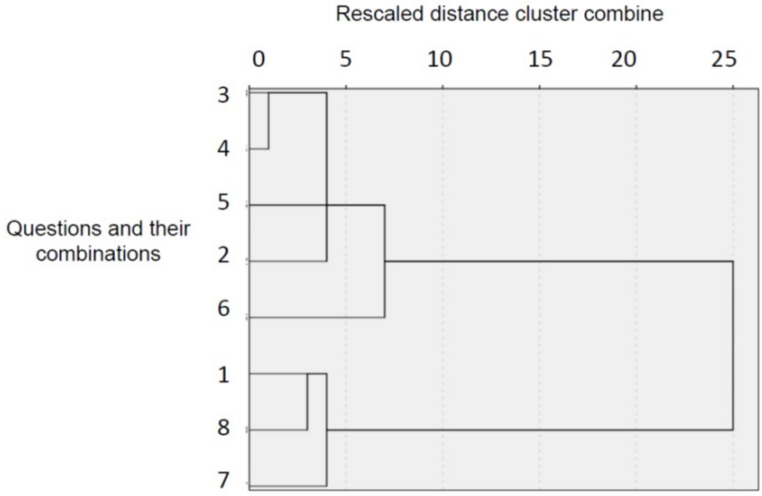


Figure 1: Dendrogram using Ward Linkage

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	3	4	59.000	0	0	3
2	1	8	274.000	0	0	4
3	3	5	537.667	1	0	5
4	3	2	845.333	3	0	7
5	1	7	1317.667	2	0	6
6	3	6	2094.667	4	0	7
7	1	3	3671.500	5	6	0

Table 6: Agglomeration schedule (Output of the SPSS cluster analysis)

On gender are dependent questions number 3 (χ^2= 13.293, p<0.05), 6 (χ^2=23.105, p<0.001), 7 (χ^2=29.66, p<0.01), 8 (χ^2=18.6, p<0.01). Women are in all these cases more careful than men. The second hypothesis was neither confirmed nor rejected, as the results are not unanimous.

The investigation of correlations between the fear of reputation harm and the eight questions found weak correlations in questions 1 (r_s=0.237, p<0.05) and 2 (r_s=0.214, p<0.01). That shows respondents are not afraid of their reputation because of their socially negative behaviour.

As for the statement that it is not necessary to hide one's privacy if one doesn't do anything illegal students are rather sceptical (M=2.17, SD=1.26). The correlations between students behaviour and position to this statement is in most cases insignificant with the exception of downloading illegal content (r_s=-0.224, p<0.01), stating false registration information (r_s= 0.0223, p<0.01), using an access code to a paid account (r_s= -0.204, p<0.05) and breaking into an email (r_s=-0.193, p<0.05). The negative sign can be explained by the fact that the less students agreed with the statement the more careful they are online. It further supports our hypothesis that students behaving unethically don't hide their privacy more than other students. Privacy seems to be an independent category. The other types of behaviour are probably not considered so problematic in terms of privacy.

Additionally, we were also investigating the correlations between benefits and risks of privacy disclosure (closer relationship, increasing attractiveness of one's own blog, personalization, price discounts, free services, manipulation, harmed reputation, bothering with marketing offers, blackmailing), context (knowledge of the information processor, knowledge of the purpose of information processing,) and unethical online behaviour. The results were not correlated with the exception of the fear of blackmailing and using someone else's seminar work (rs=0.223, p<0.001). It follows the risks and benefits of privacy disclosure are not influenced by fears of disclosing unethical behaviour. All these three investigations lead to the rejection of our third hypothesis and we may conclude that students' privacy protection is not influenced by their unethical behaviour.

Discussion

Our results correspond to the current research, but doesn't seem to be in compliance with theories that suppose people will hide their private information in order to harm their reputation. We may explain the seeming contradiction by relatively harmless character of the facts that we have asked our respondents or respondents' certainty that it will not be revealed or that their social group will not penalize them for it. None of the researches we have analysed found significant differences between man and women. The clustering of our answers is innovative and may be a ground for further differentiation of students' online behaviour.

As for privacy, which was the main topic of our investigation, many researches on privacy aim at young people as they use social networks a lot and seem to be careless (Marwick, Murgia-Diaz and Palfrey, 2010). Marwick and Hargittai (2018) carried out in-person focus group interviews. The respondents expressed their willingness to provide information for some benefits like personalization,

convenience, improved service, financial and health benefits. All respondents positively assessed connecting accounts that allows companies to aggregate data. Loyalty cards, discounts, services free of charge were also welcomed in exchange for private information. It was, however, not clear if respondents understood the trade-offs of personal information. Respondents in general think that opting out is not an option for them. They need social media for work and school projects, information distribution, reputation management, job hunting or personal promotion. Our results don't support the indifferent approach towards privacy, but it would be necessary to test students' actual behaviour or to carry out focus group interviews.

Siibak and Muruuma (2011) found out in their qualitative research reasons why the young people disclose private information that may help explain our results concerning not hiding unethical behaviour. One of the reasons may consist in underestimating the size of imagined audience. When posting messages online the authors keep only a small audience in mind. The messages are targeted to certain people only and the rest is forgotten. The reasons for such a behaviour may lie in the third person effect, which states that the effects concern other people and not themselves. Some of the young respondents found changing the privacy setting of social networks too boring or they don't know how to technically change it to be in accordance with their privacy profile. Oversharing information may be also caused by seeking popularity by posting socially inappropriate content. Larsen (2007) suggested that social networks reassure authors they are all right and the audience likes them. It is part of the person's popularity. In addition, the last reason consisted in the illusion of anonymity online. Young people thought that nobody would have any reasons for visiting their profiles or messages, that their posts would be unimportant and uninteresting to others. The use of internet and social networks is considered an entertainment.

It may also be the case that for the young generation the understanding of privacy changes. For them communicating online is considered as writing a diary, social contexts become more complex and nuanced. In our research, we came to more differentiated results. Students worry about their privacy, but are not afraid of any reputation harm related to their unethical behaviour.

Conclusion

To conclude we may say that students don't seem to hide their unethical behaviour online. The reasons may lie in the fact that they consider such a behaviour to be all right and their social group as well, in not considering the wider audience of the posted content or in underestimating the abilities of the modern ICTs. Other reasons may consist in the imaginary users' anonymity or indifference of other people. That would a topic for further research.

As for the unethical behaviour, we may say students consider pirating digital content acceptable, but harming somebody's rights rather inacceptable. Maybe in case of digital content the direct relation to the owner is missing or pirating the digital content has become a widely used practice. Women seem to be more careful in their online behaviour than men. We didn't confirm the validity of the nothing to hide argument that states that privacy is important for hiding unethical or illegal behaviour only.

On the other hand, students are concerned about their privacy. The reasons may lie in general awareness of privacy issues. Probably a more nuanced approach towards privacy is necessary. Maybe the privacy calculus should be reconsidered and the role of social norms that suggest privacy protection should be strengthened in theory.

Acknowledgement

This paper was supported by the grant VŠE FIS IGA IG430020.

References

Ellemers, N. and Barreto, M. (2006). 'Social identity and self-presentation at work: How attempts to hide a stigmatized identity affect emotional wellbeing, social inclusion and performance', *Netherlands journal of psychology,* vol. 62, no. 1, pp. 51-57. https://doi.org/10.1007/BF03061051

Ferreira, L. and Hitchcock, D.B. (2009) 'A Comparison of Hierarchical Methods for Clustering Functional Data', *Communication in Statistics- Simulation and Computation*, vol. 38, no. 9, pp. 1925-1949. https://doi.org/10.1080/03610910903168603

Frable, D., Blackstone, T. and Scherbaum, C. (1990) 'Marginal and mindful: Deviants in social interactions', *Journal of Personality and Social Psychology*, vol. 59, no. 1, pp. 140-149.

Harris, C. (2001). 'Cardiovascular responses of embarrassment and effects of emotional suppression in a socialsetting', *Journal of Personality and Social Psychology*, vol. 81, pp. 886-897.

Jeden svět na školách (2018) 'Jedinečný výzkum mediální gramotnosti středoškoláků. Její úroveň je nízká', *Tisková zpráva JSNS 6. září 2018*, [Online], Available: https://www.jsns.cz/nove/pdf/tz_nizka_medialni_gramotnost_stredoskolaku_web.pdf [3 Jan 2020].

Kang, R., Brown, S. and Kiesler, S. (2013) 'Why do people seek anonymity on the Internet? Informing policy and design', *Conference on Human Factors in Computing Systems – Proceedings, pp.* 2657-2666. https://doi.org/10.1145/2470654.2481368

Kaufman, L. and Rousseeuw, P.J. (2005) *Finding Groups in Data. An Introduction to Cluster Analysis*, New Jersey: John Wiley & Sons, Inc.

Larsen, M.C. (2007) '35 Perspectives on Online Social Networking'. *Social Computing Magazine*, 5. July, [Online], Available: http://vbn.aau.dk/files/17515817/35_Perspectives_on_Online_Social_Networking_by_Malene_Charlotte_Larsen.pdf [13 Sep 2019].

Marwick A. and Hargittai E. (2019) 'Nothing to hide, nothing to lose? Incentives and disincentives to sharing information with institutions online', *Information, Communication & Society*, vol. 22, no. 12, pp. 1697-1713. https://doi.org/10.1080/1369118X.2018.1450432

Marwick, A. and Hargittai E. (2018) 'Nothing to hide, nothing to lose? Incentives and disincentives to sharing information with institutions online', *Information, Communication & Society*, vol. 22, no.12, pp. 1697-1713. https://doi.org/10.1080/1369118X.2018.1450432

Marwick, A., Murgia-Diaz, D. and Palfrey, J. (2010) 'Youth, privacy and reputation (literature review', In *Berkman Center Research Publication No. 2010-5,* Boston, MA: Berkman Center for Internet and Society at Harvard University.

Milita, K., Ryan J.B. and Simas, E.N. (2013) 'Nothing to Hide, Nowhere to Run, or Nothing to Lose: Candidate Position-Taking in Congressional Elections', *Political Behaviour*, no. 36, pp. 427–449 (2014). https://doi.org/10.1007/s11109-013-9235-3

Siibak, A. and Murumaa, M. 2011 'Exploring the 'Nothing to Hide' Paradox: Estonian Teens' Experiences and Perceptions About Privacy Online', [Online], Available: https://ssrn.com/abstract=1928498 [2 Jan 2020]

Solove, D.J. (2011) 'Why Privacy Matters Even if You Have ‚Nothing to Hide', *The Chronicle of Higher Education*.

Šmahel, D., Machackova, H., Mascheroni, G., Dedkova, L., Staksrud, E., Ólafsson, K., Livingstone, S. and Hasebrink, U. (2020) *EU Kids Online 2020: Survey results from 19 countries*. https://doi.org/10.21953/lse.47fdeqj01ofo

USING MOBILE DEVICES IN GRAMMAR SCHOOL LESSONS

[1]Václav Šimandl, [2]✉Václav Dobiáš, [1]Miroslav Ditrych

[1]Department of Informatics, Faculty of Education, University of South Bohemia in České Budějovice, Czech Republic

[2]Department of Informatics, Faculty of Education, University of South Bohemia in České Budějovice, Czech Republic, dobias@jcu.cz

Abstract

The article looks at the use of mobile devices in high schools. Our qualitative research was based on a multiple case study carried out in three grammar schools and was composed of interviews with teachers who use mobile devices in lessons and their pupils. Our study shows that mobile devices are used in these schools in almost all subjects, mostly to search for information on the internet or do quizzes. Tablets increase the degree of individualization of lessons, promoting independence and boosting pupil activity. However, tablets do have their drawbacks. Pupils can be distracted and lose concentration due to announcements generated by applications running in the background. Moreover, they can easily access activities that have nothing to do with a lesson. Complications can also be caused by technical problems, which prevent pupils from working effectively with their device.

Keywords

High school, ICT, mobile device, qualitative research, tablet, teaching

Introduction

According to the ICILS (International Computer and Information Literacy Study), Czech schools are less equipped with tablets than schools abroad. Only 6 % of Czech pupils have access to them as opposed to an average of 19 % in countries surveyed in the ICILS (Basl, Boudová and Řezáčová, 2014: 35). Although there are a number of Czech publications dealing with the possibilities of using tablets in lessons (Neumajer, Rohlíková and Zounek, 2015; Černý, Mazáčová et al., 2015, Burianová et al., 2018), less attention is paid to the actual use of tablets in lessons. Benediktová (2017) is an exception, claiming that only around half of lower secondary school teachers use or would like to use tablets in their lessons.

The decision whether to use digital technologies in lessons depends on teachers themselves. Teachers' beliefs are the main factor in digital mobile technology acceptance (Leem and Sung, 2019; Karolčík, Čipková and Mázorová, 2016; Hew and Brush, 2007; Mumtaz, 2000). 'If teachers feel that digital mobile technology are stable, comfortable or have interactivity for the educational context, they can positively use it for educational purposes' (Leem and Sung, 2019: 610-611).

Many teachers require further insight into the pedagogical role of ICT and training (Gigantesco et al., 2019: 108). Almost half of the teachers involved in the ICILS 2018 survey reported using digital technologies in lessons every day (Fraillon et al., 2019: 179). Graves and Bowers (2018: 10) divide teachers into four basic groups according to the way they use digital technologies in lessons:

- Dexterous - flexible and wide ranging users that integrate technology for different modes and purposes.
- Evaders - resistant to use technology in any way, including sending emails to students and taking daily attendance.

- Presenters – prefer using technology to aid with lectures, while also guiding students to use presentation software to produce written texts and presentations.
- Assessors - most comfortable with using technology as drill and practice software, directing students to use technology to practice basic skills.

Each group comprises of around a quarter of teachers (Graves and Bowers, 2018: 10).

Pupils often welcome the use of digital technologies in lessons (Curto Prieto et al., 2019: 10; John and Yunus, 2019: 1481; Gigantesco et al., 2019: 108; Fabian and Topping, 2019: 1). Mobile digital technologies can be used in lessons in various ways and to complement various teaching methods. According to the findings of Gigantesco et al. (2019), pupils like to use mobile digital technologies in lessons to watch online videos but consider collaborative games to be the most useful (Gigantesco et al., 2019: 113). Having carried out a meta-analysis of 110 articles published during the period 1993–2013, Sung, Chang and Liu (2016) discovered that using mobile digital technologies can significantly enhance lessons. 'Usage in inquiry-oriented learning was more effective than usage along with lectures, self-directed study, cooperative learning, and game-based learning; informal educational environments were more effective than their formal counterparts, and medium- and short-duration interventions were superior to long-term interventions' (Sung, Chang and Liu, 2016: 265). 'Mobile learning intervention is dependent on various factors, such as student characteristics, stability of the technology and content compatibility' (Fabian and Topping, 2019: 1) and on pupils' digital literacy (Thompson, 2013: 23).

According to the findings of the PISA 2013 survey, 'students who use computers moderately at school tend to have somewhat better learning outcomes than students who use computers rarely. But students who use computers very frequently at school do a lot worse in most learning outcomes, even after accounting for social background and student demographics' (OECD, 2015: 3). The results of research by Fabian and Topping (2019) corroborate these findings.

Brestenská et al. (2005) claim that software used in lessons can be classified according to implemented paradigm:

- Instructional paradigm – it is based on the belief that the knowledge which learners need to acquire can be expressed through language and taught through verbal communication.
- Revelatory paradigm – its aim is to encourage the study of a model or simulation of an event, phenomenon or experience while its structure remains hidden.
- Conjectural paradigm – its aim is to provide an environment or laboratory where a learner can express and test his hypotheses.
- Emancipatory paradigm – its aim is to gain more time for actual teaching and learning by reducing the amount of work required to process information.

The above mentioned findings led us to the decision to find out how mobile devices are used in lessons in Czech high schools, specifically grammar schools. The aim of the study is to examine the way tablets are used in grammar school lessons. The aim of the study gave rise to our research questions concerning subjects and types of activity where tablets are used; advantages and disadvantages of using tablets; difficulties preventing them from being used effectively; rules regarding their use and pupils' opinions on the benefits of using them.

Materials and Methods

Our research was designed and carried out as qualitative. This approach was chosen because it was intended to give a detailed description of the way tablets are used in lessons from both pupils' and teachers' perspective. On the contrary, it was not intended to obtain a representative sample of schools and to interpret the results statistically. In our opinion, pupils are likely to give more realistic accounts of lessons than teachers. Unlike teachers, pupils have no reason to speak well of lessons. Consequently, pupils' perspectives have provided the focus for our study.

Participants chosen for the research were teachers and pupils from three grammar schools where tablets are used in lessons. One grammar school was chosen due to it having special so-called tablet classes. First year pupils attending these classes were advised by the school to purchase tablets to be used in lessons. Moreover, pupils at this particular school use electronic course books in lessons. The other two grammar schools loan school tablets to pupils for a particular lesson and do not use electronic course books.

Four teachers claiming to use tablets in their lessons at these schools, each with a different subject specialization, were selected for our study. Data collection involved individual meetings with research participants. A semi-structured in-depth interview formed the basis of each meeting. The interviews concerned the ways teachers employ tablets in their lessons. The triangulation concept was incorporated into data collection (Švaříček, Šeďová et al., 2007). Approximately 11 pupils taught by the addressed teachers were selected from each of the schools. Pupils were questioned in pairs on the ways tablets are used in lessons. A total of 33 pupils were interviewed in this way for our study.

Research participants were informed of the aims of the study and assured anonymity. They were subsequently requested to take part in the research and to agree to have their interview recorded on a voice recorder.

Analysis of acquired data was based on the open coding method. The analyzed text was divided into units and these units were allocated a certain code that represents a certain type of reply and differentiates it from the others (Švaříček, Šeďová et al., 2007). Codes from the generated list were subsequently grouped into categories according to internal similarity (Strauss and Corbin, 1999). The principle of constant comparison was included in the process of overall analysis (Švaříček, Šeďová et al., 2007). The aim of this comparison was to find differences within data sources relating to one research participant and within data concerning various participants. The results of comparison, which concern the data of various participants, were quantified for illustration in some cases.

Results

Analysis of the interviews identified several categories characterizing the way tablets are used in lessons from both pupils' and teachers' perspectives. The basic categories are: Subjects, method and intensity of use; Types of activity where tablets are used; Electronic course books; Checking activities carried out on tablets; Advantages and disadvantages of using tablets; Rules regarding the use of tablets and violation of them; Difficulties preventing the effective use of tablets; Pupils' opinions on the intensive use of tablets in lessons. Each of these categories will now be looked at in more detail.

Subjects, method and intensity of use

Our study found tablets are used in most subjects, specifically in Czech Language and foreign languages, history, biology, chemistry, physics, IT, mathematics, geography and physical education. However, some of the addressed pupils felt that tablets cannot be used in all subjects. Such an assumption seems to have been made due to lack of experience with using tablets in lessons.

The intensity of employing tablets varies depending on the extent to which a particular teacher is willing to use them and whether he can put them to use in a meaningful way in a particular subject. The teachers addressed by us agree that tablets are only suited for use in certain stages of a lesson. However, one of the pupils claimed that tablets are used in a particular subject for the whole lesson (obviously only being used in some lessons).

Statements of pupils addressed by us imply that only some teachers are able to use tablets in lessons in an appropriate way. Other teachers do not employ tablets in their lessons in a very

meaningful way, using them for a limited range of activities with no innovation. There have been cases of lessons in which tablets are used simply for taking notes of the teacher's presentation.
Other teachers avoid using tablets in lessons. This is perceived not only by their colleagues but also by pupils. Hostility towards using tablets in lessons or for lesson preparation is not only related to a teacher's age but is probably caused by other factors as well.

Types of activity where tablets are used

Pupils addressed in our study report using tablets most often to search for information on the internet according to a teacher's instructions (assigned either verbally or via a worksheet). Pupils also search for information on their own accord, perhaps if they do not understand something during a teacher's presentation or if they want to verify and possibly complement information presented by a teacher.
There are great differences in pupils' opinions regarding whether they prefer a teacher's presentation or searching for information on the internet by themselves. Some (six pupils) favor searching for information on their own and claim to acquire a better understanding of a particular subject matter than from a teacher's presentation while others (two pupils) are of the very opposite opinion.
One specific type of search is looking up vocabulary in foreign language lessons. Such an approach allows a teacher to assign his pupils more complex texts, which they would struggle with in the absence of a dictionary.
Quizzes are quite often used as a tool for revising subject matter and pupils can profit from having their answers checked automatically. Some quizzes are available from external authors while others are composed by the teacher himself. These quizzes are often used by teachers to practice subject matter but they were found to be used for examination purposes as well. A similar activity is text completion, which is also evaluated automatically.
Tablets are also used in lessons to work on divergent tasks, ranging from shorter tasks: "*in IT we practiced programming in Minecraft"* up to carrying out extensive projects on a particular topic. Output of these projects could be posters or computer presentations that pupils go on to present to the rest of the class. In science subjects, tablets are used during experiments and to analyze data obtained from them.
Tablets are used as visualization tools in subjects such as math or biology. They are used to practice listening skills in foreign language lessons. Another specific area of using tablets is for recording audio sequences or videos which are subsequently edited and, in some cases, analyzed.
At the school where pupils bring their own tablets to lessons, these devices are used for teacher-pupil communication. Teachers can use shared folders to pass on lesson materials and task assignments electronically knowing that all pupils have access to them. Electronic communication via email is also possible.

Electronic course books

Pupils appreciate that electronic course books provide access to additional materials that are not available in classic printed course books. These include 3D visualization, listening exercises for foreign language learning and the procedure for solving a particular math or physics problem. Not having to acquire printed course books, which are large and heavy, could be considered as another advantage.
However, the addressed pupils are rather sceptical about some electronic course books, claiming they bring hardly any benefits as opposed to their printed versions, one of the teachers being of the same opinion. There are actually drawbacks to using these electronic course books. For example, it is nearly impossible or complicated to make notes on particular subject matter into some of them.

Checking activities carried out on tablets

The way activities that are carried out on tablets are checked depends on the type of activity

that pupils are supposed to do. Quizzes are evaluated automatically and the teacher can view the results on his device. The final products of other activities are usually continuously checked by the teacher either directly on the pupils' tablets or handed in by pupils in an agreed way and later checked by the teacher. Where a project is to be assessed, some teachers have pupils presenting their work to the rest of the class. In some cases the teacher does not check each pupil's work individually but discloses the correct answers and leaves pupils to check their answers for themselves.

Advantages and disadvantages of using tablets

Some of the pupils addressed in our study perceive the use of tablets as a way of bringing variety into normal lessons. Due to their newness effect, pupils are highly motivated by tablets. If they were to be used more intensively, this effect would be lost. For that reason, other benefits were looked into and the following was found:

- Tablets can allow for a more individualized approach, promoting independence and boosting pupil activity: "*I can find everything by myself and I don't have to wait for somebody to tell me*".
- Quizzes and text completion exercises allow for answers to be checked automatically.
- Pupils appreciate the illustrative nature of visualization tools, i.e. the possibility of moving the presented object around in a 3D area.
- Pupils consider the speed of searching for information on the internet to be beneficial, as opposed to looking this information up in books.
- Pupils in tablet classes, who bring their own tablets to lessons, value having all lesson materials along with their own notes in one place as well as having online access to them through cloud storage.

There are also certain drawbacks to using tablets, including the following problems:

- Pupils can be distracted and lose concentration due to announcements generated by applications running in the background (e.g. instant messenger).
- Pupils can easily access activities that have nothing to do with a lesson, leading to pupils not focusing on lessons.

Schools are obviously aware of this risk, establishing rules on using tablets.

Rules regarding the use of tablets and violation of them

Pupils from all of the schools researched in our study mentioned rules regarding the use of tablets in lessons. Pupils differ in terms of violating these rules. Some of them deny breaking the rules while others admit to doing so. Pupils often report to have broken the rules by using social networks and instant messaging, watching online videos or downloading and playing games. One of the pupils actually mentioned how easily such violations can be covered up by deleting browsing history to remove traces of a particular activity.

Difficulties preventing the effective use of tablets

The use of tablets is accompanied by a number of problems which prevent such devices from being used effectively in lessons. These can be divided into several groups, the first being problems of a technical nature:

- Pupils may have trouble connecting their device to a computer network due to poor Wi-Fi signal or absence of Wi-Fi connection (occurred in all three schools).
- Some of the tablets provided by the school might not work, may have become outdated or might not be powerful enough (occurred in those two schools which loan tablets to pupils).

- An unexpected operating system update might be launched (occurred in those two schools which loan tablets to pupils).
- The battery may be low at the beginning of a lesson or might not last long (occurred in those two schools which loan tablets to pupils).

Consequently, some pupils are authorized by a teacher to use their own devices, which work better.

Another group of problems involves difficulties related to pupils' lack of ability to use a device in the best possible way. These problems are usually only temporary, lasting until pupils become accustomed to working in a particular way. They may lack experience of working with a tablet (two pupils) or lack experience of working with particular applications (four pupils) or the ergonomics of a device may be inconvenient (one pupil). However, pupils might also be distracted from their work due to activated notifications.

The last group of problems identified in our study covers difficulties related to a teacher's lesson preparation. These include the demanding nature of creating lesson curriculum and preparing lesson materials.

Pupils' opinions on the intensive use of tablets in lessons

Pupils from schools where tablets are used less often have different opinions on the appropriateness of using tablets intensively. While some of them would like to use them as much as possible (four pupils) or at least more often (twelve pupils), others (five pupils) disapprove of using tablets intensively.

Pupils in the tablet classes, who bring their own tablets to lessons, also have different opinions on the appropriateness of using tablets intensively. Some of them (four pupils) are satisfied and would prefer digitalization of classic printed course books while only one of them disapproves of tablets being used so often and calls for minimization of their use. Some pupils at this school claim that the use of tablets in lessons did not meet their expectations. One cause of disappointment is the way pupils work with electronic course books. In some subjects, printed course books are used instead of electronic ones or purchased electronic course books are not used. Another problem is that pupils do not benefit from some course books much more than from printed course books and the possibilities for making their own notes in electronic course books are limited.

There are differences in the way pupils at this school take notes. Some of them use their tablets to write notes electronically while others prefer to take notes in their exercise book and others combine the two methods as they need. Some pupils print or copy electronic materials (electronic course books, their notes or lesson materials compiled by a teacher) into their exercise books, arguing that handwritten notes and printed materials are better for learning and that they cannot make their own notes in some read-only electronic materials.

Discussion

If we are to draw from the typology of teachers in Graves and Bowers (2018: 10), some of the pupils addressed in our study are taught by teachers who are classified as Evaders and others are taught by teachers classified as Dexterous. The frequent use of quizzes in tablet-based lessons indicates that some of their teachers will fall into the Assessors category. The large number of Evaders among teachers corresponds to findings made by Benediktová (2017), who claims that over two fifths of teachers find no benefit in using tablets in lessons.

In accordance with the classification of didactic software according to function (Brestenská et al., 2005), tablets were found to be used in lessons for working with Tools for acquiring information (e.g. for doing an internet search) and Instructional programs (e.g. doing a quiz). Lessons also constitute working with Tools for communication (e.g. using email) but this mainly involves communication between a teacher and individual pupils.

If we are to consider the classification of didactic software according to implemented paradigm (Brestenská et al., 2005), the Instructional paradigm is used primarily and the Emancipatory paradigm is also used during project work. Our study did not observe extensive use of the Revelatory paradigm and Conjectural paradigm, which would indicate an inclination towards constructivist lessons.
The fact that pupils break the rules on working with tablets and use tablets to access activities that have nothing to do with a lesson implies that pupils could be bored in particular lessons and that traditional teacher-based lessons might not be effective. Pupils are aware that they can easily catch up on lessons (from course books, the internet or directly from computer presentations provided by teachers). This shows the need to incline towards pupil-based active learning and teaching methods. Unlike those in other countries (Gigantesco et al., 2019; Sung, Chang and Liu, 2016), teachers participating in our study use only a limited range of types of activities, not incorporating activities involving online videos, role-play activities, collaborative games or inquiry-oriented learning in their lessons. In view of this, our findings correspond to research done by Benediktová (2017), which made no reference to these activities either.

Conclusion

Our qualitative study focuses on the use of tablets in lessons at grammar schools that proclaim their use of tablets in lessons. However, some teachers at these schools disapprove of tablets while others mainly have their pupils using them as a tool for acquiring information and for working with instructional programs.
Since tablets were found to be used in almost all subjects, the argument that tablets are not suitable for use in some subjects is disproved. It is clear that tablets cannot be used in all activities and there are activities where traditional methods cannot be replaced by tablets. On the contrary, there are areas where such devices can be of appropriate help. It emerged that some teachers have trouble finding appropriate ways to use tablets in their lessons. This problem could be related to a lack of high quality electronic course books, didactic software or teachers not knowing how to put tablets to good use.
Only three grammar schools were involved in our study, which could be considered a limit to our research. For our results to be generalized, a quantitative study involving a wider sample of schools would have to be carried out. Further research could aim to carry out such a study.
Our research brings us to the conclusion that teachers who are interested in using tablets in their lessons need to be supported in their efforts through examples of good practice. At the same time, tablets need to be perceived as a means through which aims of the individual stages of lessons can be accomplished more effectively, as opposed to being the main aim of the lesson as a whole. Only in that way will the use of tablets in lessons become both modern as well as meaningful.

References

Basl, J., Boudová, S. and Řezáčová, L. (2014) *Národní zpráva šetření ICILS 2013: Počítačová a informační gramotnost českých žáků*, Praha: Česká školní inspekce.
Benediktová, L. (2017) 'Využití tabletů z pohledu učitelů ZŠ', *Journal of Technology and Information Education*, vol. 9 no. 1, pp. 5-14. https://doi.org/10.5507/jtie.2016.025
Brestenská, B., Čipková, E., Gálik, Z., Hrušecká, A., Hrušecký, R., Kalaš, I., Karolčík, Š., Kubincová, Z., Lehotská, D., Mandíková, K. and Melišová, K. (2005) *Klasifikácia a hodnotenie edukačného softvéru*, [Online], Available: edi.fmph.uniba.sk/~tomcsanyiova/TPS/edusoftver.doc [20 Dec 2019].
Burianová, M., Turčáni, M., Balogh, Z. and Mudrák, M. (2018) 'Mobile technologies and the ways of use in teaching it related subjects', *Proceedings of the 15th International Conference Efficiency and Responsibility in Education (ERIE 2018)*, Prague, pp. 21-28.
Černý, M. and Mazáčová, P. et al. (2015) *Tablet ve školní praxi,* Brno: Flow.

Curto Prieto, M., Orcos Palma, L., Blázquez Tobías, P.J. and León, F.J.M. (2019) 'Student Assessment of the Use of Kahoot in the Learning Process of Science and Mathematics', *Education Sciences*, vol. 9 no. 1. https://doi.org/10.3390/educsci9010055
Fabian, K. and Topping, K.J. (2019) 'Putting "mobile" into mathematics: Results of a randomised controlled trial', *Contemporary Educational Psychology*, vol. 59. https://doi.org/10.1016/j.cedpsych.2019.101783
Fraillon, J., Ainley, J., Schulz, W., Friedman, T. and Duckworth, D. (2019) *Preparing for Life in a Digital World: IEA International Computer and Information Literacy Study 2018 International Report*, Amsterdam: IEA, [Online], Available: https://www.iea.nl/publications/study-reports/preparing-life-digital-world [28 Jan 2020].
Gigantesco, A., Palumbo, G., Zadworna, M., Cascavilla, I., Re, D. and Kossakowska, K. (2019) 'An international study of middle school students' preferences about digital interactive education activities for promoting psychological well-being and mental health', *Annali dell'Istituto superiore di sanita*, vol. 55, no. 2, pp. 108-117. https://doi.org/10.4415/ANN_19_02_02
Graves, K.E. and Bowers, A.J. (2018) 'Toward a Typology of Technology-Using Teachers in the "New Digital Divide": A Latent Class Analysis of the NCES Fast Response Survey System Teachers' Use of Educational Technology in US Public Schools, 2009 (FRSS 95)', *Teachers College Record*, vol. 120, no. 8, pp. 1-42. http://www.tcrecord.org/Content.asp?contentid=22277 [30 Jan 2020].
Hew, K.F. and Brush, T. (2007) 'Integrating technology into K-12 teachingand learning: current knowledge gaps and recommendations for future research', *Educational Technology Research and Development*, vol. 55, no. 3, pp. 223–252. https://doi.org/10.1007/s11423-006-9022-5
John, D.S. and Yunus, M.M. (2019) 'Students' Perceptions on the Use of Mobile Learning to Improve Writing Proficiency in the MUET', *Pertanika Journal of Social Sciences & Humanities*, vol. 27, no. 3, pp. 1481-1492, [Online], Available: http://www.pertanika.upm.edu.my/Pertanika%20PAPERS/JSSH%20Vol.%2027%20(3)%20Sep.%202019/06%20JSSH-2601-2017.pdf [24 Jan 2020].
Karolčík, Š., Čipková, E. and Mázorová, H. (2016) 'Application of digital technologies in the geography teaching process from the teachers' perspective', *International Research in Geographical and Environmental Education*, vol. 25, no. 4, pp. 328-343. https://doi.org/10.1080/10382046.2016.1207992
Leem, J. and Sung, E. (2019) 'Teachers' beliefs and technology acceptance concerning smart mobile devices for SMART education in South Korea', *British Journal of Educational Technology*, vol. 50, no. 2, pp. 601-613. http://doi.org/10.1111/bjet.12612
Mumtaz, S. (2000) 'Factors affecting teachers' use of information and communications technology: a review of the literature', *Journal of Information Technology for Teacher Education*, vol. 9, no. 3, pp. 319-342. https://doi.org/10.1080/14759390000200096
Neumajer, O., Rohlíková, L. and Zounek, J. (2015) *Učíme se s tabletem: využití mobilních technologií ve vzdělávání*, Praha: Wolters Kluwer.
OECD (2015) *Students, computers and learning: Making the connection, PISA*, Paris: OECD Publishing. http://doi.org/10.1787/9789264239555-en
Strauss, A. and Corbin, J. (1999) *Základy kvalitativního výzkumu: Postupy a techniky metody zakotvené teorie*, Boskovice: Albert.
Sung, Y.-T., Chang, K.-E. and Liu, T.-C. (2016) 'The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis', *Computers & Education*, vol. 94, pp. 252-275. https://doi.org/10.1016/j.compedu.2015.11.008
Švaříček, R. and Šeďová, K. et al. (2007) *Kvalitativní výzkum v pedagogických vědách*, Praha: Portál.
Thompson, P. (2013) 'The digital natives as learners: Technology use patterns and approaches to learning', *Computers & Education*, vol. 65, pp. 12-33. https://doi.org/10.1016/j.compedu.2012.12.022

GENDER SCHEMAS AND RELATIONSHIPS IN SCHOOL PEER GROUPS

[1]✉Irena Smetáčková, [2]Petr Pavlík

[1]Department of Psychology, Faculty of Education, Charles University, Czech Republic, irena.smetackova@pedf.cuni.cz

[2]Department of Gender Studies, Faculty of Humanities, Charles University, Czech Republic

Abstract

School peer group is a natural environment for gender socialization, including its cognitive and socio-emotional aspects. Girls and boys develop their gender schemas, build their gender identity and learn gender patterns in behaviour in this context. The paper presents a study of 435 students of primary and lower-secondary schools who were studied as individuals and as members of social groups. Data were collected via drawings, observation and sociometry questionnaires. Results show that gender schemas were rather homogenous, rigid and contrasting masculinity and femininity. Connection between schemas and behaviour was not stable. Four strategies of students´ reactions in gendered situations were identified. Social position of students with unconventional gender schemas was rather low in a group.

Keywords

Gender, gender identity, peer groups, schema, school

Introduction

Alongside family, school is a key institution of socialization, including learning about gender. Fagot, Rodger and Leinbach (2000) explain that children are socialized through interaction with textbooks and other materials, teachers and peers. With respect to gender, all three sources work usually in the same direction to instil gender stereotypes.

While there is a number of studies that address teacher-student communication, teachers´ expectations toward girls and boys and gender stereotypes in educational content (Skelton, Francis and Smulyan, 2006), gender stereotypes in school peer groups (SPGs) received much less attention (Thorne, 1993). The available studies conclude that children spontaneously use gender categories (masculinity, femininity) to characterize others and to explain their behavior. Within the SPGs, children inform each other about femininity and masculinity, have an opportunity to perform their own femininity/masculinity, and receive feedback from peers. The SPGs are crucial for development of gender identity both in cognitive and emotional ways (Martin, Ruble and Szkrybalo, 2002).

In the article, we start by discussing most relevant theories of gender development from our perspective. With their help, we interpret the research data and formulate the recommendation for school practice on how to work with gender-mixed groups of students who implicitly learn from each other about gender roles.

Gender cognition and gender identity

Psychology offers several theories of gender development. Arguably, cognitive theories are the most influential building on a strong empirical evidence concerning importance of cognition in human identity and behaviour. We draw on theories of socio-cognitive development that are located between traditional cognitive approach and social learning approach. They stress the crucial role of child's cognitive maturity with respect to the use of specific cognitive processes (Bussey and Bandura, 1999). They also suggest that child's cognition is anchored in the concrete

socio-cultural and situational context that raises expectations or even pressure (Martin, Ruble and Szkrybalo, 2002). The key theoretical concept is a gender schema.

Gender schema represents structured mental patterns organizing information about masculinity and femininity (Sternberg, 2002) that influence evaluation, motivation and behaviour. In Piaget´s tradition, we can define gender schema as a subjective theory about what women and men are and what their relationships look like (Bem, 1993; Bigler and Liben, 2007).

Cognition has two characteristics – rigidity and flexibility. As child grows, rigidity is growing to peak between five and seven years of age. Gradually, child's cognition becomes more flexible with flexibility peaking around the age of 12 years (Fagot, Rodgers and Leinbach, 2000) depending also on personality and social influences. Children also differ in the use of gender schemas. Some are highly gender schematic, others tend to be gender aschematic (Bem, 1993). Situational factors may be important here – some situations invoke gender schema stronger than others (Martin, Ruble and Szkrybalo, 2002).

The relationship between gender schema and behaviour has been studied systematically (Rudman and Glick, 2010; Campbell, Shirley and Candy, 2004). Research shows that children's behaviour is driven by gender schemas and attitudes. They tend to act consistently with their understanding of social reality and her/his position within it (Bigler and Liben, 2007; Powlishta, 2002). Subscription to a gender category also increases child's motivation to collect more information about this category. In other words, gender identity (Tajfel, 2010) and gender subjectivity (Nielsen and Rudberg, 1994) are developing in the cognitive background.

Egan and Perry (2001) identify four dimensions of gender identity: 1. Knowing what is my gender category; 2. Feeling of congruence with one's own gender category; 3. Recognition of social pressure to follow gender norms; 4. Relating to other groups based on the gender principle. In order to develop strong identity, children form more comprehensive and more positive gender schemas of their own gender category. This mechanism involves self-categorization (Turner and Onorato, 1999), favouring one own's category (group) and homogenizing other groups (Skelton, Francis and Smulyan, 2006). This happens primarily through interactions with people of the same gender, who are seen as more variable, and through unique identity experience. The school provides a crucial environment for such socio-cognitive process.

Our research is focused on cognitive and social aspects of gender socialization in the SPGs at primary and lower secondary schools. It was guided by the following questions: 1) What are gender schemas of girls and boys? What is the extent of similarity and variability of gender schemas across different age groups and gender?; 2) What is the structure of school peer groups? What is the social status of girls and boys? What kind of relationships develop between girls and boys?; 3) What strategies do children use to build their gender schemas within peer groups?

Materials and Methods

The sample covered 435 students (216 girls, 219 boys) from 20 classes of 18 grammar schools in Prague and surroundings. The sample was evenly distributed among nine grades of elementary school.

Multiple case studies of school peer groups were performed (20 in total). Each case study combined several methods of data collection: a) semi-structured observations in the SPGs during classes and breaks; b) drawings of ideal girl and ideal boy (as a tool for detection of gender schemas); c) SO-RA-D, sociometry questionnaire (popularity and influence of each child were evaluated); d) individual interviews with selected children about relationships in mixed SPGs; e) individual interviews with selected teachers about SPGs and certain boys and girls.

Analytical procedures included both qualitative and quantitative approaches. First, drawings were analysed using thematic analysis (Braun and Clark, 2006) followed by quantitative analysis,

mostly t-test and chi-quadrate to compare the prevalence of particular features in female and male drawings. Second, sociometry data were analysed using statistical methods given by SO-RA-D manual (Hrabal, 2011). Third, observations which complemented interviews were analysed using thematic analysis (Braun and Clark, 2006). Finally, all data were triangulated.

Results

An analysis of 381 drawings of ideal boy and ideal girl was used to get children´s gender schemas. Majority of children stick to conventional gender schemas. Only 10% of drawings represented different ideas then predominated in the class.

Conventional gender schemas were based mostly on clothes, colors and haircuts. In 82-91% of drawings, masculinity was associated with trousers, dark colors as blue, black or brown, and short hair. Femininity was associated with skirts, red or pink color and long hair. The differences between girls and boys were significant only with respect to haircut for femininity (long hair draw 84% of girls but 57% of boys, $p>.001$).

Biological markers such as genitals, breasts, body shapes or beards were not employed as often as was expected. Femininity was associated with breasts in 24% of drawings and with genitals in 2%, while masculinity was indicated by muscles in 20%, beards in 12% or genitals in 5%. Children used biological markers mostly to depict their own gender, i.e. they did not serve as markers of sexual attraction.

The analysis revealed that schemas of masculinity and femininity were based on contrast in 4/5 of drawings. Femininity and masculinity were implicitly (or explicitly) considered as opposites in the same dimensions, for example bright-dark, weak-strong, short-long etc. Contrast can imply complementarity which represents connection. In 1/3 of drawings, femininity and masculinity were explicitly connected in a romantic relationship.

Girls and boys as authors of drawings showed the gender difference. Girls´ gender schemas were more elaborated and more detailed than boys´ schemas ($p<.05$). Boys drew less elaborate and less real figures than girls.

The age was significant as well. Gender schemas of younger children were more homogeneous and less complex ($p<.01$). At the same time, younger children used more frequently markers of complementarity.

Gender schemas of girls changed with age more than gender schemas of boys ($p<.05$). Younger boys and girls differed in the level of elaboration and complexity more than older boys and girls. Younger girls´ drawings were more detailed than younger boys´ drawings. Drawings of adolescent boys and girls were more similar with respect to content and form.

Following comments by two boys describing their drawings illustrate the point: "*Girl should be smart and pretty, boy should be smart and strong*" (boy, third grade).; "*The proper girl should sing beautifully, she should be careful, considerate, showy, reliable, funny, skinny, right, strict, smart, beautiful, fair. The proper boy should be strong, kind, fair, smart, a little careless, beautiful, big, he should like lego, be normal and be good at math"* (boy, seventh grade). The comments also show polarization and complementarity.

Focusing on gender relationships, sociometry data, observations and interviews were analyzed. An analysis of seating plans revealed that children spent most of school time in gender homogenous dyads (72% of dyads) which spilled from classes to breaks. Girls created more dyads than boys (41% versus 32%).

In total, 26% of students sat alone, more often boys (69%) than girls (31%). The boys´ lack of discipline (real or presumed) was offered as a reason given both by students and teachers.

Boy-girl dyads were most frequent in the age group 8-11 years and later their number decreased. The main reason was more frequent teacher intervention into sitting arrangements in younger

age groups based on a belief that girl-boy dyads (two different "species") minimize discipline problems: "*I think it's good to have a girl, who is calmer and has everything in order, siting with an unfocused boy. He can learn from her. That's why I usually put girls and boys together"* (teacher, third grade).

The sociometry analysis showed that social position of individuals and their relationships were based rather on popularity rather than power. In older age, popularity dominated over power more strongly because children became more critical (especially with respect to power). The average grade was the same for popularity but different for power 0.15 (in five points scale). Among boys, lower power status was more frequent than among girls – with respect to other boys as well as girls. Relationships among girls were seen as more positive.

Children with unconventional gender schemas had significantly worse social position in classes with strongly homogenous gender schemas across the group ($p<.05$). Among girls, this mainly influenced their popularity. Among boys, it had impact on power.

In some classes, unconventional gender schemas did not correlate with low social status as strongly. It depended on composition of the group (a number of children respecting diversity) and on teacher´s approach. Class groups with higher tolerance to un/conventional gender schemas were taught by teachers who presented diversity as a positive feature of social group, actively handled conflicts among children, and addressed gender and other stereotypes.

Children expressed their opinions on suitability of concrete behaviors for boys or girls on many occasions. In 20 class groups, 69 unambiguous situations were identified when children communicated their definitions of masculinity and femininity. Children pointed out, defended, violated or shifted gender boundaries. Younger children (6-10 years of age) did so more frequently and more explicitly ($p<.01$). In all age groups, more situations concerned masculinity.

Children used three basic strategies to keep existing boundaries between masculinity and femininity: 1. relabeling of behavior (example: Kids criticized a male-schoolmate for his obedience toward teachers, some of them used argument that such behavior is not suitable for boys, others did not agree, the conclusion was that obedience fits to masculinity.), 2. ridiculing of behavior (example: *Group discusses which type and color of clothes is suitable for girls. Army clothes was rejected*.), 3. ridiculing of person (example: *Behavior was rejected as nonmusculine and the author of behavior as a fool, so the behavior is not important for the group any more*.). Only one strategy was used to shift boundaries effectively: accepting a new behavior (example: *Velvet color for boy´s bag was rejected, however, involving boys with high social status brought acceptation of the velvet color for masculinity*.). Which strategy is used toward behavior including gender, depends strongly on gender schemas of students and social positions of actors in particular situations. To sum up, the behavior and appearances of boys and girls were more variable than their gender schemas.

Discussion

First, we must acknowledge that there were certainly some limits coming from instruction to draw the ideal (proper) girl and boy. Children were prompted to think about two gender categories and they compared them. In the same time, children were asked for socially preferred, suitable definitions of masculinity and femininity. As a result, they could stress differences between masculinity and femininity somewhat more than in spontaneous production. It confirms previous cognitive theories showing that construction of gendered reality is based on opposition of masculinity and femininity (Bussey and Bandura, 1999).

With these limits in mind, we found that majority of children presented conventional gender schemas. The children´s tendency to follow the common definition of masculinity and femininity was described also by other studies (Bem, 1993; Martin, Ruble and Szkrybalo, 2002). Based on

that, arguments claiming that gender should not be part of the school curriculum, because a free environment in which girls and boys can express themselves in their own way is considered wrong. Students spontaneously adhere to gender stereotypes, and the school should teach them to think about them critically. This would then ensure that each student really "freely" decides whether or not to follow gender stereotypes. The current model in which pupils profess stereotypes but are not encouraged at school to realize that they are stereotypes leads to their blind following.

Some studies emphasized that gender identity development consists of two synchronicity of gender schemas and gender behaviour patterns (Egan and Perry, 2001). Previous theories of border-work (Thorne, 1993) and category maintenance work (Davies, 2006) claimed how important is to build the boundaries between girls and boys which followed the ideological boundaries between femininity and masculinity. These theories supposed that cognition is first and followed by behaviour. However, our research showed that the behaviour was not entirely influenced by the gender schemas, but also behaviour could change the gender schemas. We identified four strategies applied in the gendered situations by students. Their occurrence depended on classrooms settings and teachers´ style of thinking about gender and responding to pupil behavior related to gender. In general, behavior and appearances of boys and girls were more variable than their gender schemas. This discrepancy can result from two mechanisms:

- Non-correspondence of mental and behavioural levels. The behaviour is not fully determined by ideas. Sometimes behaviour is primary, and schemas are employed only later during justification of behaviour. Ideas can be also changed if there is a risk of inner conflict or identity threat.
- Situational context. In some situations, gender is the basic grid for understanding, but in others gender is unimportant and, therefore, children do not apply their gender schemas. If the flexibility is already high enough children can use other explanatory tools beside gender.

With respect to socio-cognitive theory (Bussey and Bandura, 1999; Powlishta, 2002) and theory of social identity (Turner and Onorato, 1999), we found that both mechanisms work, however, they vary across the situations. Based on our research, we conclude that for better understanding of gender development during schooling we need to address three factors: 1) personality traits of individual girls and boys, including the level of rigidity and flexibility and their personal gender schemas, 2) social group, including social position of individual girls and boys and dominant gender schemas and norms regulating behaviour in the group, 3) cultural context in which school exists, including external sources of gender schemas and behavior patterns which can help to avoid a peer pressure.

Conclusion

Our research confirms that gender schemas are an important source for students to evaluate concrete people and situations. Although schools usually claim that they do not pay attention to gender because students are just students, based on our research we prompt them to do so. Because students are captured by stereotyped gender schemas, they need the help of their teachers to think about gender to make bias-free decisions. However, schools, classes and students vary. Besides the situational context, it is also important whether a child is gender schematic or aschematic. Children who are highly schematic use gender schemas more often even in situations when it is not very helpful for better understanding. The dominance of specific gender schemas within a class depended on composition of the group and on teachers´ approach. Children's negotiation of gender schemas is moderated by teachers. Some of them legitimize gender rigidity, others question it and, thus, make it weaker.

Based on the research results, we can formulate tentative recommendations how teachers can address gender schemas and support positive relationships in gender-mixed school peer groups. Firstly, it is necessary to address several aspects of gender schemas simultaneously. Changing

only one aspect (for example occupation) does not lead to the overall change of the schema. Secondly, socio-cultural aspects occupy an important position in the hierarchical structure of gender stereotypes and they are relatively accessible to change. Biological aspects of femininity and masculinity are not so visible, but they can be included in socio-cultural ones such as clothes. If students are exposed to gender diversity in clothing, colors, hairstyles, occupations etc. their tendency to resort to biological determinism would probably decrease. Thirdly, students tend to resort to conventional gender schemas. This can be countered with presentation of different masculinities and femininities. Through positive role models of different women and men students´ flexibility with respect to gender schemas may grow. At the same time, it is important to minimize gender polarization. Teachers can help it by questioning children's comments which compare women and men and by stressing heterogeneity within both gender categories.

References

Bem, S. L. (1993) *Lenses of gender: transforming the debate on sexual inequality*, New Haven: Yale University Press.

Bigler, R. S., Liben, L. S. (2007) 'Developmental intergroup theory: Explaining and reducing children's stereotyping and prejudice', *Current Directions in Psychological Science,* 16, 162–166.

Braun, V., and Clarke, V. (2006) 'Using thematic analysis in psychology', *Qualitative research in psychology*, vol. 3, no. 2, 77-101.

Bussey, K., Bandura, A. (1999) 'Social cognitive theory of gender development and differentiation', *Psychological review*, vol. 106, no. 4, 676.

Campbell, A., Shirley, L., and Candy, J. (2004) 'A longitudinal study of gender-related cognition and behaviour', *Developmental Science,* vol. 7, no. 1, 1-9.

Davies, B. (2006) 'Identity, abjection and otherness', *The Routledge Falmer Reader in Gender and Education*, 72.

Egan, S. K., Perry, D. G. (2001) 'Gender identity: A multidimensional analysis with implications for psychological adjustment', *Developmental psychology,* vol. 37, no. 4, 451-463

Fagot, B. I., Rodgers, C. S., Leinbach, M. D. (2000) 'Theories of gender socialization', *The developmental social psychology of gender*, 65-89.

Hrabal, V. (2011) *SORAD – Sociometrická ratingová metoda*. Praha: Hogrefe – Testcentrum.

Martin, C. L., Ruble, D. N., Szkrybalo, J. (2002) 'Cognitive theories of early gender development', *Psychological bulletin*, vol. 128, no. 6, 903-933.

Nielsen, H. B., and Rudberg, M. (1994) *Psychological gender and modernity.* Oslo: Universitetsforlaget.

Powlishta, K. (2002) 'Measures and models of gender differentiation', *Monographs of the Society for Research in Child Development*, vol. 67, no. 2, 167-178.

Rudman, L. A., and Glick, P. (2010) *The Social Psychology of Gender: How Power and Intimacy Shape Gender Relations.* New York: The Guilford Press.

Skelton, C., Francis, B., Smulyan, L. (Eds.) (2006) *The Sage handbook of gender and education*, Sage.

Sternberg, R. J. (2002) *Kognitivní psychologie*. Praha: Portál.

Tajfel, H. (ed.) (2010) *Social identity and intergroup relations*, Cambridge: Cambridge University Press.

Thorne, B. (1993) *Gender play: Boys and girls in School*, New York: Rutgers University Press.

Turner, J. C., Onorato, R. S. (1999) 'Social identity, personality, and the self-concept: A self-categorization perspective', *The psychology of the social self*, 11-46.

GEOGEBRA IN SECONDARY SCHOOL EDUCATION IN THE CZECH REPUBLIC: TEACHERS' PERCEPTIONS

Petra Surynková

Department of Mathematics Education, Faculty of Mathematics and Physics, Charles University, Czech Republic, surynkov@karlin.mff.cuni.cz

Abstract

The article addresses the using of GeoGebra software in secondary school education in the Czech Republic. GeoGebra software is helpful for teaching a wide range of mathematical topics and can be integrated into various forms of learning processes. First, my aim is to show an example of using GeoGebra in a specific topic of spatial geometry in order to activate my students and to enhance their understanding. GeoGebra software can be used for describing, solving, and illustrating mathematical problems. Second, the article describes a study aimed at the real experiences of secondary school mathematics teachers. The data for the study were collected via online questionnaire. The results of the inquiry are analyzed in detail. Finally, findings of the study will provide the basis for the possible extension and modification of the questionnaire, the improvement of teaching GeoGebra at our faculty, and the development of new GeoGebra materials for secondary schools teachers.

Keywords

GeoGebra, questionnaire, secondary school mathematics teachers

Introduction

After several decades of intensive promotion of information and communication technologies (ICT), the integration of technologies became an inseparable part of school instructions and learning processes (Oldknow, Taylor and Tetlow, 2010). Most of the teachers and students at all school levels and at universities have far more access to computers and software than ever before (Cuban, Kirkpatrick and Peck, 2001). Speaking of software in mathematics education, dynamic geometry systems (DGS) and computer algebra systems (CAS) have highly influenced teaching and learning mathematics (Straesser, 2002). Indisputably, GeoGebra belongs among DGS which are the most widespread all over the world among teachers and students. Because of its popularity GeoGebra is even further modifying and extending (Hohenwarter, Kovács and Recio, 2019). An immense popularity of GeoGebra among teachers and students comes from the facts that it is open-source software which is easy to use and understandable even for the absolute beginner. This is in contrast to CAS which are more sophisticated, require different amounts of time for users, and are more suitable for upper level education. Furthermore, an extensive user community around GeoGebra has been developed and so called GeoGebra institutes unite the GeoGebra users from all over the world (Hohenwarter and Lavicza, 2007; Hohenwarter and Lavicza, 2011).

There are several studies which show that the integration of ICT and namely DGS has a positive effect on better understanding, motivation of students, and transformation of the school instruction (Bate, Day and Macnish, 2013; Leikin and Grossman, 2013). Some research results state that using GeoGebra in classroom (not only in secondary schools but at universities too) support discovering and experimentation and its visualization features can effectively impact the acquiring of learning objectives by students (Lavicza, 2007). With the new features of automated reasoning, GeoGebra could start helping students in discovering new mathematical facts and in developing their own explanations (Hohenwarter, Kovács and Recio, 2019).

Anyway, the integration of software into education has never been an easy process. Numerous research studies revealed that the attempts to add technology in classroom teaching in various forms encountered difficulties (Cuban, Kirkpatrick and Peck, 2001). Hohenwarter and Lavicza (2011) realized soon that there is the necessity to encourage teachers and support them in using GeoGebra. They started establishing the international GeoGebra Institute, organizing and coordinating research projects, providing the specific training and so on. Nowadays, the network of GeoGebra users is huge. Teachers and students can share their materials on www.geoogebra.com or they can get the inspiration there. Obviously, the majority of teachers need to get some support for the successful integration of GeoGebra into their teaching.

I have a long term experiences of teaching geometry courses at the Faculty of Mathematics and Physics (Charles University) and mathematics instructions in the Grammar School in the Czech Republic. To understand what is meant by using dynamic software GeoGebra in mathematics lesson and its application to the learning process, I show a specific example from spatial geometry and demonstrate its description and solution using GeoGebra. Let a cube *ABCDEFGH* be given, the task is to find a cross section of a cube and a plane *XYZ*, if points *X*, *Y*, *Z* are on the edges *AB*, *CG*, *EH*; respectively. This example is a typical one from the theme on solid geometry (stereometry) and according to the Czech National Educational Program for Grammar School (NÚV, 2007) is taught in grammar schools in the Czech Republic. A cross section is the non-empty intersection of a solid and a plane. A plane containing a cross section of the solid is called a *cutting plane* (Pottman et al., 2007). This task requires to project three-dimensional situation in two dimensions because students solve it graphically. Usually some type of parallel projection is used. There are several basic steps in solving a cross section of solids based on the fundamental geometric statements regarding the intersection of three planes. Three non-coincident planes can intersect in one point; each plane cuts the other two in a line; two parallel planes and the other cuts each in a line; three planes intersect in a line; or three planes can be parallel. According to my experiences, students have problems with the visualization of the three-dimensional situation (sketching the three-dimensional situation in a parallel projection), understanding a two-dimensional image (the result of a parallel projection), determining the visibility of a cross section, understanding the resulting image if it is not viewed from above but from below. Now GeoGebra software can be used with a potentially positive impact. GeoGebra offers basic features to model the situation and its solution using 3D graphics. Dragging the points *X*, *Y*, *Z* on the edges in GeoGebra, students can observe and discuss the possible shapes of cross section which are changing continuously in real time, see Figure 1a.

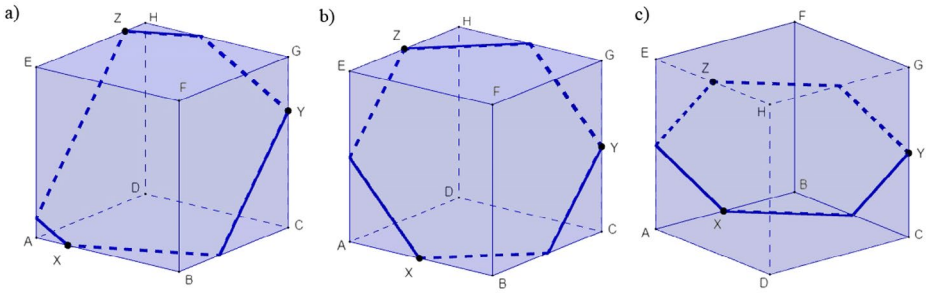


Figure 1: The cross section of a cube, 2020 (source: own drawing using GeoGebra)

For instance, they can find the interesting solution for the case the points are centers of the edges, see Figure 1b. Moreover, the situation can be arbitrary rotated so it is viewed from different viewpoints, see Figure 1c. The example is available online too (Surynková, 2020a). Based on my observations students understand better such types of examples and can easily find the correct solution when I am

demonstrating it using GeoGebra. For example, the problem of visibility is clear for students when I rotate the model using 3D graphics.

My aim is to explore the real situation of using GeoGebra in mathematics instructions in secondary school education in the Czech Republic. There are several aspects of using GeoGebra in the Czech classrooms what I am interested in. Namely, what features and tools are teachers using in GeoGebra or what are their experiences, recommendations, and suggestions. Especially, what effect GeoGebra has on their teaching. I decided to conduct the survey among secondary school mathematics teachers via online questionnaire. The results are discussed in this article. Findings of the study will be useful for further research and work with secondary school teachers in a number of ways. According to these findings I plan to improve teaching geometry and mathematics courses at the Faculty of Mathematics and Physics, Charles University, in the Czech Republic where I currently hold the position of assistant professor and work with pre-service mathematics teachers. At the same time I plan to support secondary school mathematics teachers in the Czech Republic in various ways.

The rest of the paper is organized as follows. In the next section I describe the design of the questionnaire for secondary school mathematics teachers and the methodology for the assessment of the survey. Then the results of the study are presented and the discussion afterwards. Short summary, suggestions and ideas for future work are given lastly.

Materials and Methods

As has been already pointed out, my aim is to analyze the impact of using GeoGebra on teaching and learning in secondary school education according to teachers' perceptions and to obtain better insight into using GeoGebra in Czech secondary schools.

The survey was carried out online and the data were collecting during February 2020. 202 secondary school mathematics teachers from all around the Czech Republic and different types of secondary schools were asked to answer the questionnaire via emails. I received 87 completed questionnaires in total by the end of February.

The questionnaire contains the introductory requiring questions such as gender, age, type of school, teachers' specialization, years of teaching experiences, regions of the Czech Republic of professional activity, and the school from which teachers graduated. These data shows the basic characteristics of teachers who filled in the questionnaire. These basic characteristics were used for an analysis of certain dependencies. From the group of 87 teachers, 57 were females (65.5%), 30 males (34.5%). Years of teaching experiences were divided into 6 categories – 15 teachers have been teaching less than 5 years (17.2%), 5 teachers 6-10 years (5.7%), 7 teachers 11-15 years (8%), 8 teachers 16-20 years (9.5%), 17 teachers 21-25 years (19.5%), and 35 teachers more than 26 years (40.2%). The types of schools where respondents are employed as teachers are summarized in Table 1.

Type of School	Teachers	
	abs.	rel.
Grammar School	71	81.6
Secondary School of Civil Engineering (SPŠ Stavební)	1	1.1
Secondary School of Mechanical Engineering (SPŠ Strojnická)	5	5.7
Secondary School of Electrical Engineering (SPŠ Elektrotechnická)	4	4.6
Secondary School of Telecommunication Engineering (SPŠ Sdělovací techniky)	3	3.4
Secondary School of Geodesy (ŠPŠ Zeměměřická)	2	2.3
Other Secondary Technical Schools	1	1.1
Total	**87**	**100.0**

Table 1: Types of schools where respondents are employed as teachers, 2020 (source: own calculation)

The number of respondents by Czech regions is depicted in Figure 2.

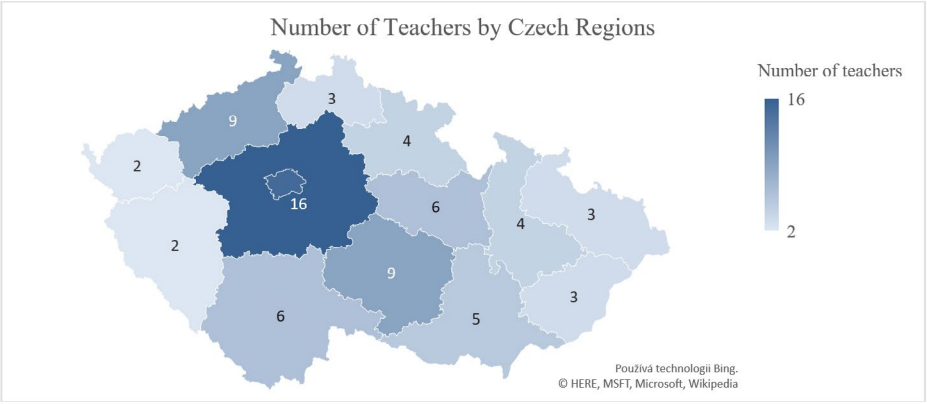


Figure 2: Number of teachers who participated in the survey according to the regions in the Czech Republic, 2020 (source: own calculation)

The questionnaire was divided into two branches according to whether or not teachers use GeoGebra in their teaching. 70 teachers (80.5%) claimed that they are using GeoGebra in their teaching, the rest 17 teachers (19.5%) answered that they do not use GeoGebra in the classroom. Teachers who work with GeoGebra were asked for example how often, why, when, or how do they use GeoGebra in the classroom, how did they learn to use it, what topics do they teach using GeoGebra, or what are the advantages and disadvantages of using GeoGebra. Two more questions were added on the basis of first teachers' reactions regarding the participating in GeoGebra community and recommendations for training GeoGebra and creating GeoGebra materials adapted to Czech teachers' needs. These questions were multiple-answer multiple choice questions or open-ended questions. Furthermore, in Likert scale questions teachers who use GeoGebra were asked to evaluate the effectiveness and the impact of using GeoGebra on their instructions and students' success rate.

Teachers who do not work with GeoGebra were asked for example why do not they use GeoGebra in the classroom, do they use another software, or if do they plan to start using GeoGebra. The scheme of the questionnaire is available online (Surynková, 2020b). I plan to use the questionnaire for further research that is why I do not share the original source.

I considered only selected questions and answers for the purposes of this article; the rest will be used for further research. From these selected data, the absolute and relevant frequencies of teachers' answers were determined, several items in the survey were measured on a five-point Likert scale, and certain dependencies were observed, described graphically or summarized in tables and figures. To show dependencies between answers and certain basic characteristics of teachers, the data were also processed into a contingency table of the absolute frequencies. Pearson's chi-squared test of independence was used; the results were interpreted at the chosen level of significance.

I formulated hypotheses and research questions; several of them I present here.

- H0: The using of GeoGebra in the classroom and years of teaching experiences are independent.
- H1: The using of GeoGebra in the classroom and years of teaching experiences are not independent.
- RQ1: How many users and non-users of GeoGebra is in the sample?

- RQ2: Why do/ do not Czech secondary school teachers use GeoGebra in the classroom?
- RQ3: How do Czech secondary school teachers learn to use GeoGebra?
- RQ4: Do Czech secondary school mathematics teachers need the specific support in using GeoGebra (the courses, new materials)?
- RQ5: What are the advantages and disadvantages of using GeoGebra in the classroom?
- RQ6: What is the effect of using GeoGebra on students' understanding of mathematical terms, students' success rate, and students' attitudes towards mathematics regarding interest and motivation (from teachers' perspective)?

Results

Selected data acquired in the survey are presented graphically. Not all questions were required to be answered by respondents; the number of respondents in a concrete question is always stated.
Figure 3 presents the reasons for using GeoGebra. These statements were claimed by teachers (70) who work with software. GeoGebra users also answered when is suitable to use GeoGebra. According to their opinions the most appropriate situations were – when teachers need to show the change of the solution dynamically depending on the change of input parameters; when teachers need to show all possible solutions of the problem.
Regarding the question how did teachers learn to use GeoGebra; the most common answers were that teachers are learning by themselves or they took part in GeoGebra courses in the past. I was also interested in teachers' recommendations. Teachers expressed the need to have the database of materials created in GeoGebra which would refer to Czech curriculum. Some teachers answered that the database shared online on official GeoGebra website by GeoGebra users is not sufficient for Czech teachers. Some teachers also mentioned that GeoGebra should be included in pre-service teacher education because the novice secondary school mathematics teachers are then better prepared for the real practice.

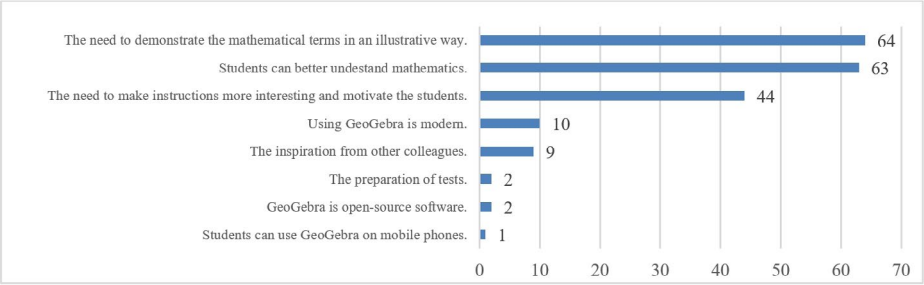


Figure 3: Absolute frequency of the reasons for using GeoGebra in the classroom, 2020 (source: own calculation)

	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)	Total	Mean
Question A	17 (24.3%)	38 (54.3%)	15 (21.4%)	0 (0.0%)	0 (0.0%)	70 (100%)	4.03
Question B	2 (2.9%)	22 (31.4%)	43 (61.4%)	2 (2.9%)	1 (1.4%)	70 (100%)	3.31
Question C	19 (27.1%)	38 (54.3%)	10 (14.3%)	2 (2.9%)	1 (1.4%)	70 (100%)	4.03

Table 2: Answers to questions related to the effect of using GeoGebra on students' understanding, students' success rate, and students' attitudes from teachers' perspective, 2020, (source: own calculation)

The effect of using GeoGebra on students' understanding of mathematical terms, students' success rate, and students' attitudes towards mathematics regarding interest and motivation from teachers'

perspective was measured using a five-point Likert scale. The scale was ranging from 'strongly agree' to 'strongly disagree' with 'neutral' item in the middle. We can see that the most common answer about if students can better understand mathematical terms was 'agree', Question A. Regarding the question whether teachers can see some positive effect on students' success rate the most common answer was 'neutral', Question B. Finally, question targeted on students' motivation and interest in mathematics had the most common response 'agree', Question C. The data measured using scales are interpreted also using coefficients. The items from 'strongly agree' to 'strongly disagree' were assigned coefficients from 1 to 5 and the mean was evaluated, see Table 2.

	Under 10	11-20	Over 21	Total
YES	18	11	41	70
NO	2	4	11	17
Total	**20**	**15**	**52**	**87**

Table 3: Number of teachers who use or do not use GeoGebra according to years of their teaching experiences, 2020 (source: own calculation)

Finally, the contingency table which illustrates the number of teachers who are using/are not using GeoGebra and years of their teaching experiences is provided, see Table 3. Years of teaching experiences were merge only into 3 categories (less than 10 years, 11-20 years, more than 21 years) here to meet the required conditions for the test. The hypothesis H0 was tested by Pearson's chi-squared test. The statistical value $\chi^2 = 1.73$ is lower than the critical value 5.99 with two degrees of freedom and at the 5% level of significance. Therefore, the hypothesis H0 cannot be rejected. We cannot conclude that there is any dependency between using of GeoGebra and years of teaching experiences.

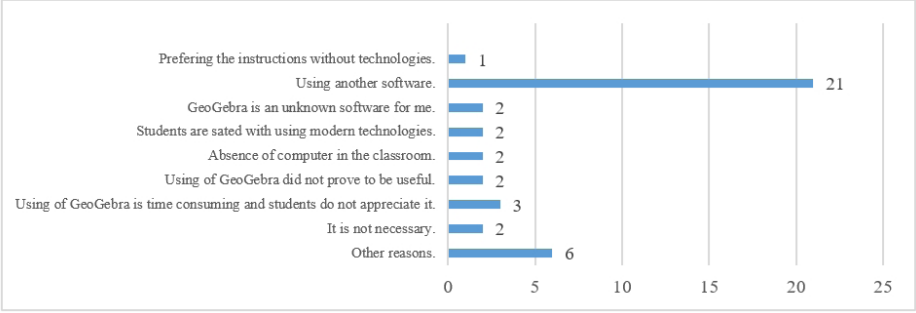


Figure 4: Reasons for not using GeoGebra, 2020 (source: own calculation)

Figure 4 presents the reasons why teachers do not use GeoGebra. These statements were claimed by 17 teachers. Almost one third of these teachers is well disposed towards using GeoGebra.

Discussion

According to Kriek and Stols (2011) the most significant predictor of attitude towards the use of DGS is its perceived usefulness. The users of GeoGebra in my sample expressed beliefs in the usefulness of software when listing the reasons for using it and in the Likert scale questions. From the results of my research, using of GeoGebra in learning process has a positive motivational impact on students. Teachers also claimed that with GeoGebra students can better and faster understand mathematical terms. These results are consistent with the findings of Tatar (2013).
A study of Niederhauser and Stoddart (2001) revealed that years of teaching experience did not

significantly influence the using of ICT; software use was spread evenly across teachers of all experience levels. I also did not find any dependency of this kind in the sample.
Several reasons for not using GeoGebra in my study and in the study of Molnár and Lukáč (2015) were common (for example that it is time consuming).
The study revealed what teachers consider as advantages and disadvantages of using GeoGebra in the classroom. Among advantages teachers stated the most often – GeoGebra can engage students' attention; mathematics instruction is more attractive and interesting for students. Among disadvantages teachers stated the most often – the preparation for the mathematics lecture is much longer; GeoGebra does not develop manual skills of students such as writing, sketching, or drawing.
Molnár and Lukáč (2015) found out in their study that the teachers use DGS mainly for teaching geometry (it is not specified if planar or spatial) and then functions follow. The GeoGebra users in my sample use GeoGebra mainly for teaching elementary functions.

Conclusion

The results of the study revealed several interesting teachers' opinions. Teachers' opinions are important for me because I am organizing training in GeoGebra at the Faculty of Mathematics and Physics for secondary school mathematics teachers. I can modify the content of these courses according to the survey. I will focus on preparing GeoGebra applets which will reflect the Czech curriculum and will be available for secondary school teachers. My aim is to support and unite GeoGebra users in the Czech Republic. Moreover, I assume this research can significantly help to improve the pre-service mathematics teacher education. I also plan to conduct a further survey which will include a bigger data sample. When I was interpreting the data in this study I realized that for further research it will be necessary to add several specific questions. Some questions need to be required to get data of a good quality. I will also analyze other dependencies in the sample which were skipped here because of the limited length of the article.

Acknowledgement

The paper was supported by the project PROGRES Q17 *Teacher preparation and teaching profession in the context of science and research* and by Charles University Research Centre No. UNCE/HUM/024.

References

Bate, F.G., Day, L. and Macnish, J. (2013) 'Conceptualising Changes to Pre-Service Teachers' Knowledge of how to Best Facilitate Learning in Mathematics: A TPACK Inspired Initiative', *Australian Journal of Teacher Education*, vol. 38, no. 5, pp. 14-30. http://dx.doi.org/10.14221/ajte.2013v38n5.3
Cuban, L., Kirkpatrick, H. and Peck, C. (2001) 'High Access and Low Use of Technologies in High School Classrooms: Explaining an Apparent Paradox', *American Educational Research Journal*, vol. 38, no. 4, pp. 813-834. https://doi.org/10.3102/00028312038004813
Hohenwarter, M., Kovács, Z. and Recio, T. (2019) 'Using Automated Reasoning Tools to Explore Geometric Statements and Conjectures', In: Hanna G., Reid D., de Villiers M. (eds) *Proof Technology in Mathematics Research and Teaching*. *Mathematics Education in the Digital Era*, vol. 14. Springer, Cham.
Hohenwarter, M. and Lavicza, Z. (2007) 'Mathematics teacher development with ICT: towards an, International GeoGebra Institute', *Proceedings of the British Society for Research into Learning Mathematics*, vol. *27*, no. 3, pp. 49-54. University of Northampton, UK: BSRLM.
Hohenwarter, M. and Lavicza, Z. (2011) 'The Strength of the Community', In: Bu L., Schoen R.

(eds) *Model-Centered Learning. Modeling and Simulations for Learning and Instruction*, vol. 6, pp. 7-12. https://doi.org/10.1007/978-94-6091-618-2_2
Kriek, J. and Stols, G. (2011) 'Why don´t all math's teachers use dynamic geometry software in their classrooms?', *Australasian Journal of Educational Technology*, vol. 27, no. 1, pp. 137-151.
Lavicza, Z. (2007) 'Factors Influencing the Integration of Computer Algebra Systems into University-level Mathematics Education', *International Journal for Technology in Mathematics Education*, vol. 14, no. 3, pp. 121-129.
Leikin, R. and Grossman, D. (2013) 'Teachers modify geometry problems: from proof to investigation', *Educational Studies in Mathematics*, vol. 82, pp. 515-531. https://doi.org/10.1007/s10649-012-9460-4
Molnár, P. and Lukáč, S. (2015) 'Dynamic Geometry Systems in Mathematics Education: Attitudes of Teachers', *International Journal of Information and Communication Technologies in Education*, vol. 4, no. 4, pp. 19-33. https://doi.org/10.1515/ijicte-2015-0017
Niederhauser, D.S. and Stoddart, T. (2001) 'Teachers' instructional perspectives and use of educational software', *Teaching and Teacher Education*, vol. 17, no. 1, pp. 15-31. https://doi.org/10.1016/S0742-051X(00)00036-6
NÚV (2007) *The National Institute for Education, Education Counselling Centre and Centre for Continuing Education of Teachers, the Czech National Educational Program for Grammar School*, [Online], Available: http://www.nuv.cz/file/161 [February 28 2019]
Oldknow, A., Taylor, R. and Tetlow, L. (2010) *Mathematics Using ICT,* 3rd Edition, New York: Continuum.
Pottmann, H., Asperl, A., Hofer, M. and Kilian A. (2007). *Architectural Geometry*, Exton, USA: Bentley Institute Press.
Straesser, R. (2002) 'Cabri-géomètre: Does Dynamic Geometry Software (DGS) Change Geometry and its Teaching and Learning?', *International Journal of Computers for Mathematical Learning*, vol. 6, pp. 319-333. https://doi.org/10.1023/A:1013361712895
Surynková, P. (2020a) *The Cross Section of a Cube*, [Online], Available: https://www.geogebra.org/m/sgdxrbku
Surynková, P. (2020b) *The Scheme of the Questionnaire*, [Online], Available: https://drive.google.com/file/d/1woMk_GQcy7WwUEdegCIvwmwh8z3xX8kX/view?usp=sharing
Tatar, E. (2013). 'The Effect of Dynamic Software on Prospective Mathematics Teachers' Perceptions Regarding Information and Communication Technology', *Australian Journal of Teacher Education*, vol .38, no. 12. http://dx.doi.org/10.14221/ajte.2013v38n12.6

SECURITY OF CONNECTION TO SCHOOL WEBSITES: A COMPARISON OF VISEGRÁD GROUP MEMBER COUNTRIES

[1]✉Jaroslav Svoboda, [2]Jiří Georgiev

[1]Department of Multimedia, Faculty of Informatics and Statics, University of Economics, Prague, Czech Republic, jaroslav.svoboda@vse.cz

[2]Department of Econometrics, Faculty of Informatics and Statics, University of Economics, Prague, Czech Republic

Abstract

Websites are the essential communication channel for many companies and organizations, and educational institutions are no exception. These institutions are generally late in implementing the newest ICT security measures, but without proper security measures and connection security websites fail their primary purpose and, in some cases, may not be considered safe to use. This contribution compares the implementations of connection security to websites of educational institutions in V4 member countries. The focus is on the implementation of DNSSEC, HTTP/2 and mainly HTTPS, which is analysed in detail. In total, 39 746 domains were scanned and assessed. Only 26.5 % of websites have HTTPS implemented in a way that can be considered as good enough. The rest of the implementations are unusable, faulty or non-existent. Research finds widespread flaws with a varying degree in all V4 countries. Many issues are caused by providers which offer web as a service on a third-level domain.

Keywords

Education, ICT security, encryption, HTTPS

Introduction

As the internet spreads into all areas of human activities, education is no exception. Universities were one of the first institutions to use the internet (Howe, 2016), but nowadays, even nursery schools use the internet for everyday communication with parents, companies and the government. By default, communication over the internet is not secured in any way. Therefore, a set of encryption protocols must be used. One of the most common ones is HTTPS protocol which uses TLS encryption protocol to transmit web content over the internet securely. HTTPS is necessary for applications such as internet banking, webmail or social networks.

In many cases, the school web may provide services with necessary login, therefore, sensitive data are sent over the network. After successful login, sensitive data might flow the other way because the user requested sensitive information, e.g. national identification number, grades from last week or emails from school email post-box. According to (Fraillon et al., 2014), 83% of teachers and 59% of pupils of Czech ISCED 1 and 2 schools are provided with a school email account. 87% of schools provide access to an education site or a network maintained by an education system. Even if a website does not provide these services, encryption is vital to prevent tracking and to ensure the security and privacy of the user. Website presentations play a crucial role in the communication of educational institutions with students and parents, and without correctly implemented security, they are failing their purpose.

HTTPS encrypts the data so nobody except the rightful recipient can decipher them. However, this is not the only function of HTTPS. Its main advantages are (Felt et al., 2019):

1. The data cannot be read during the transmission by the third-party
2. The data cannot be modified during the transmission by the third-party

3. Third-party cannot find out what web page is the user accessing on the server which still might be visible[1]
4. There is no distinction between sensitive and not sensitive data, and all are treated the same
5. Encryption builds trust and increases user comfort
6. Websites using HTTPS get a higher ranking from Google (Bahajji and Illyes, 2014)
7. Some implementations increase the connection speed as a side-effect (HTTP vs HTTPS Test, 2020)

Thanks to Extended Validation (EV) certificates, it is also possible to identify the web owner, but with recent changes in browser's graphical user interfaces, this feature is becoming marginal (EV UI Moving to Page Info, 2019).
Implementing HTTPS is not a technically and financially demanding process, but it is also not a straightforward operation. There are vulnerabilities in old implementations which need to be mitigated by updating the webserver software, turning off deprecated SSL/TLS protocols and supporting newer, more secure ones. In 2020 the main event concerning HTTPS is the depreciation of TLS 1.0 and 1.1 (Turner, 2020)if approved, formally deprecates Transport Layer\n Security (TLS.
The focus of this paper is on educational institutions in the Czech Republic, Republic of Poland, Slovak Republic and Hungary and security of the connection to their websites. Focus is divided into several topics: use of DNSSEC, HTTP/2 and mainly detailed analysis of HTTPS implementation. This paper is a continuation of (Svoboda and Georgiev, 2019), which focused only on the Czech Republic. The addition of other countries of the Visegrád group allows to compare and potentially pinpoint underlying reasons behind insufficient implementation in one of the key security elements in educational websites.
Remark: The security of the connection to websites is assessed regardless of the actual content on the website.

Materials and Methods

Primary data sources are official databases: Czech database Stistko, Hungarian database Oktasi, Polish database Wykaz and Slovakian database CVTI. In addition to these sources, web-scraping has been used for InspIS PORTÁL of Czech School Inspectorate and Institutional Register of the Public Education Information System in Hungary. Additional database from The Ministry of Education, Science, Research and Sport of the Slovak Republic (RIS - portal) was also merged. This was very important due to the poor quality of data in the official database provided by the Ministry of Education, Youth and Sports of the Czech Republic and the Hungarian Office of Education database file. Especially contact information and website addresses were either partially missing or were unavailable at all in data sources of all countries. In the case of Slovakia, the data were not up to date in the primary source. Possibly some of the investigated websites are not currently used because of the lower quality and currency of the data sources.
Country specific types of educational institutions were manually mapped according to (ISCED) to three-digit ISCED-P. Each institution is represented only once according to the highest ISCED level of education it provides, e.g. in case the institution is nursery, elementary and high school, it is considered a high school only. Our focus is on ISCED levels 0 to 3. Furthermore, ISCED levels 1 and 2 were merged as they are indistinguishable in some countries.
In order to assess the quality of implementation, 39 746 domains were scanned, of which 3622 were not working. 32 490 domains were analysed in detail because they belonged to the ISCED level 0-3 educational organisation, and the website was working.

1 if other than TLS 1.3 with ESNI is used

Testssl.sh was used for evaluation of available connection, HTTPS implementation and certificate (Wetter, 2019). Dig (domain information groper) was used for DNSSEC check.
Selected statistics are compared with SSL Pulse from January 04, 2020, made by Qualys (Qualys SSL Labs - SSL Pulse, 2020). It is "a continuous and global dashboard for monitoring the quality of SSL / TLS support over time across 150,000 SSL- and TLS-enabled websites, based on Alexa's list of the most popular sites in the world".

Results

DNSSEC is used by 57.87% of Czech, 25.96% of Polish, 21.17% Slovakian and 20.34% Hungarian domains. Higher usage of DNSSEC in Czechia could be explained by an information campaign of national registrar CZ.NIC launched to support the use of DNSSEC and because of the Report on the deployment of DNSSEC from 2013 which mandates all government-owned domains to use DNSSEC by the end of June 2015 (DNSSEC, 2006; Rusnok, 2013).
Protocol HTTP/2, which speeds up the connection, is used by 44.97% of Czech, 52.70% of Polish, 23.08% Slovakian and 25.89% Hungarian web sites but only 54.64%, 32.16%, 43.02% and 51.35% of them also has good enough HTTPS implementation. According to SSL Pulse, the HTTP/2 is used by 43.6% of websites, the W3Techs states the share similarly, 43.3% (W3Techs, 2020).
Table 1 sums up the main categories the websites were divided into. The main category with websites with good enough HTTPS implementation includes only websites where the browser does not show visible errors or warnings when visited. This differs among browsers and different versions, that is why quite strict criteria have been set. Cases which implement HTTPS in a way which does not work correctly - user encounters warnings and errors - are in the category poor HTTPS implementation, and the last category is websites which do not implement HTTPS at all.

	Domains in the database	Working domains	Working domains					
			HTTPS not implemented		Poor HTTPS implementation		Good enough HTTPS implementation	
CZ	8254	8000	564	7.0%	4027	50.3%	3409	42.6%
PL	24201	21466	754	3.5%	15967	74.4%	4745	22.1%
SK	3132	2993	138	3.8%	2949	80.5%	578	15.8%
HU	4159	3665	671	22.4%	1472	49.2%	850	28.4%
Total	**39746**	**36124**	**2127**	**5.9%**	**24415**	**67.6%**	**9582**	**26.5%**

Table 1: Main categories of HTTPS implementation

Figure 1 shows the distribution of protocols offered by web servers in each country and worldwide. TLS 1 and 1.1 are still offered very often, but TLS 1.2 is the most common. The newest TLS 1.3 is less common but is significant in Slovakia thanks to edupage.org websites. Deprecated SSL2 and 3 are still offered, but their combined share is lower than 7% in all countries except for Hungary where those protocols reach approximately 10.5%.
Table 2 shows how many websites are accessible by use of only non-deprecated TLS protocol versions and on the other side, how many of them are accessible by using only deprecated ones.

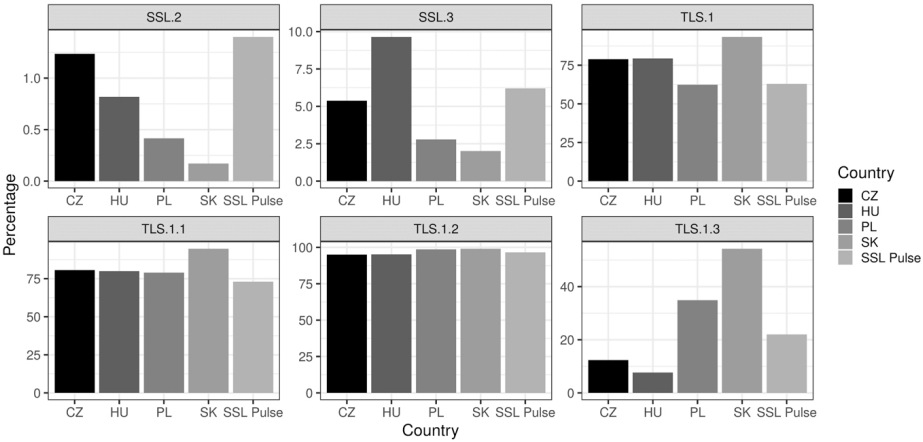


Figure 1: Protocol Support

	CZ	HU	PL	SK
TLS1.2+ only	657	199	1769	42
TLS1.1- only	397	122	304	29

Table 2: Websites implementing only deprecated and only nondeprecated protocols

Table 3 shows the evaluation of websites divided by ISCED level and then by country. Educational institutions from Czechia achieved the highest share of good enough HTTPS implementations in all educational levels. Hungary follows Czechia, but although both countries have almost the same size as the population, the number of Hungarian domains is only 37.41% of Czech ones. Interesting is the slump of the ISCED 1-2 group compared to the rest in Slovakia, Poland and Hungary compared to the correlation between ISCED level and share in category good enough HTTPS implementation in Czechia, where also the higher provided education, the better the connection security. This can be expected because higher education is associated with demand for more services and increased information flow between students and institutions, thus need for a secure connection is increased as well. Why similar trends are not visible in Poland, Hungary and Slovakia is unclear, and it might point out that the situation might be more troublesome in these countries compared to the Czech Republic.

Figure 2 shows the share of 8 most common certificate authorities which educational institutions use. Let's Encrypt, a non-profit Certificate Authority providing TLS certificates, has a vast majority in all countries except Poland where local CAs with Cloudflare and cPanel have not a negligible share. cPanel is also popular in Hungary. While Polish CA nazwaSSL offers sufficient 2048-bit RSA certificates for free, company cPanel provides the certificate as part of their paid web site management product. Certyfikat SSL is a traditional certificate reseller.

The last table 4 shows how strong keys are used in certificates. Czechia shows a share of longer keys which is twice the size of the other countries.

		Without HTTPS		Broken HTTPS		Good enough HTTPS	
ISCED 0	CZ	125	6.20%	1178	58.10%	723	35.70%
	PL	218	3.30%	4701	72.10%	1597	24.50%
	SK	18	3.60%	351	70.20%	131	26.20%
	HU	49	8.90%	335	60.70%	168	30.40%
	Total	**410**	**4.30%**	**6565**	**68.40%**	**2619**	**27.30%**
ISCED 1-2	CZ	254	6.90%	1828	49.80%	1591	43.30%
	PL	295	3.10%	7590	80.50%	1547	16.40%
	SK	32	1.80%	1597	89.80%	149	8.40%
	HU	292	31.20%	427	45.60%	218	23.30%
	Total	**873**	**5.50%**	**11442**	**72.30%**	**3505**	**22.20%**
ISCED 3	CZ	96	8.30%	452	39.00%	612	52.80%
	PL	99	4.80%	1375	66.80%	584	28.40%
	SK	56	8.90%	446	71.10%	125	19.90%
	HU	140	25.40%	230	41.70%	181	32.80%
	Total	**391**	**8.90%**	**2503**	**56.90%**	**1502**	**34.20%**

Table 3: Categories of HTTPS implementation among ISCED levels and countries

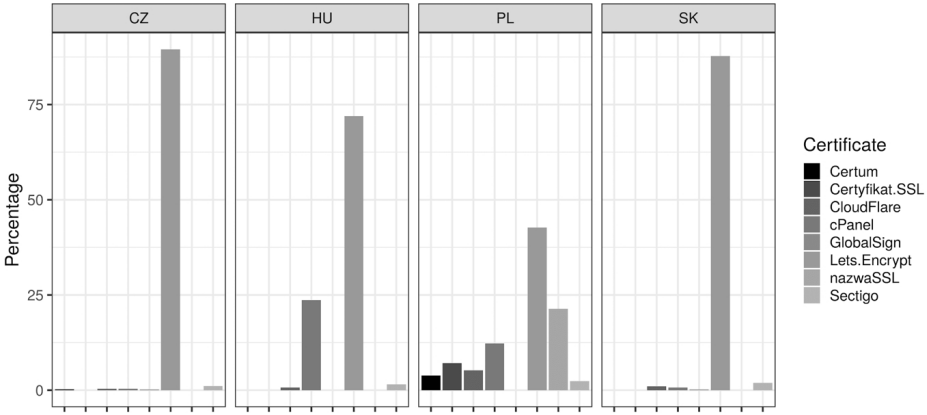


Figure 2: Share of Certification Authorities

	below 2048	2048 bits	3072 bits	4096+ bits
CZ	2.85%	68.71%	1.05%	23.79%
HU	3.96%	78.85%	0.65%	12.83%
PL	1.41%	82.60%	1.77%	12.33%
SK	0.54%	72.19%	0.28%	10.94%
SSL Pulse	0.00%	89.20%	4.20%	6.50%

Table 4: Key strength

Discussion

Comparison between the years 2019 and 2020 in Czechia shows improvements in DNSSEC, HTTP/2 and Good enough HTTPS adoption by 11.99, 14.05 and 7.11 percentual points (Svoboda and Georgiev, 2019). It is important to note that part of this improvement is caused by an increase in the number of websites in Czechia, as these new websites have a higher probability of correct implementation.

Poor HTTPS implementation is, in most cases, still caused by an issue with a certificate. The most common issue is the untrusted certificate. This can be caused by either an outdated certificate or the certificate does not match the supplied Uniform Resource Identifier (URI). The main reasons for a broken chain of trust are the inclusion of self-signed or expired certificate, or that the chain is incomplete. In approximately 10% of cases, the certificate of the website is self-signed. This suggests that the implementation of HTTPS is probably accidental as self-signed certificates cannot be used in proper implementation.

Across all followed countries there are 852 domains which support only older TLS versions than 1.2. Because of the mentioned deprecation of older TLS protocols, accessing those websites will result in an error message "secure connection failed" since March 10 in Firefox, March 17 in Chrome, WebKit and April in Microsoft browsers (Anderson, 2020).

Some differences in HTTPS implementations among countries of V4 can be explained by the fact that many websites, especially in Slovakia and Poland, use website providers with a focus on educational institutions. Such a service has the same implementation across all the websites they host. Unfortunately, the implementation is, in many cases, suboptimal. In the Czech Republic, universal freehosting providers are far more popular than services which specialize in websites of educational institutions despite additional advertisements added to the websites and low price of regular hosting providers.

Data show that each country has several preferred third-level domain website hosting providers. Service EduPage is used in 1278 cases by Slovakian schools and in 1803 cases by Polish schools. This service has both paid and free plans, and because it is used by 34.87 % of all Slovakian websites and implements TLS 1.3, it dramatically raises the share of this protocol in this country. Sadly, the implementation lacks either redirect from https://www to https:// or both www and non-www versions of the domain in the certificate, therefore it has not been evaluated as good enough implementation of HTTPS. Edu.sk is the case of abandoned web hosting service which was provided by Slovak Telekom, a.s. and Slovak Centre of Scientific and Technical Information since 2003, but now seems not to be maintained anymore. Edu.sk is used by 505 institutions, but many of the institutions have new websites hosted elsewhere, and the old domain either redirects there automatically or presents new URLs. Those which are still working do not have homogeneous HTTPS implementation. The Office of Education (Oktatási Hivatal) and Government Information Technology Development Agency (KIFÜ), which is part of the Hungarian government, runs Sulinet, among other things, the web hosting service for primary and secondary schools. Czech alternative provided by ČSI as part of InspIS PORTÁL is not very popular, and according to used databases, we found only 8 institutions using it. Even though for many, it would mean improvement over their current solution (Svoboda and Georgiev, 2019).

Except for Poland, schools also use Webnode service provided by Swiss company Webnode AG. This service provides good enough HTTPS, but while deprecated TLS protocols are still offered, TLS 1.3 is not.

There is also no need to use any commercial certificates because there are no benefits of using them compared to Let's Encrypt. Quite the opposite because the organisation recently announced that they are the first to use multi-perspective domain validation at the scale (Aas, McCarney and Shoemaker, 2020) and the certificates are valid for only 90 days, therefore it solves the issue with recent changes made by Apple (Shaun, 2020).

Conclusion

This contribution focuses on the security of the connection to the websites of educational institutions in V4 member countries. To assess the situation, 39 746 domains were scanned.

Our findings show that the issue of missing DNSSEC and poorly implemented HTTPS is widespread among countries of the Visegrád Group, although in varying degrees.
In comparison to the Czech Republic, other countries of the Visegrád group have many hosting providers specializing in websites of educational institutions. This does not improve the situation as implementation provided by these specialized hosting is, in many cases, suboptimal. In the case of higher use of DNSSEC in the Czech Republic, it seems that campaigns focused on stakeholders can significantly improve the situation in ICT security. With suboptimal implementation, website fails its primary goal as a communication channel with parents, students and others, because it cannot be trusted as it cannot provide security and privacy for users. Lack of security and overall low quality of ICT in education should create demand for at least minimal governance by relevant government agencies and departments. Information campaigns and compulsory training should be set in place mainly in the case of public institutions to increase awareness of decisionmakers (headmasters, heads of IT,…).
In further studies, it might be beneficial to compare education institutions of V4 with group of more developed countries such as Benelux or Scandinavia not only in the scope of security but also to assess the content and use of the website.

Acknowledgement

This paper has been supported by the IGA grant VŠE IGS F4/37/2020.

References

Aas, J., McCarney, D. and Shoemaker, R. (2020) *Multi-Perspective Validation Improves Domain Validation Security - Let's Encrypt - Free SSL/TLS Certificates*. [Online], Available: https://letsencrypt.org/2020/02/19/multi-perspective-validation.html [20 Feb 2020].
Anderson, T. (2020) *These truly are the end times for TLS 1.0, 1.1: Firefox hopes to 'eradicate' weak HTTPS standard by blocking it*. [Online], Available: https://www.theregister.co.uk/2020/02/10/tls_10_11_firefox_complete_eradication/ [20 Feb 2020].
Bahajji, Z. A. and Illyes, G. (2014) 'HTTPS as a ranking signal', *Official Google Webmaster Central Blog [EN], 6 August.* [Online], Available: https://www.webmasters.googleblog.com/2014/08/https-as-ranking-signal.html [20 Feb 2020].
DNSSEC (2006). [Online], Available: https://www.dnssec.cz/ [20 Feb 2020].
EV UI Moving to Page Info (2019). [Online], Available: https://chromium.googlesource.com/chromium/src/+/HEAD/docs/security/ev-to-page-info.md [20 Feb 2020].
Felt, A. P. et al. (2019) 'Measuring HTTPS Adoption on the Web', in *Proceedings of the 26th USENIX Conference on Security Symposium*. 26th USENIX Security Symposium, Vancouver, BC, Canada: USENIX Association, pp. 1323–1338.
Fraillon, J. et al. (2014) *Preparing for Life in a Digital Age: The IEA International Computer and Information Literacy Study International Report*, Cham: Springer International Publishing. http://dx.doi.org/10.1007/978-3-319-14222-7
Howe, W. (2016) A Brief History of the Internet. [Online], Available: https://www.walthowe.com/navnet/history.html [28 Jan 2020].
HTTP vs HTTPS Test (2020). [Online], Available: http://www.httpvshttps.com/ [20 Feb 2020].
Qualys SSL Labs - SSL Pulse (2020). [Online], Available: https://www.ssllabs.com/ssl-pulse/ [20 Feb 2020].
Rusnok, J. (2013) USNESENÍ VLÁDY ČESKÉ REPUBLIKY ze dne 18. prosince 2013 č. 982. [Online], Available: https://apps.odok.cz/attachment/-/down/VPRA9EVEBJYC [11 Feb 2020].

Shaun, N. (2020) Apple drops a bomb on long-life HTTPS certificates: Safari to snub new security certs valid for more than 13 months. [Online], Available: https://www.theregister.co.uk/2020/02/20/apple_shorter_cert_lifetime/ [28 Feb 2020].
Svoboda, J. and Georgiev, J. (2019) 'State of connection security to websites of educational institutions in Czech Republic', in I*DIMT-2019 Innovation and Transformation in a Digital World,* Interdisciplinary Information Management Talks, Kutná Hora: Em.o.Univ.-Prof. Dr. Gerhard Chroust, Johannes Kepler Universität, Linz, pp. 319–326. [Online], Available: https://idimt.org/wp-content/uploads/2019/08/IDIMT-2019-proceedings.pdf [21 Oct 2019].
Turner, S. (2020) Deprecating TLSv1.0 and TLSv1.1. draft-ietf-tls-oldversions-deprecate-06, p. 22. [Online], Available: https://datatracker.ietf.org/doc/draft-ietf-tls-oldversions-deprecate/ [20 Feb 2020].
W3Techs (2020) Usage statistics of HTTP/2 for websites. [Online], Available: https://w3techs.com/technologies/details/ce-http2 [20 Feb 2020]
Wetter, D. (2019) testssl.sh. [Online], Available: https://github.com/drwetter/testssl.sh [13 Apr 2019].

TEACHING ERP CONCEPTS FOR NON-USERS AND USERS: A SURVEY AMONG COLLEGE STUDENTS

[1]✉Miloš Ulman, [2]Marek Dvořák, [3]Eva Kánská, [3]Věra Motyčková

[1]Department of Information Technologies, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, ulman@pef.czu.cz

[2]Department of Management, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

[3]Department of Information Technologies, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

Teaching ERP curricula has become beneficial both for higher education institutions who want to keep pace with job market needs and businesses that have been shifting to full digitalization and require more highly skilled workers. The paper presents results of a survey among 96 business college students who took a course with two ERP modules. We delivered theoretical lectures about ERP basic concepts and offered students to elaborate on two independent case studies as their credit project. Through a questionnaire survey, we identified difficulties encountered during the work on practical tasks in SAP S/4 HANA system, measured usability of provided instruction materials and system UI, and efficiency of work. Teaching transactions on an ERP system should not be left to self-study due to challenging nature of ERP tasks and complex user interfaces.

Keywords

Curriculum, ERP, Fiori, SAP S/4 HANA, usability

Introduction

Enterprise Resource Planning (ERP), also known as Enterprise Information Systems (EIS), or Enterprise Systems (ES), has been around for almost four decades and has become an indispensable part of corporate IT infrastructure. ERP systems help to manage end-to-end business processes by integrating vital business functions for sales, procurement, manufacturing, storage and warehouse management, finance, human resources and others. Business and IT study programs follow the market needs and try to provide curricula with substantial portions of ERP elements such as business process management, information system architecture, design and lifecycle, and so forth. Yet, the reality in many colleges is that students rarely get real exposure in class to a major ERP system that is currently used by businesses, let alone hands-on training in using system transactions. SAP, Microsoft or Oracle are ERP vendor names that university graduates are familiar with, but many know their ERP systems only from theory and lack applied knowledge.

Schools and educators realize the importance of giving training in ERP concepts with a strong practical exercise component. However, they struggle with the complexity of these systems, which require relevant hardware equipment on a server, licenses for the installation of the end-user software and a database. Using a cloud version of an ERP is of course a feasible option, but getting the relevant data, creating a data model of a company and the relevant training materials require a much larger effort, which eventually turns away the majority of educators from this idea. Since it is difficult and expensive to develop and maintain a high-quality ERP curriculum together with a fully operational ERP system, universities turn to third parties such as SAP University Alliances, Microsoft Dynamics Academic Alliance, or Odoo. These programs are established

by ERP vendors who have a vested interest to make ERP skills a part of university curricula (Ruhi, 2016). An example of this provision is SAP University Competence Center (SAP UCC) that provides a preconfigured hosted SAP system with free licenses and valid data, and training materials meeting the current pedagogy standards. This works upon signing an agreement and service contract and payment of an annual service fee which guarantees that the institution will be provided with regular updates of materials and software from the SAP UCC.
The paper aims to contribute to understanding the impacts of using ERP as a method of instruction in classes for business college students. First, we provide a brief overview of practices in teaching ERP followed by usability aspects of interactions with an ERP system user interface. Second, we formulate more specific research questions and present used methods. In the Results section, a detailed evidence from an empirical study is provided and results are contrasted with literature. Finally, we summarize further findings and our contributions in the Conclusion section.

Overview of pedagogical practices in ERP

A thorough overview of pedagogical practices in ERP has been recently done by Ruhi (2016). The first approach to teaching enterprise systems curriculum is to teach it as a single course or to teach it in multiple courses. The single course is usually an option for business students who need to learn ERP concepts and applications. This is provided in courses such as Business Information Systems, Management Information Systems or Accounting Information Systems. A multi-course ERP curriculum might aim to rather provide a "big picture" or cross-functional view of business issues in organizations (Wang and Hwang, 2011).
In general, a single course approach is easier to deliver as it requires only one or two teachers with proper ERP training (Ruhi, 2016). In case of multiple-course delivery, topics can be distributed either horizontally, i.e. students work with ERP software in several courses during the semester, or vertically, i.e. the work with the system spans across two or more semesters (Hejazi, Halpin and Biggs, 2003). A specific instance of the latter approach is a capstone project that requires integration of knowledge and skills from previous courses. This would also require a closer curriculum integration in order to avoid teaching business management in silos (Nisula and Pekkola, 2018).
A solid body of literature exists on practices of teaching ERP classes. A recurring line of the literature is that there is a gap between training of work in ERP systems and students' understanding of the underlying processes (Ruhi and Ghatrenabi, 2015; Ruhi, 2016). While students can easily follow the instructions what to do, the step-by-step process of clickstreams and data entry in ERP applications do not support their understanding of what they do and why they do it. Therefore, it should be the lecturer who closes this gap (Kurbel, 2014).

Usability of ERP user interface

Besides the complexity of processes that enterprise systems handle, they are also notorious with usability issues that hinder users' training. Usability is defined as 'a subset of quality in use consisting of effectiveness, efficiency and satisfaction, for consistency with its established meaning' (ISO, 2011). Usability inspection methods allow collecting feedback from end users in order to identify problems that the users have when interacting with the user interface (Nielsen, 1994). EIS are very large-scale software applications that are sold with hundreds of pre-installed features but used by a number of users with different information needs (Akiki, Bandara and Yu, 2016). In a study among 98 EIS users, user interface (UI) design had major impact on users' performance and expected effort needed to accomplish tasks (Turetken, Ondracek and Ijsselsteijn, 2019).
Several researchers short-listed key ERP UI usability criteria as follows: navigation, presentation, task support, learnability and customization (Calisir and Calisir, 2004; Matthews, 2008). In addition to the usability criteria that can be evaluated by a questionnaire, it is necessary to collect

both more qualitative data about user's behavior with ERP UI (Scholtz, Cilliers and Calitz, 2010) but also quantitative data such as screen and activity recording to measure task efficiency and navigation issues (Akiki, Bandara and Yu, 2016).

Research questions

Further to the literature review and the focus of this study, we formulate the following research questions.

- RQ1: What factors affect *perceived difficulty of ERP case studies* by students?
- RQ2: What factors affect *perceived usability of instruction materials* by students?
- RQ3: What factors affect *perceived usability and efficiency of SAP Fiori UI* by students?

Materials and Methods

Participants

We have conducted the study with a sample of 256 students in a master's degree program of economics and management at a public university located in Prague, Czech Republic during the winter semester 2019/2020. The structure of the sample is described in Table 1. There were no statistically significant differences between groups according to the chi-square tests.

		Men	Women
Number		29	67
Proportion		30.2%	69.8%
Age group	20-24	65.5%	67.2%
	25-29	17.2%	17.9%
	30+	17.2%	14.9%
Type of study	Full-time	65.5%	62.7%
	Part-time	34.5%	37.3%
Work	None	10.3%	10.4%
	Part-time	51.7%	53.7%
	Full-time	37.9%	35.8%
ERP experience	None	37.9%	43.3%
	Up to 3 months	31.0%	25.4%
	More than 3 months	31.0%	31.3%

Table 1: Survey sample structure (N=96)

Procedure

The students were given an alternative option for getting a credit – to elaborate on two complex case studies in SAP S/4 HANA system. By giving students these hands-on tasks, we took ERP system as a method of instruction which is encouraged by several educators (Corbitt and Matthews, 2009; Wang and Hwang, 2011). The case studies consisted of a series of transactions that made up a complex process. The case study instructions were distributed to the students via Moodle. The prompt for each case study consisted of a one-page document describing the overall process and objective of the case study, a list of all the steps needed to complete the case study, and a detailed explanation of the steps needed to complete. The first case study consisted of 23 steps; the second case study had 16 steps; both studies suggested 140 minutes as the estimated time for completion. In addition, all the steps were illustrated with screen shots and highlighted text in order to differentiate the entry data from a menu item or control button names. The explanations of certain procedures or functions were highlighted with a grey box.

Students were given one lecture with explanations of SAP terminology used in both case studies. After that, they had to register in order to get an SAP account and case study materials. The first

case study covered the steps needed to complete the procurement process (Material Management, MM) in a manufacturing company, the second dealt with the production process (Production Planning, PP) in the same company. The time given for completion of both case studies was four weeks with the possibility to check the case study progress and resolve issues in person or via email on a weekly basis. The passing limit was 80% of steps completed correctly.

Measurements

After all case studies were submitted and checked, students were given a questionnaire in order to provide their personal feedback about working with SAP and the method of instruction. The dataset used for analysis consisted of 96 valid responses. We used five items to collect demographic data: gender, age, mode of study, work status, and length of ERP experience. We then asked Likert-type scale questions about perceived usability of two groups of ERP applications and two sets of instruction materials. The usability questions were adapted from ISO 25000 standard (ISO, 2011) and users rated the items on an ordinal scale from 1 (best) to 5 (worst). High summary scores are indicative of negative perception. The Cronbach Alpha across all items was.933 which indicates a good scale reliability.

For demographics items we structured the answers by gender and analyzed differences by performing a chi-square test. For the Likert items we could not use methods analyzing means (e.g. ANOVA, MANOVA) as they assume equal distance between response categories, and an underlying normal distribution (Dittrich et al., 2007). Therefore, we used the Kruskal-Wallis H-test complemented with the Mann-Whitney test to analyze the relationship between factors groups and perceived usability and efficiency of both the ERP system and instruction materials. For correlations, we applied Spearman rank criterion. Data were analyzed using the IBM SPSS.

Results

The results of the statistical analysis are summarized in Table 2 indicating which factors had significant impact on evaluation, and Table 3 that describes correlations between variables. Evaluation of the difficulty of both case studies and usability of instruction materials comprised the first part of the analysis. Students were asked to order both case studies by difficulty and then specify what issues they encountered. On average, the material management (MM) case study was perceived more difficult than the production planning (PP) case study. It should be noted that MM case study was longer by seven steps. The full-time students ranked the MM case study as more difficult (N=60, mean rank 38.05) than the part-time students (N=32, mean rank 62.34) with a moderate level of correlation. Also, the students who worked part-time (N=50, mean rank 35.27) viewed the MM study as more difficult than the full-time students (N=32, mean rank 51.23), but the correlation was small. Among specific difficulties experienced by the students were complicated menu options (36 cases), lack of training with the instructor (35), lack of UI clarity (29) and lack of freely accessible help (29). Almost a third of those who reported a difficulty were with none or up to three-month experience with ERP. They also were more critical about the usability of the provided instruction materials. However, half of the reported problems were given by the respondents who already worked between one to three months with a similar system. The instruction material for both case studies used same structure and resembled a textbook method of instruction with plenty of screenshots and visual aids to guide the student. In general, both instruction materials were evaluated with a quite positive average score and no significant difference in evaluation was caused by a single factor.

The second part of the analysis was focused on usability of the ERP user interface, which in our case was SAP Fiori. For each case study, students had to use a specific group of applications provided by the S/4 HANA system; these groups are indicated in the Table 2. As for the UI

usability, the group of MM apps was ranked slightly higher than the group of PP apps but with no statistical significance. Men viewed the MM apps as more usable (*N*=29, mean rank 47.76) than women (*N*=67, mean rank 48.82), but with a small correlation. The usability of the PP group of apps differed only between full-time students (*N*=61, mean rank 42.04) and part-time students (*N*=32, mean rank 56.45), but with a rather small correlation.

Finally, we measured efficiency of the UI according to the estimated case study completion time as students reported it. As expected, students with no prior ERP experience reported on average longer time needed for completion than those with a three-month or longer experience, but the differences were not significant for both case studies. Given the fact that the respondents answered with at least a three-week delay, the estimated time might be inaccurate. Since students had freedom to decide in which order they will complete the work, we could not counterbalance possible unfair effects of learning from the first case study (Preece, Sharp and Rogers, 2015). For the MM case study, which was deemed as more challenging and time consuming, the males reported significantly shorter completion time (*N*=29, mean rank 37.47) than the females (*N*=67, mean rank 53.28). Also, students aged 25-29 needed less time to complete the MM case study (*N*=17, mean rank 24.41) than those between 20-24 (*N*=64, mean ranks 45.41, 13.44) and 30+ (*N*=15, mean rank 19.97), but again with a small correlation. Further, the students who had more than three-month ERP experience completed the MM case study faster (*N*=30, mean rank 29.32) than those with no prior experience (*N*=40, mean rank 40.14). With regards to the complexity of work with an ERP system, this was expected.

	M	SD	Gender	Age group	Type of study	Work	ERP experience
Perceived difficulty – MM (*N*=94)	3.46	1.104	.635	.602	.948	.740	.352
Perceived difficulty – PP (*N*=92)	2.40	1.028	.171	.140	.000*	.007*	.141
Instruction material usability (*N*=96)	1.88	.668	.863	.082	.722	.913	.993
UI usability – MM (*N*=94)	2.69	.762	.025*	.217	.787	.961	.504
UI usability – PP (*N*=93)	2.35	.771	.923	.411	.014*	.175	.314
Efficiency – MM (*N*=96)	3.18	1.704	.007*	.002*	.059	.303	.058
Efficiency – PP (*N*=96)	2.64	1.466	.613	.244	.128	.351	.134

** sig. at 0.05*

Table 2: Factors affecting perceived usability and efficiency

	Gender	Age group	Type of study	Work	ERP experience
Perceived difficulty – MM (*N*=94)	0.049	-0.071	-0.007	-0.020	-0.077
Perceived difficulty – PP (*N*=92)	-0.143	0.190	.458**	.254*	0.123
Instruction material usability (*N*=96)	0.018	-0.180	-0.037	-0.040	-0.012
UI usability – MM (*N*=94)	.232*	-0.150	-0.028	-0.008	0.039
UI usability – PP (*N*=93)	0.010	0.015	.256*	0.113	0.082
Efficiency – MM (*N*=96)	.278**	-.249*	-0.193	-0.075	-.241*
Efficiency – PP (*N*=96)	-0.052	0.087	0.156	0.148	0.070

**sig. at 0.05, ** sig. at 0.001*

Table 3: Spearman's rank correlation coefficient

Discussion

Work with ERP systems is challenging even for experienced users, let alone beginners. According to the additional comments in the survey, students highly appreciated the relevancy of hands on training with a leading ERP for the job market. Some also perceived the amendment of the course curricula with the ERP modules as an extra added value to their skill set. On the flip side, several students objected to the experimental method of instructions when they were given only one

lecture, access to the system and case study instructions but had to complete the case studies on their own. This was the most prominent factor cited by the part-time students who worked during their studies. The self-study approach was as well criticized for its mechanical nature without deeper understanding of underlying processes, mismatch between illustrative pictures and text, or English language used in materials and UI.

Despite the overall good usability of study materials, we are aware that we used only one method of delivery. Using a lecture session and assigning tasks without hands-on training with the lecturer may be efficient for a part-time mode of study with limited time but does not conform to all learning styles. According to Ruhi's experiential learning pedagogical framework for enterprise systems (Ruhi, 2016) that is derived from Kolb's Experiential Learning Theory (Kolb, 1984), our experiment employed pedagogical practices of lectures with theoretical explanations and walkthrough assignments which allowed for doing and exploring. Ruhi (2016) also argues that the ERP class should complement lectures with seminars that enable interaction and collaboration which bring further positive learning outcomes, case discussions that support the development of critical thinking and problem-solving approaches. In addition, ERP vendors provide system demonstrations and screencast tutorials on their YouTube channels, but rarely in other languages than English. ERP simulation games are a highly popular method since they stimulate decision making and performing transactions on the systems at the same time (Léger et al., 2011).

In contrast, the usability of SAP Fiori UI in both groups of apps was rated rather negatively and the users also conveyed their dissatisfaction in comments regarding encountered difficulties. This highlights the missing element of hands-on training which proved to be essential not only for users with zero ERP experience but also for those who already work and have some practical knowledge of ERP.

Conclusion

The contributions of the paper are two-fold. First, we confirmed that adding a module with ERP curricula is highly beneficial for the students but requires a combination of methods of instructions and sufficient amount of time. Teaching transactions on an EIS system due to its complexity and user interfaces should not be left to self-study. This is also an important implication for managers who seek for optimization of time spent on training of employees who should work with EIS. Second, we were able to identify and analyze weak spots in the method of delivery and UI usability problems through the quantitative and qualitative approach. However, we cannot generalize our usability inspection results due to lack of empirical data such as from eye-tracking and screen activity capture.

Acknowledgement

This work was supported by the Internal Grant Agency of the Faculty of Economics and Management, Czech University of Life Sciences Prague under grant number 2019MEZ0002.

References

Akiki, P.A., Bandara, A.K. and Yu, Y. (2016) 'Engineering Adaptive Model-Driven User Interfaces', *IEEE Transactions on Software Engineering*, vol. 42, no. 12, pp. 1118–1147. http://dx.doi.org/10.1109/TSE.2016.2553035

Calisir, Fethi and Calisir, Ferah (2004) 'The relation of interface usability characteristics, perceived usefulness, and perceived ease of use to end-user satisfaction with enterprise resource planning (ERP) systems', *Computers in human behavior*, vol. 20, no. 4, pp. 505–515.

Corbitt, G. and Matthews, H.C. (2009) 'Teaching Hands-On Enterprise Systems', *AMCIS 2009 Proceedings*, p. 77.

Dittrich, R. *et al.* (2007) 'A paired comparison approach for the analysis of sets of Likert-scale responses', *Statistical Modelling*. London: Sage Publications Ltd., vol. 7, no. 1, pp. 3–28. http://dx.doi.org/10.1177/1471082X0600700102
Hejazi, S.S., Halpin, A.L. and Biggs, W.D. (2003) 'Using SAP ERP technology to integrate the undergraduate business curriculum', in *Developments in Business Simulation and Experiential Learning: Proceedings of the Annual ABSEL conference*, pp. 122–125.
ISO (2011) '25010: 2011 systems and software engineering–systems and software quality requirements and evaluation (square)–system and software quality models'. *International Organization for Standardization*, p. 34.
Kolb, D.A. (1984) 'The experiential learning theory of development', *Experiential Learning: Experience as the Source of Learning and Development,* pp. 132–160.
Kurbel, K.E. (2014) 'Reengineering the Teaching of SAP SCM–How to Make Students Understand What They are Clicking in Supply Network Planning', *Procedia Technology*, vol. 16, pp. 110–117. http://dx.doi.org/10.1016/j.protcy.2014.10.074
Léger, P.-M. *et al.* (2011) 'Business simulation training in information technology education: guidelines for new approaches in IT training', *Journal of Information Technology Education: Research*. Informing Science Institute, vol. 10, no. 1, pp. 39–53.
Matthews, D. (2008) 'Usability as an ERP selection criteria', *IFS White Paper, January*.
Nielsen, J. (1994) *Usability engineering*. Elsevier.
Nisula, K. and Pekkola, S. (2018) 'How to move away from the silos of business management education?', *Journal of Education for Business*. Routledge, vol. 93, no. 3, pp. 97–111. http://dx.doi.org/10.1080/08832323.2018.1425283
Preece, J., Sharp, H. and Rogers, Y. (2015) 'Experimental design', in *Interaction Design: Beyond Human-Computer Interaction*, p. 486.
Ruhi, U. (2016) 'An experiential learning pedagogical framework for enterprise systems education in business schools', *The International Journal of Management Education*, vol. 14, no. 2, pp. 198–211. https://doi.org/10.1016/j.ijme.2016.04.006
Ruhi, U. and Ghatrenabi, P. (2015) 'Experiential Learning Spaces for Enterprise Resource Planning Courses in Business Schools', In *2015 Fifth International Conference on e-Learning (econf)*, pp. 316–323. http://dx.doi.org/10.1109/ECONF.2015.30
Scholtz, B., Cilliers, C. and Calitz, A. (2010) 'Qualitative techniques for evaluating enterprise resource planning (ERP) user interfaces', In *Proceedings of the 2010 annual research conference of the South African Institute of Computer Scientists and Information Technologists*, pp. 284–293. http://dx.doi.org/10.1145/1899503.1899535
Turetken, O., Ondracek, J. and Ijsselsteijn, W. (2019) 'Influential characteristics of enterprise information system user interfaces', *Journal of Computer Information Systems*, vol. 59, no. 3, pp. 243–255. http://dx.doi.org/10.1080/08874417.2017.1339367
Wang, M. and Hwang, D. (2011) 'An Innovative Framework of Integrating ERP into IS 2010 Model Curriculum', *Communications of the IIMA*, vol. 11, no. 3, pp. 75–86.

STUDENT TYPOLOGY IN TERMS OF CAREER LEARNING NEEDS

[1]✉Jiří Votava, [2,3]Kamila Urban, [4]Jitka Jirsáková

[1]Department of Professional and Personal Development, Institute of Education and Communication, Czech University of Life Sciences Prague, Czech Republic, votava@ivp.czu.cz

[2]Department of Pedagogy, Institute of Education and Communication, Czech University of Life Sciences Prague, Czech Republic

[3]Institute for Research in Social Communication, Slovak Academy of Sciences, Slovakia

[4]Department of Professional and Personal Development, Institute of Education and Communication, Czech University of Life Sciences Prague, Czech Republic

Abstract

Career guidance and counseling have been gaining importance in the last ten years. Given the changes in the labor market and the context of the Fourth Industrial Revolution, the young person must be prepared for these changes. The research aimed, as a part of the broader and long-term scientific scope, to evaluate the situation of career counseling and learning from the perspective of secondary school students in the Czech upper secondary vocational schools (ISCED3). Specifically, the question was asked about what these pupils expect in terms of career learning and how schools, in reality, respond to this demand. A questionnaire survey ($N = 1126$) provided feedback on 21 topics relevant to vocational training and career management. Factor analysis identified four basic types of pupils in terms of their needs: Pragmatic, Personality-oriented, Seekers and Ambitious. The examples of strategies and methods suitable for working with identified categories of pupils are discussed.

Keywords

Vocational guidance and counseling, career learning, vocational education, student typology

Introduction

Vocational guidance and counseling

Career guidance and counseling has undergone many changes over more than a century. The methods, that were primarily based on comparing the personality characteristics of individuals with the work demands or a work position, were supplemented with procedures based on a constructivist and holistic approach. Among other things, this development can be documented in the change of terminology used from the concept guidance to the concept of counseling. Kaplan et al. (2014: 368) understands counseling as "*a professional relationship that empowers diverse individuals, families, and groups to accomplish mental health, wellness, education, and career goals*". Recent comprehensive publications define career guidance and counseling as "*activities associated with career choice over a life span. In the career counseling process, all aspects of individual needs (including family, work, personal concerns, and leisure) are recognized as integral parts of career decision making and planning*." (Zuker, 2016: 7)

According to the main goal of the study, the paper concentrates on the situation of career guidance and counseling in the field of vocational education, especially as it is integrated into the system of the Czech vocational schools. Preparation for the future work became a priority listed in many relevant positional and policy documents. OECD, European Commission or World Bank stressed that the main scope of vocational guidance and counseling is to provide "*services and*

activities intended to assist individuals, of any age and at any point throughout their lives, to make educational, training and occupational choices and to manage their careers. Such services may be found in schools, universities, and colleges, in training institutions, in public employment services, in the workplace, in the voluntary or community sector, and in the private sector." (OECD, 2004: 10) In the Czech Republic, career guidance and counseling belongs to the whole complex of life long learning and lifelong counseling. Vocational schools play an important role not only in initial education and training, but also in helping students to understand better their learning pathways, to establish connections between school experience and world of work, and to stimulate career decision making and career maturity. It is important that schools can respond to student needs, to distinguish among various situations and to select proper strategies for each concrete target group (ELGPN, 2015).

Role of vocational schools in career guidance and counseling

There are many research projects describing the situation, roles, functions and effects of career guidance and counselling in vocational schools (Hlaďo, Lazarová and Houšková, 2019; Jirsáková, Herout, 2017; Vintere, Balode, 2016). These institutions create visible part of the whole educational system as they in the Czech Republic drain almost 70 % of total student population at upper secondary level (OECD, 2019). This position should also affect provision of services that would ensure future life satisfaction, job security and career sustainable development.

Concerning the upper secondary school level in the Czech Republic, career guidance and counseling is organized in the three main stages. First, there are key competencies described in curricula, understood as outputs applicable in all teaching subjects. Secondly, national frame curricula define a transversal topic "Man and the world of the work". Each school has three different options on how to implement it. Very seldom it is taught as an independent subject usually labeled as career guidance. Sometimes schools prepare short-term project or project days. More frequently the content is spread among other teaching subjects (economics, languages, civic education). Finally, there is a level of guidance professional. At each vocational school there is at least one educator appointed to the position of the school advisor, or to a more specific position of the career advisor. Agenda of this staff consists of individual and group interventions, organization of school excursions or arranging presentation sessions about job market and future study options. Nevertheless according to our current research feedbacks, the overall penetration of career guidance and counseling among its target group (students) is not perfect (Jirsáková, Votava and Urban, in press). As in other countries (Draaisma, 2018), it appears that students have sufficient information about schools to continue their education, but it is not enough. According to Lodi et al (2019) students do not see real benefit of career guidance and counselling. Professionals in schools do not provide enough opportunities for acquiring career management skills, self-knowledge or applicable orientation in job opportunities. Despite the fact that most stakeholders agree on the importance of career guidance and counseling, there is still much improvement necessary.

Typology of career decision making

One way to increase the effectiveness of career guidance could be to approach the specific needs of the target group. Students have different expectations of career guidance concerning their stage of the decision-making process or personality traits. Development of occupational identity is so an important task of adolescence. From a psychological point of view, development of occupational identity is a part of psychosocial development in adolescence. According to Erik Erikson, the fifth stage of the development is characterized by a crisis between identity versus identity diffusion. Based on Erikson's theory, four identity statuses were identified: identity achievements, moratoriums, foreclosures and identity diffusions. The first group of adolescents

already achieved the commitments in the areas of occupation and ideology, the second group is in an exploratory period, third group did not explore the possibilities but adopted an identity from the identification with others, mostly parents, and the fourth group did not make the commitment and change the identity according to social groups in which they appear (Kroger, Marcia, 2011). In moratorium adolescents often diversify their interests, seek different directions and activities without being able to set their main priorities (Super, 1957).

Based on the theory of identity statuses, Skorikov and Vondracek (2011) proposed six occupational identity statuses. In their theory, two aspects are studied: if the occupational commitment is made or not and if occupational self-exploration is completed, active or limited. The occupational identity is constructed by social factors, education, leisure activities and person‘s abilities.

In contrast to this theory, Holland suggested that vocational (occupational) identity is stable and based on personality types and occupational preferences (Skorikov and Vondracek, 2011). Holland (1973, 1997) characterized six basic personality types: realistic, investigative, artistic, social, enterprising and conventional and six same types of work environment. According to this theory, individuals look for a work environment in which they can develop and apply their skills and abilities that correspond to their attitudes and values. Parsons (2008) believes that the success of career choices depends primarily on individual´s self-knowledge and the knowledge of the world of work. The assessment of two factors allows the individual to find the agreement between them.

Based on the theories mentioned above the main preoccupations in this acrticle will be to explore if there are any significant subgroups or types of vocational school students divided according to their preferences or learning needs. The authors presuppose that respondents differ on the level of their occupational commitment and occupational self-exploration completion (Skorikov and Vondracek, 2011). Some differences could also be expected according to Ginsberg´s division to three developmental strategies (Ginsberg et al, 1957 and Ginsberg, 1979). Vocational school students should achieve the third level (exploration, crystallization, and specification) and most of them probably did. Contrary to the theory, some of them could still stay in the uncertainty about their career path. We hope that a better understanding of the current typology of students´ needs and the situation could also help in finding better and functional guidance techniques.

Materials and Methods

The research underlying this article covers a three-year period in which our team monitors the situation of career guidance and counseling in secondary vocational schools. The overall research concept works with a mixed methodology. The outputs in this publication are the result of processing the quantitative part of the data. A questionnaire was created, after its piloting in March 2019, followed by two waves of data collection using the pencil paper method (April to June 2019 and September to November 2019). The distribution covered a total of 10 regions of the Czech Republic, including three-year study programs with apprenticeship certificates and four-year graduation courses. For logistic reasons, the selection of regions did not cover the most eastern part of the country where data collection will continue during the next stage of research. A total of 1126 high school pupils from vocational education (467 men and 659 women) aged 15 to 23 (*mean* age = 18.1; *SD* = 1.2) participated in the research. The overall previous experience with vocational guidance during school attendance was among respondents not high – only 17% of these students reported that they knew which teacher is appointed as a career counselor, 15% of them have noticed the term career guidance and only 11% of them has experienced an individual counseling session.

The questionnaire consists of a total of 23 items, which we asked about, among other things, the experiences of pupils with career guidance, the representation of career guidance in school

education and the assessment of students' needs in the field of career guidance. Given the above research questions, we were interested in what pupils considered important and in what areas they would like to develop further. Question number 13 offered a total of 21 items on a Likert-type scale, ranging from 1 ("I need to improve or to learn more from this area.") to 6 ("I don't need to improve or to learn anything from this area."). Example of question: "*Do you need to improve your CV writing?*" or "*Do you need to find out which field of following education would be right for you?*" The list of items for evaluation was based on two sources. Firstly, we started with valid teaching documents, ie assuming what pupils should learn in schools. Secondly, items have also been included in the list on the basis of a theoretical balance sheet, taking into account the knowledge and skills that are mentioned in the literature as an important part of preparing for the profession of managing one's own career.

First, an initial descriptive data analysis was performed. All the analyses were conducted in IBM SPSS 26. It revealed which items the students considered important in terms of the need to learn and prepare for their careers. As the individual items showed a sufficient correlation, factor analysis was carried out to reduce the number of variables and create more general factors. The advantage of creating a new typology may be its use in counseling practice. Counselors and teachers will be able to choose appropriate methods and strategies for working with pupils based on the types described.

A principal Axis Factoring using varimax rotations was used to identify types of pupils. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = .87. Bartlett's test of sphericity χ^2 (171) = 7106.44, p <.001. Initial eigen values indicated that the first four factors explained 33%, 8.7%, 7.9% and 6.3% of the variance respectively, fifth factor had eigen value .98 and explained additional 5% of the variance. The four factor solution explained 56% of the variance and was preferred to five factor solution because the fifth factor did not reach eigen value 1. A total of 2 items were not used because they did not contribute to a simple factor structure. The Remaining 19 items had acceptable internal consistency. Table 1 shows the factor loadings after rotation.

Results

The factor analysis results in four basic types of students: Pragmatic, Personality-oriented, Seeker and Ambitious. Each type was described first by using the items that achieved the highest factor load, then a brief description was created for each category. Finally, more general characteristics related to the student's position in the process of managing their career were added, namely the position of certainty - uncertainty and decided - undecided.

Pragmatic (F1, unconfident and decided students). Factor *Pragmatic type* was comprised of 10 items reported on a 6-point Likert scale and explained 33% of the variance with factor loadings from .313 to .584. These students are interested in the specific situation in the labor market, they need to gain knowledge about employees' rights and what to do in case of unemployment. They are confident about their educational trajectory and the choice of future career. The process of career decision making is no longer so important, but the transition from school to the labor market.

Personality-oriented (F2, unconfident and undecided students). Factor *Personality-oriented type* consisted of 6 items and explained 8.7% of the variance with factor loadings from .354 to .697. They need to strengthen their learning and study skills, cope with stressful situations, deepen self-knowledge and find motivations to study current school, rather than choosing a particular direction for further education or employment. They do not perceive the training of situations leading to success in seeking employment (for example, job interview training) a priority. They are looking for security and anchoring at home, do not plan to study or work abroad.

Seeker (F3, confident but undecided students). Factor *Seeker* was composed of 6 items, explained 7.9%

of the variance with factor loadings from .328 to .805. Although they study a vocational school, they are not entirely sure of their choice and future direction. From school education, they expect help in thinking about future learning and work trajectories. For these students, orientation and guidance are important, such as how to find job offers or what are the requirements of potential employers. Indecision is also reflected in the need to clarify their ideas about life and how to get motivated to learn. Overall they are more confident about themselves, but they feel the need to find meaning (what are my ideas about life, knowing the strengths and weaknesses). However, unlike the personality-oriented type, they do not favor the development of soft skills (stress management, learning skills, job interview).

Ambitious (F4, confident and decided students). Factor *Ambitious* was comprised of 2 items and explained 6.3% of the variance with factor loadings .771 and .820. Students in this category may be described as ambitious. They are clear about their future, in which they do not exclude the possibility of studying or working abroad. They perceive an important priority in learning the knowledge and skills needed to start a business. Concerning future education, they are interested in opportunities for further education and deepening their competences. They do not prefer the development of soft skills (preparation of presentations, public performance).

Item	F1	F2	F3	F4
Q2 Writing a CV	.52			
Q3 Preparation for a job interview	.58			
Q5 Knowing your strengths and weaknesses		.35		
Q6 Choice of further education (where to go to school)			.74	
Q7 Finding which field of further education is suitable for me			.81	
Q8 How to find a job in the field I am studying	.51		.46	
Q9 Requirements of employers in the field I study	.55		.40	
Q10 Searching for job offers via the Internet	.43		.33	
Q13 What to do in case of unemployment	.55			
Q14 What are my plans for life		.40	.33	
Q15 How to start a business	.40			
Q16 What to do if I am tired of my current study direction		.50		
Q17 What can I do if I can t handle the lessons?		.70		
Q18 How to learn effectively		.68		
Q19 How to manage stress		.52		
Q20 Which are my rights and duties as employees	.64			
Q21 Information on the labor market situation	.60			
Q11 Possibilities of working abroad	.31			.77
Q12 Possibilities of education abroad				.82

Table 1: Rotated Factor Loadings, 2019-2020 (source: own calculation)

Discussion

The aim of the paper was to identify students‘ specific needs for career learning and future career preparation. Based on the factor analysis four basic types of students were determined concerning their preferences in the field of career counseling.

The four identified types correspond to occupational identity statuses. Only one type - *Pragmatic* - already made an occupational commitment (Skorikov and Vondracek, 2011). Those adolescents have fully developed their occupational identity (Kroger and Marcia, 2011) and can be prepared for work requirements. Other three groups of students have not made the occupational commitment yet. We assume that the identified categories are not final and other three groups of students will acheive their career identity later in their development. *Seekers* are in moratorium phase (Kroger and Marcia, 2011). They explore the possibilities and their occupational identity is not established yet. *Ambitious* do not

need to seek different options, their self-exploration is completed (Skorikov and Vondracek, 2011). They are in specification stage (Ginzberg et al. 1957) where they search for the educational experiences needed for their career path. *Personality-oriented* students do not look for the knowledge of the world of work because their primary orientation is on individual´s self-knowledge. Their career choices will be based on the knowledge of their skills (Parsons, 2008).

In the context of career education, the needs of all identified types of pupils should be taken into account. Teachers must, therefore, include different types of activities in the instruction to meet the needs of all types of pupils. Examples of connections between type categories and educational measures are indicated in the following section.

So how could schools respond to the above categories of students in the vocational education curriculum to meet all four types? First of all, individual forms of school counseling need to be strengthened. In the whole sample of respondents only 11% of students had experience with individual counseling. However, given the capacity of the school guidance system, it cannot be assumed that it will completely replace the group or frontal work. We hope that also in the group counseling it could be proceeded in such a way that the needs of all 4 types are met. Here are concrete examples of the four-year curriculum.

In the first year, it is advisable to include activities for students‘ self-knowledge, identification of their strengths and weaknesses, what motivates them to perform. It is also possible to concentrate on learning styles and practical stress management techniques (relevant for *Personality-orented*). From the first year onwards, students should also start to maintain their personal portfolios containing evidence of their knowledge, experience, skills, including interests, values or volunteering (relevant for *Seekers*). As a result, they will be able to better argue and show what they are unique in and what they can present during a job interview. At the same time, there should be a meeting with graduates in the given field every year to allow students to meet the real career paths of former students (relevant for *Pragmatic* and *Ambitious*).

Since the second year, it is good to start excursions to selected companies and institutions so that students have the opportunity to get to know various possibilities of their employment in the labor market, including possible passages into related occupations (important especial for *Pragmatic* and *Ambitious*). It could also be beneficial to attend work fairs and presentations of universities, which can help students to get an overview of their work and study opportunities (relevant for *Pragmatic* and *Ambitious*). However, it should not be a one-off event, but always a complex of activities. Before the excursion and the fairs, it is necessary to speak with students in the class, assign them tasks, what to monitor, what to ask and after the event again with the pupils to reflect what interested them, surprised what they learned new (important for *Personality-oriented* and *Seekers*). Counseling in this way could provide enough time for the target group to decide about the future.

In the third year it would be appropriate to include preparation and training for a job interview, how to address and find a potential employer, familiarize with labor-law issues, visit the employment office, continue excursions with potential employers and visits to labor and university fairs. Focusing more on the demands of employers and the labor market in general, so that pupils are prepared for the reality that will be awaiting them in the labor market. Emphasize also the possibilities of internships, trainee programs and junior positions for graduates. And last but not least, include topics on how to start a business, business conditions and opportunities in the field of study, linking pupils with entrepreneurs who will be willing to share their business experience (relevant for all types).

In the fourth year, it is good to focus on improving the students‘ personal brand through social networks, especially LinkedIn, to continue their previous activities in the labor market and employers‘ knowledge, or possibly to create a business incubator for pupils (relevant for all types).

Conclusion

The results of the questionnaire survey among students of selected secondary vocational schools were created 4 types - Pragmatic (decided, but unconfident students), Personality-oriented (unconfident and undecided students), Seekers (confident but undecided students) and Ambitious (confident and decided students). Individual types are related to the way pupils manage their careers. Therefore, schools must offer different types of activities to meet the needs of all types. Based on the results of the questionnaire survey the four types could help to find appropriate teaching and counseling activities.

1. *Pragmatic* (unconfident and decided students). It could be recommended to focus on following topics: job search and job contracting (labor law, contracting, how to start own business, how to prepare structured CV, cover letter or how to improve communication skills), labor market situation (how to monitor work supply and demand, where to obtain up-to-date information), what to do in case of job loss, prevention of burn-out syndrome.
2. *Personality-oriented* (unconfident and undecided students). It could be recommended to focus on the following topics: self-knowledge, identification of strengths and opportunities, development of intrapersonal and interpersonal skills, personal portfolio processing, identification of learning styles, work with stress. It could be also suggested to offer individual counseling and other methods of personal-social development (coaching, mentoring) to overcome insecurity and support occupational exploration and crystallization.
3. *Seekers* (confident but undecided students). This type is characterized by higher self-confidence. It could be useful to focus on the following topics: information about occupations, exploration of the labor market, a reflection of own skills and interests, information about tertiary and further education.
4. *Ambitious* (confident and decided students). It could be recommended to focus on the following topics: how to begin my career, use of start-ups, improvement of communication skills, presentation of companies, national and international mobilities and internships.

With regard to the current state of knowledge the research is about to continue in three main directions. First of all, the team will continue in further data collection to learn more about the current state of career learning and counseling in VET secondary schools. Second, the suggested typology will be validated. Third, in the future, it would also be worth paying attention to how research outputs could improve school practice.

Acknowledgement

This article was supported by the Technology Agency of the Czech Republic, the ÉTA program under the grant: Design and Implementation of the Concept and Methodology of Career Learning in Vocational Education (TL02000256).

References

Draaisma, A., Meijers, F. and Kuijpers, M. (2018) 'The development of strong career learning environments: the project 'Career Orientation and Guidance' in Dutch vocational education', *Journal of Vocational Education & Training*, vol. 70, no. 1, pp. 27-46. https://doi.org/10.1080/13636820.2017.1392995

ELGPN (2015) *Guidelines for Policies and Systems Development for Lifelong Guidance. A Reference Framework for the EU and for the Commission*, Jyväskylä: The European Lifelong Guidance Policy Network, [Online], Available: http://www.elgpn.eu/publications/browse-by-language/english/elgpn-tools-no-6-guidelines-for-policies-and-systems-development-for-lifelong-guidance/

Ginzberg, E., Ginsburg, S.W. and Axelrad, S. (1951) *Occupational Choice: An Approach to a General Theory*. New York: Columbia University Press.

Ginzberg, E. (1979) 'Toward a theory of Occupational Choice: A Restatement', In Weinrach, S.G. *Career Counseling: Theoretical and Practical Perspectives,* New York: McGraw-Hill.
Hlaďo, P., Lazarová, B. and Hloušková, L. (2019) 'Career adaptability of vocational education and training graduates in the period of prospective school-to-work transition', *Studia Paedagogica,* vol. 24, no. 2, pp. 59-83. https://doi.org/10.5817/SP2019-2-3
Holland, J.L. (1973) *Making Vocational Choices: A Theory of Careers.* Englewood Cliffs, NJ: Prentice-Hall.
Holland, J.L. (1997) *Making Vocational Choices: A Theory of Vocational Personalities and Work Environments*. Odessa, FL: Psychological Assessment Resources.
Jirsáková, J., Votava, J. and Urban, K. (2020, in press) 'Experience and awareness of upper secondary school students with career counseling in Czech Republic', in *Rural Environment, Education, Personality (REEP),* Proceedings of the International Scientific Conference, Jelgava, Latvia, Latvia University of Agriculture, Institute of Education and Home Economics.
Jirsáková, J. and Herout, L. (2017) 'Career Guidance at Vocational Schools in Czech Republic', *EDULEARN17 Proceedings: 9th International Conference on Education and New Learning Technologies,* Barcelona: IATED Academy, pp. 6014-6022. https://doi.org/10.13140/RG.2.1.1513.3680
Kaplan, D.M., Tarvydas, V.M. and Gladding, S.T. (2014) '20/20: A Vision for the Future of Counseling: The New Consensus Definition of Counseling', *Journal of Counseling & Development*, vol. 92, no. 3, pp. 366-372. https://doi.org/10.1002/j.1556-6676.2014.00164.x
Kroger, J., Marcia, J.E. (2011). 'The identity statuses: Origins, meanings, and interpretations', in *Handbook of Identity Theory and Research,* New York: Springer-Verlag, pp. 31-53. https://doi.org/10.1007/978-1-4419-7988-9_2
Lodi, E., Boerchi, D. and Magnano, P. (2019) 'High-School Satisfaction Scale (H-Sat Scale): Evaluation of Contextual Satisfaction in Relation to High-School Students' Life Satisfaction', *Bahavioral Sciences*, vol. 9, no. 125, pp. 1-17. https://doi.org/10.3390/bs9120125
OECD (2004) *Career guidance: a handbook for policy makers*, Brussels: OECD and European Commission, [Online], Available: https://www.oecd.org/education/innovation-education/34060761.pdf
OECD (2019) *Education at a Glance 2019: OECD Indicators*, OECD Publishing, Paris. https://doi.org/10.1787/f8d7880d-en
Parsons, F. (2008) *Choosing a Vocation*, Boston: Brousson Press.
Skorikov V.B. and Vondracek F.W. (2011) 'Occupational Identity', in Schwartz S., Luyckx K., Vignoles V. (eds) *Handbook of Identity Theory and Research*, New York: Springer-Verlag, pp. 693-714. https://doi.org/10.1007/978-1-4419-7988-9_29
Super, D.E. (1957) *The Psychology of Careers: An Introduction to Vocational Development*. New York: Harper & Row.
The European Lifelong Guidance Policy Network, ELGPN (2015) *Guidelines for Policies and Systems Development for Lifelong Guidance: A REFERENCE FRAMEWORK FOR THE EU AND FOR THE COMMISSION*, [Online], Available: http://www.elgpn.eu/publications/browse-by-language/english/elgpn-tools-no-6-guidelines-for-policies-and-systems-development-for-lifelong-guidance/
Vintere, A., Balode, I. (2016) 'Comparative Analysis of the Career Guidance Needs in the Baltic Countries', in *Rural Environment, Education, Personality (REEP),* Proceedings of the International Scientific Conference, Jelgava, Latvia, Latvia University of Agriculture, Institute of Education and Home Economics, [Online], Available: https://llufb.llu.lv/conference/REEP/2016/Latvia-Univ-Agricult-REEP-2016proceed2255-808X.pdf
Zunker, V.G. (2016) *Career counseling: a holistic approach.* Boston MA: Cengage Learning.

TEACHING STAFF RECRUITMENT IN PRE-UNIVERSITY EDUCATION: CASE OF ALBANIA

[1]✉Orhan Zaganjori, [2]Vladimír Krepl, [2]Mansoor Maitah

[1]Department of Economics, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic, zaganjori@pef.czu.cz

[2]Department of Economics, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

Abstract

Recruiting quality teachers is significantly important because high-quality teachers are considered to be paramount for students' success. However, particularly in developing countries recruiting and selection processes are often deemed to be biased and not sufficiently transparent. As such, this article seeks to address transparency and fairness issues. For this purpose, a sample of 5 prospective teachers and 4 criteria were analyzed by using the fuzzy TOPSIS technique for order preference by similarity to ideal solutions which is a method widely applied to deal with problems in multi-criteria decision making. In addition, results, as well as recruitment criteria and their importance weights, are discussed.

Keywords

Education, efficiency, teaching staff, TOPSIS, recruitment

Introduction

Education is important at the individual, local, and national levels (Johnes, Portela, and Thanassoulis, 2017) and it is a process based on knowledge transfer from educators to their learners (Horakova et al., 2019). Haskova and Lukacova (2017) considered an educator as the core element within teaching or learning processes, having among other factors a decisive impact on teaching and learing quality. However, measuring teaching and learning progress or educational quality is long questioned, not only among academics but also among policymakers and practitioners. Mortimore (1991) argued that such a question is closely bound up with more fundamental questions about the nature of education itself. Harvey and Green (1993) examined the nature of the quality of education. They added that quality is relative and carries different meanings to different people. Based on their examinations, quality can be viewed as exception, as perfection, as fitness for purpose, as value for money and as transformative. Schindler et al. (2015) suggested four groups of stakeholders that must be considered when defining the quality of education: providers (e.g., taxpayers, funding bodies); users of products (e.g., pupils, students); users of outputs (e.g., employers); and employees (e.g., teachers, academics, administrators). Thus, the definition of the quality of education depends greatly on the perspective. Considering the wide variety of interpretations and multidimensional nature of the quality concept, authors of this article refer to quality definition as the capability of preparing students to perform well on standardized tests (Hanushek and Woessmann, 2008) and on the labor market (Flegl, Jimenez-Bandala, and Andrade Rosas, 2019). In addition, the authors regard teachers to be an indispensable first step in preparing students assuming that effective teachers and teaching are crucial factors contributing to student achievement.

Gore et al. (2017) described two distinctive approaches in addressing concerns regarding the quality of teaching. One approach attempts to improve quality by allowing entry into teaching to

only “the best and the brightest”. This approach rests on the premise that the quality of teaching is a function of the quality of the teacher. According to Gore et al. (2017), the second approach seeks to improve the quality of teaching by using robust measures of quality to remove the worst teacher and learn from the best. This study is based on the first approach that the quality of teaching is a function of the quality of the teacher and restricted entry into the teaching profession is an alternative way of hiring “the best and the brightest”. In other words, the study is focused on the recruitment and selection process of prospective teachers.

Especially in developing countries, transparency during the recruitment process and unbiased decision-making remain a sensitive and long-discussed issue. This article aims to address the transparency issue in decision-making by using the fuzzy TOPSIS method for teaching staff selection. The recruitment process in the pre-university education system in Albania was chosen for the purpose of this study.

The structure of pre-university education in Albania is given in Table 1:

Level	Stage	Character	Age (Years)	Length (Years)
Secondary Education	Upper Secondary Education / Vocational and Oriented Schools	Non-compulsory	15-18 / 15-19	3 / 2-4
	Lower Secondary Education	Compulsory	12-15	3
Primary Education	Primary Education	Compulsory	6-12	6
Pre-School Education	Kindergarten	Non-compulsory	3-5	3
	Creche	Non-compulsory	0-2	2

Table 1: Structure of Pre-University Education System in Albania (source: Authors’ own research based on data from MESY, 2013)

The pre-university education system is divided into pre-school education (creche and kindergarten), primary education, and secondary education (lower and upper). In Albania, pre-school education and upper secondary education are non-compulsory, while primary and lower secondary education is of compulsory character. Compulsory schooling lasts for 9 years, until around age 15. The earliest school starting age is 6 and the latest is 7 years old. Generally, in pre-school and primary education all subjects are taught by one teacher. However, exceptions may be applied (e.g., minority ethnic groups, children with special needs, etc.). Later in secondary education, the subject teacher system is used. Vocational and oriented schools vary in length from 2 to 4 years and are non-compulsory.

Materials and Methods

TOPSIS methodology

TOPSIS multi-criteria decision method is used for the purpose of this study. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was originally proposed by Hwang and Yoon (1981) and developed by several academics and researchers (Chen, 2000; Park et al., 2011). TOPSIS is a mathematical method applied in the literature for the selection of the best options from all feasible alternatives through distance measures. Most of the decision-making problems arise when qualitative and quantitative attributes are assessed using human judgment and inaccurate data (Li and Yang, 2004). TOPSIS to the fuzzy environment method proposed by Chen (2000) is applied in this paper. Fuzzy TOPSIS is applied because the authors consider the teaching staff evaluation and selection process in this study as a decision-making process mainly based on qualitative data more than quantitative. In comparison with general TOPSIS, a fuzzy logic approach is commonly more suitable when analyzing qualitative information during the assessment process. Nevertheless, both methods provide comparable results. A multi-criteria decision making (MCDM) problem is given in the matrix expressed as follows:

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} W_1 & W_2 & \cdots & W_n \\ C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array} \quad (1)$$

Where D refers to the decision-maker, { A_1, A_2, …, A_m } are alternatives among decision-makers choose, { C_1, C_2, …, C_n } are criteria which measure alternatives, and X_{mn} is the evaluation of alternative A_m with respect to criterion C_n. While, { W_1, W_2, …, W_n } represents the weight of criterion C_n assessed by decision-makers.

Linguistic scale and triangular fuzzy numbers are used to evaluate alternatives with respect to qualitative attributes. Triangular fuzzy numbers are used to express the vagueness and the uncertainty of information, and to represent fuzzy terms in information processing (Zhang, Ma, and Chen, 2014). In other words, linguistic scales employing triangular fuzzy numbers are used in order to capture the linguistic terms expressed by decision-makers. Linguistic variables for evaluation are shown in the Table 2:

Linguistic Terms	Very High (VH)	High (H)	Medium (M)	Low (L)	Very Low (VL)
Fuzzy Number	(8, 10, 10)	(6, 8, 10)	(3, 5, 7)	(0, 2, 4)	(0, 0, 2)

Table 2: Linguistic Scale for Evaluation (source: Chen, 2000)

Formulas used for calculating the importance of the criteria and alternative evaluation with respect to each criterion are:

$$\tilde{X}_{ij} = \frac{1}{K}\left[\tilde{x}_{ij}^{1}(+)\tilde{x}_{ij}^{2}(+)gs\cdots(+)\tilde{x}_{ij}^{K}\right] \quad (2)$$

$$\tilde{W}_{j} = \frac{1}{K}\left[\tilde{w}_{j}^{1}(+)\tilde{w}_{j}^{2}(+)\cdots(+)\tilde{w}_{j}^{K}\right] \quad (3)$$

Where K represents decision maker. Also, normalized fuzzy decision matrix (1) can be expressed as $\tilde{R} = \left[\tilde{r}_{ij}\right]_{mxn}$ (4), where B and C represent benefit and cost criteria as follows $\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right)$, $j \in B$ and $\tilde{r}_{ij} = \left(\frac{a_j^-}{a_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{c_{ij}}\right)$, $j \in C$ where $c_j^* = \max c_{ij}$ if $j \in B$, and $a_j^- = \min a_{ij}$ if $j \in C$.

Taking into consideration the different importance of each criterion, Chen (2000) constructed the weighted fuzzy decision matrix as $\tilde{V} = \left[\tilde{v}_{ij}\right]_{mxn}$ (5), i= 1, 2, …, m, j = 1, 2, …,n where $\tilde{v}_{ij} = \tilde{r}_{ij} x \tilde{w}_j$.

Also, variables $\tilde{v}_{ij}$, $\forall i, j$ are normalized positive triangular fuzzy numbers ranging between 0 and 1. So, fuzzy ideal solution (A^*) and fuzzy inferior solution (A^-) can be expressed as $A^* = \left(\tilde{v}_1^*, \tilde{v}_2^*, \cdots, \tilde{v}_n^*\right)$ and $A^- = \left(\tilde{v}_1^-, \tilde{v}_2^-, \cdots, \tilde{v}_n^-\right)$ where $\tilde{v}_1^*$ =(1, 1, 1) and A^- = (0, 0, 0), j = 1, 2, …,n.

Distances from ideal solution (D^*) and inferior solution (D^-) are calculated based on the formulas:

$$D_i^* = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right), i = 1,2,\ldots,m. \quad (4)$$

$$D_i^- = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right), i = 1,2,\ldots,m. \quad (5)$$

Where d (.,.) shows the distance between fuzzy numbers. The closeness coefficient (CC) determines the ranking order of alternatives. Values closest to 1 are the closest to ideal solution A^* and values closest to 0 are the closest to inferior solution A^-. Using the formula below we can rank alternatives from the best to the worst:

$$CC_i = \frac{D_i^-}{D_i^* + D_i^-}, i = 1,2,\ldots,m. \quad (6)$$

Teaching staff recruitment process

The teaching staff recruitment process is divided into two phases (MESY, 2019). Phase one includes the online application, document authenticity verification, and candidate evaluation. Phase two consists only of computerized testing. Firstly, all candidates must submit online the application together with supporting documentation via "Teacher for Albania" portal. After online application, the authenticity of submitted documents is verified by the regional directorate selected in the application form by the candidate. Only after successful document authenticity verification, the candidate is considered for evaluation. The evaluation is conducted through in-person interviews carried out by the File Evaluation Commission composed of 5 commissioners responsible for screening and assessing candidates. A minimum threshold of 50% of points from the evaluation is required in order to pass to the next phase, computerized testing. Computerized testing is a standardized and centrally administered test. The final score is the arithmetic mean of points from evaluation and computerized testing. In the end, candidates are ranked in descending order based on their total score and then selected for the job position. For this purpose, a sample of 5 candidates is selected for this study. All of the candidates are applicants for teaching positions in the lower secondary education stage, for the academic year 2019-2020, in the regional directorate of Lezhe at the local education office of Shkoder district.

Results

A set of 4 criteria are used in the paper. Criteria are shown in Table 3:

Abbreviation for Criteria	C_1	C_2	C_3	C_4
Criteria	Grade Point Average of Higher Studies	Professional Qualifications and Licensing	Foreign Language Proficiency	Training Certificates

Table 3: Criteria (source: Decision No. 13 Date 22.05.2019 / 5426, MESY (2019))

The General Directorate of Pre-University Education in Albania consists of four regional directorates namely Lezhe, Korce, Fier and Durres (MESY, 2019). Each regional directorate has File Evaluation Commission. The commission is composed of 5 commissioners who are responsible for the evaluation process. Decisions are taken based on the one-member-one-vote (OMOV) method. Therefore, a set of 5 decision-makers is applied with all equal in importance

weight to 0.20. There are two additional decision-makers in case of an application from teachers whose employment terminated due to lack of teaching load. Nevertheless, the study analyzes only first-time applicants. Thus, 5 decision-makers model is applied.
Table 4 shows criteria importance weight matrix considering linguistic terms and triangular fuzzy numbers:

Criteria	Decision Makers					Weight	Rank
	D_1	D_2	D_3	D_4	D_5		
C_1	VH	VH	H	VH	VH	(7.6, 9.6, 10)	1
C_2	VH	VH	H	VH	H	(7.2, 9.2, 10)	2
C_3	H	H	H	VH	M	(5.8, 7.8, 9.4)	3
C_4	M	H	M	VH	M	(4.6, 6.6, 8.2)	4

Table 4: Criteria Importance Weight Matrix (source: Decision-makers' evaluation and authors' calculations)

After alternatives evaluation by decision-makers and considering formulas presented in this study, the fuzzy decision matrix, normalized decision matrix, weighted normalized fuzzy decision matrix and distance to the fuzzy ideal and inferior solution for each alternative are calculated. Closeness coefficient results are calculated considering formula (**8**) and presented in Table 5:

	CC_i	Percent Grade	Rank
A_1	0.2625	26.25%	5
A_2	0.3440	34.40%	4
A_3	0.6103	61.03%	2
A_4	0.6803	68.03%	1
A_5	0.4817	48.17%	3

Table 5: Closeness Coefficient (source: Authors' calculations)

The results from Table 5 show the final ranking order of alternatives, each of them representing candidates. According to the closeness coefficient results, the five candidates are ranked in the following order $A_4 > A_3 > A_5 > A_2 > A_1$ (68.03% > 61.03% > 48.17% > 34.40% > 26.25%). The results indicate that the narrowest difference is between the fourth and third candidates by 7%. Moreover, there is a significant difference between candidate A_4 ranked as the first and A_1 ranked as the least preference by 42 %. In addition, the findings suggest that only two out of five candidates, respectively A_4 (68.03%) and A_3 (61.03%), have passed the minimum threshold of 50% in order to qualify for the next phase computerized testing. Nonetheless, it is relevant to highlight that none of both candidates received more than satisfactory levels according to the European Credit Transfer System (European Commission, 2020). Referring to ECTS definition for the satisfactory level, both candidates are fairly educated and trained but with significant shortcomings.

Discussion

Fejfarova and Fejfar (2018) considered employee training and development as one of the most crucial human resource activities, especially in organizations aiming at further adopting new trends and succeed in the market. The same principles apply even in the education system. Teacher professional development is suggested in order to address such shortcomings and improve teaching quality. Darling-Hammond, Hyler, and Gardner (2017) defined effective professional development as structured professional learning resulting in changes in teacher practices and improvements in student learning outcomes. On the other hand, Mizell (2010) added that professional development occurs even in informal context pointing out some examples

such as independent reading and research, discussions among colleagues, observations of a colleague's work, and learning from a peer. Nevertheless, there are discussions among academics and practitioners about the effectiveness of teachers' professional development with respect to teaching practices. Several scholars have reported a non-significant or weak relationship between teachers' professional development and a higher standard of teaching (Garet et al., 2008; Powell et al., 2010; Garet et al., 2011; Gore et al., 2017).

Regarding teaching staff recruitment criteria, Mikitovics and Crehan (2002), as well as Casey and Childs (2007), observed that the GPA has been the most widely used criterion when assessing prospective teachers. Imose and Barber (2015) added that the GPA criterion will remain an attractive instrument in the hiring decision-making process. Similarly in this study, the results indicate that the grade point average of higher studies is of utmost importance for candidates applying for a teaching staff position in public pre-university schools (7.6, 9.6, 10). Casey and Childs (2011) argumented that GPA is generally seen as indicative of the ability to succeed in an educational setting. Nevertheless, Moran (2008) highlighted the necessity for a more innovative and inclusive selection process rather than just criteria based on prior academic qualifications. Moran (2008) noted that a more innovative and comprehensive selection process is more effective in meeting the needs of increasingly diverse learners. In addition, the findings show that the second most influencing factor is the professional qualification and licensing (7.2, 9.2, 10). The difference in importance of weight between the first and second criterion is minimal. Foreign language proficiency is the third criterion (5.8, 7.8, 9.4) and training certificates of later importance (4.6, 6.6, 8.2). Although, the research results should be viewed in light of some limitations. Criteria stipulated by the government, decision-makers, their assessments as well as the candidates may change over time. Furthermore, in order to gain a deeper insight into the recruitment and selection process, a longitudinal study and a larger sample size in terms of numbers of candidates and locations can be proposed.

Conclusion

This article aimed at addressing the transparency and fairness issues in the recruitment process of prospective teachers. Results showed that from the sample of 5 candidates only 2 of them were eligible for the next phase, computerized testing. Moreover, both candidates were with significant shortcomings. In overcoming such deficiencies the authors discussed the need for professional development and training. However, the effectiveness and their impact on quality are mainly questioned. Also, the results suggested that the grade point average of higher studies was the most heavily weighted criteria when recruiting teaching staff. Generally, such a result is congruent with observations and studies from other authors.

References

Casey, C. and Childs, R. (2007) 'Teacher Education Program Admission Criteria and What Beginning Teachers Need to Know to Be Successful Teachers', *Canadian Journal of Educational Administration and Policy,* vol. 67, pp. 1-24.

Casey, C. and Childs, R. (2011) 'Teacher Education Admission Criteria as Measure of Preparedness for Teaching', *Canadian Jounral of Education,* vol. 34, no. 2, pp. 3-20.

Chen, C.T. (2000) 'Extensions of the TOPSIS for Group Decision-Making Under Fuzzy Environment', *Fuzzy Sets and Systems,* vol. 114, no. 1, pp. 1-9.

Darling-Hammond, L., Hyler, M. E. and Gardner, M. (2017) *Effective Teacher Professional Development.* Palo Alto, CA: Learning Policy Institute.

European Commission (2020) *European Credit Transfer and Accumulation System*, [Online], Available: https://ec.europa.eu/education/resources-and-tools/european-credit-transfer-and-accumulation-system-ects_en [27 Feb 2020].
Fejfarova, M. and Fejfar, J. (2018) 'Employee Training and Development: Organisational Aspect', *Proceedings of the 15th International Conference on Efficiency and Responsibility in Education (ERIE 2018),* Prague, pp. 45-51.
Flegl, M., Jimenez-Bandala, C.A. and Andrade Rosas, L. (2019) 'Can We Measure Professors' Productivity Over Longer Period? An Introductory Analysis', *Proceedings of the 16th International Conference on Efficiency and Responsibility in Education (ERIE 2019),* Prague, pp. 50-56.
Garet, M.S., Cronen, S., Eaton, M., Kurki, A., Ludwig, M., Jones, W. and Sztejnberg, L. (2008) *The Impact of Two Professional Development Interventions on Early Reading Instruction and Achievement.* U.S. Department of Education: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences.
Garet, M.S., Wayne, A.J., Stancavage, F., Taylor, J., Eaton, M., Walters, K. and Doolittle, F. (2011) *Middle School Mathematics Professional Development Impact Study: Findings After the Second Year of Implementation.* U.S. Department of Education: National Center for Education Evaluation and Regional Assistance.
Gore, J., Lloyd, A., Smith, M., Bowe, J., Ellis, H. and Lubans, D. (2017) 'Effects of Professional Development on the Quality of Teaching: Results from a Randomised Controlled Trial of Quality Teaching Rounds', *Teaching and Teacher Education,* vol. 68, pp. 99-113.
Hanushek, E.A. and Woessmann, L. (2008) The Role of Cognitive Skills in Economic Development', *Journal of Economic Literature,* vol. 46, no. 3, pp. 607-668.
Harvey, L. and Green, D. (1993) 'Defining Quality', *Assessment and Evaluation in Higher Education,* vol. 18, no. 1, pp. 9-34.
Haskova, A. and Lukacova, D. (2017) 'Teacher Assessment in Internal Quality Assurance Systems', *Proceedings of the 14th International Conference on Efficiency and Responsibility in Education,* Czech University of Life Science, Prague, pp. 88-95.
Horakova, T., Berankova, M.H., Mudrychova, K. and Houska, M. (2019) 'The Influence of Selected Factors on Learning Outcomes Within Transferring Knowledge Through Texts', *Proceedings of the 16th International Conference on Efficiency and Responsibility in Education (ERIE 2019),* Prague, pp. 83-89.
Hwang, C.L. and Yoon, K. (1981) *Multiple Attribute Decision Making: Methods and Applications*. New York: Springer-Verlag.
Imose, R.A. and Barber, L.K. (2015) 'Using Undergraduate Grade Point Avarage as a Selection Tool: A Synthesis of the Literature', *The Psychologist-Manager Journal,* vol. 18, no. 1, pp. 1-11.
Johnes, J., Portela, M. and Thanassoulis, E. (2017). Efficiency in Education, *Journal of the Operational Research Society,* vol. 68, pp. 331-338.
Li, D.F. and Yang, J.B. (2004) 'Fuzzy Linear Programming Technique for Multi-Atribute Group Decision Making in Fuzzy Environments', *Information Sciences,* vol. 158, no. 1, pp. 263-275.
Mikitovics, A. and Crehan, K.D. (2002) 'Pre-Professional Skills Test Scores as College of Education Admission Criteria', *The Journal of Educational Research,* vol. 95, no. 4, pp. 215-223.

Ministry of Education, Sport, and Youth (MESY) (2013) Dispozitat Normative: Për Sistemin Arsimor Parauniversitar, [Online], Available: http://www.portalishkollor.al/institucion/dispozitat-normative-per-sistemin-arsimor-arauniversitar [01 Feb 2020].
Ministry of Education, Sport, and Youth (MESY) (2019) Për Proçedurat e Aplikimit dhe të Regjistrimitnë Programet e Ciklit të Parë të Studimeve, në Programet e Studimeve me Karakter Profesional, si dhe në Programet e Integruara të Ciklit të Dytë të Studimeve, në Institucionet e Arsimit të Lartë, [Online], Available: https://arsimi.gov.al/wp-content/uploads/2019/05/Udhzimi-nr.-10-date-15.05.2019-Pranimet-ne-IAL.pdf [20.06.2019]
Mizell, H. (2010) Why Professional Development Matters. Oxford OH: *Learning Forward.*
Moran, A. (2008) C'hallenges Surrounding Widening Participation and Fair Access to Initial Teacher Education: Can It Be Achieved? ', *Journal of Education for Teaching,* vol. 34, no. 1, pp. 63-77.
Mortimore, P. (1991) 'Measuring Educational Quality', *British Journal of Educational Studies,* vol. 39, no. 1, pp. 69-82.
Park, J. H., Park, I.Y., Kwun, Y.C. and Tan, X. (2011) 'Extension of the TOSPSIS Method for Decision Making Problems Under Interval-Valued Intuitionistic Fuzzy Environment', *Applied Mathematical Modelling,* vol. 35, no. 1, pp. 2544-2556.
Powell, DR., Diamond, K.E., Burchinal, M.R. and Koehler, M.J. (2010) 'Effects of an Early Literacy Professional Development Intervention on Head Start Teachers and Children', *Journal of Educational Psychology,* vol. 102, no. 2, pp. 299-312.
Schindler, L., Puls-Elvidge, S., Welzant, H. and Crawford, L. (2015) 'Definitions of Quality in Higher Education: A Synthesis of the Literature', *Higher Learning Research Communications,* vol. 5, no. 3, pp. 3-13.
Zhang, X., Ma, W. and Chen, L. (2014) 'New Similarity of Triangular Fuzzy Number and Its Application', *The Scientific World Journal*, pp. 1-7.

PRE-GRADUAL TEACHER TRAINING IN THE AREA OF DIDACTIC TECHNOLOGICAL COMPETENCIES

[1]Jan Záhorec, [2]✉Alena Hašková

[1]Faculty of Education, Comenius University in Bratislava, Slovakia
[2]Faculty of Education, Constantine the Philosopher University in Nitra, Slovakia, ahaskova@ukf.sk

Abstract

In the paper there are presented results of a screening survey of teacher trainees' opinions about incorporation of particular topics related to their digital literacy and professional digital competence development into the study programs of teacher trainee professional training. The screening survey was a part of a broader research which main goal was to support modernization and optimation of study programs of pre-gradual teacher training in their parts related to formation and development of didactic technological professional competencies of teacher trainees. Within the screening survey a research sample of 280 teacher trainees assessed significance of incorporation of teaching issues of the use of different kinds of software applications in education into the curricula of the study programs.

Keywords

Curricula design, didactic-technological competencies, digital literacy, software applications, teacher training

Introduction

Today, technology is widely used in education, as it is in every field of our everyday life. For this reason, the use of devices and products relating to information technologies in teaching and learning processes is increasing throughout all school subjects (Klement et al., 2017; Wastiau et al., 2013). Moreover, it has belonged to one of the basic values accepted by any advanced society (Vítečková et al., 2016; Ghavifekr and Rosdy, 2015). On the other hand, teachers are not always successful in integration of technology into the teaching (Kongsgården and Krumsvik, 2016). In Slovakia digital educational technologies have their place among the topics taught in the system of compulsory, compulsory optional and optional subjects included into the curricula of pre-gradual training of teacher trainees (Petrová and Duchovičová, 2013; Kosová et al., 2012). But as the development of both hardware and software applications is very fast, there is a need to innovate continually these parts of teacher study programs, aimed at the development of teacher trainees' didactic technological competencies (Gudmundsdottir and Hatlevik, 2017).

Following the demand to ensure a conception of an optimal pre-graduate teacher training there was carried out a research (2017 – 2019) which main goal was to support modernization and optimation of teacher training study programs in their parts related to formation of didactic technological professional competencies of teacher trainees. This meant to find out an optimal structure of the concerned subjects, their curricula (content) and time allocation, and in this way to create a model how to develop the relevant competencies of students enrolled in these programs (Brečka and Olekšáková, 2013). A part of this research was a screening survey of the teacher trainees' opinions about incorporation of particular topics related to their digital literacy and professional digital competence development into the study programs of teacher trainee professional training (Záhorec, Nagyová and Hašková, 2019).

Materials and Methods

The screening survey of the teacher trainees' opinions about incorporation of particular topics related to their professional digital competence development into their study programs was based on a questionnaire inquire. Within the inquire, incorporation of nine kinds of software applications B1 – B9 (presented in Table 1) into the teacher training study programs was examined. The given applications were specified following the current situation at primary and secondary schools in Slovakia (as to the school equipment by ICT facilities) and the current ICT development tendencies. The respondents were asked to assess each of the given kinds of the applications twice, each time from another point of view:

1. from the point of view of the significance to incorporate the particular topic (topic of the use of the relevant kind of software applications in teaching process) into the study programs of teacher trainee pre-gradual preparation;
2. from the point of view of the character of the subject in frame of which the topic would be taught, i.e. obligation of teacher trainees to attend the subject within which issue of the relevant kind of the software applications would be taught.

The respondents expressed their opinions in relation to the successful professional performance of their future teaching career (pedagogical activities).

As to the first point of view, the respondents expressed their opinions by means of a 6-point scale:

1 – *definitely not to incorporate,*
2 – *not to incorporate,*
3 – *probably not needed to incorporate,*
4 – *probably needed to incorporate,*
5 – *to incorporate,*
6 – *definitely to incorporate.*

As to the character of the subject in frame of which the given issue (the use of the software applications B1 – B2 in education) should be taught, the respondents were asked to choose one of four alternative answers to the question:

Subject of the teacher training study program, in frame of which the issue of the work with the particular kind of software applications (B1 – B9) should be taught, should be incorporated into the group of which subjects?

The alternative answers to this question were the following ones:

a) among compulsory subjects of the teacher trainees' study programs,
b) among compulsory optional subjects of the teacher trainees' study programs,
c) among optional subjects of the teacher trainees' study programs,
d) this issue is not needed to incorporate into the teacher trainees' study programs.

Research sample of the questionnaire inquire consisted of 280 teacher trainees (205 in Slovakia, 75 in the Czech Republic; 49 men, 231 women). Collection of the research data was carried out in the summer term of the academic year 2018/2019. Consequently, the collected data were processed by means of descriptive statistics in *STATISTICA*.

	Kind of the software application
B1	*ActivInspire, SMART Notebook, Flow!Works* software applications used to create different electronic educational activities, interactive teaching and learning tasks and educational/knowledge games
B2	*Prezi* software applications used to create non-linear dynamic presentations with educational – but not only – content applicable in teaching and learning activities
B3	*FreeMind, Mindomo, XMind* applications used to create mind maps useable in teaching and learning activities intended also for pupils with special needs
B4	*ActivExpression2, SMART Response 2, QRF700/900, Turning Point* modern interactive voting systems through which it is possible to ask questions to diagnose, test and assess pupils and students knowledge during teaching
B5	*Socrative 2.0* internet application to diagnose, test and assess pupils and students knowledge on-line either during or out of teaching
B6	*Google Docs* modern tools for collaborative creation and management of electronic on-line documents based on the use of current possibilities of Web 2.0 internet category
B7	*Microsoft PowerPoint* application useable for creation of didactic presentations with educational content with the use of different feed-back and multimedial elements supporting teachers' explanation of the subject matter and pupils/students knowledge systemization
B8	*Microsoft Excel* (application used to process tabulated data useable in teachers' work
B9	*Microsoft Word* software application used to process and format teachers' own text documents connected with their professional work and activities

Table 1: Kinds of software applications assessed by teacher trainees with regard to their significance to be incorporated into the teacher trainee pre-graduation preparation (source: own research)

Results

Results of the processing of the obtained research data are summarised in Table 2 and Table 3. Table 2 presents final assessments of the significance of incorporation of the particular topic (software applications B1 – B9) into the study programs of teacher trainee study programs B1.1 – B9.1 (values of the means of the achieved significance assessments).

From the data presented in Table 2 it is clear that assessments of significance of the particular kinds of the software applications B1 – B9 incorporation into the teacher trainees' study programs stated by the respondents were rather positive (see the achieved mean values at all items within the interval of values from 4.15 to 5.44 of the maximal scale value 6).

Significantly the highest value of the mean was recorded at the item B9, i.e. in case of the software applications used to process and format teachers' own text documents connected with their professional work and activities (*Microsoft Word*). Mean assessment 5.44 (mean value between 5 – *to incorporate*, and 6 – *definitely to incorporate*) achieved at this item shows that the teacher trainees are aware of the need to improve their skills to work with this software product, to be able consciously to work with a broader scope of tools of the text editor in the context of their future professional activities.

High average assessments at the level of 5 were recorded also in case of the items B7 and B8. This means that the respondents ask to incorporate into their pre-gradual preparation also the topic of the work with *Microsoft PowerPoint* (B7) and *Microsoft Excel* (B8).

Kind of the software application	Mean	Stand. deviat.	Stand. error	Confidence Interval for the Mean	
				-90 %	+95 %
B1.1 – *ActivInspire, SMART Notebook, Flow!Works*	4.68	0.99	0.06	4.56	4.79
B2.1 – *Prezi*	4.38	1.09	0.07	4.25	4.51
B3.1 – *FreeMind, Mindomo, XMind*	4.42	1.11	0.07	4.29	4.55
B4.1 – *ActivExpression2, SMART Response 2*	4.15	1.21	0.07	4.00	4.29
B5.1 – *Socrative 2.0*	4.29	1.17	0.07	4.15	4.43
B6.1 – *Google Docs*	4.58	1.17	0.07	4.44	4.72
B7.1 – *Microsoft PowerPoint*	5.25	1.08	0.06	5.12	5.38
B8.1 – *Microsoft Excel*	5.06	1.09	0.07	4.93	5.19
B9.1 – *Microsoft Word*	5.44	0.96	0.06	5.32	5.55

Table 2: Descriptive statistics of the significance of incorporation of the software applications B1 – B9 into the teacher trainee pre-gradual preparation (source: own research)

Assessments of the need to teach the work with *ActivInspire*, *SMART Notebook*, *Flow!Works* (B1) and *Google Docs* (B6) are in the middle between *probably needed to incorporate* (scale value 4) and to *incorporate* (scale value 5). The other applications basically all achieved mean values expressing a „recommendation band" for incorporation into the teacher trainees' study programs (mean values over the scale value 4 – *probably needed to incorporate*).

The lowest mean values of the assessments were recorded in case of the items *Socrative 2.0* (B5.1 – 4.29) and *ActivExpression2*, or *SMART Response 2*, *QRF700/900*, *TurningPoint* (B4.1 – 4.15). These two applications were most frequently assessed as the issue which it is not necessary to incorporate into the teacher study programs (see Table 3, relative frequencies of the alternative answer *d* at the item B4.3 – 20.36 % and at the item B5.3 – 15.36 %).

Table 3 presents absolute and relative frequencies B1.3 – B9.3 of the alternative answers *a* – *d* related to the character of the subject in frame of which the issue of the particular kind of the software applications B1 – B9 should be taught. While analysing results presented in Table 3, statistically significant differences among the responses were noted, but these were due to the differences in the strength of the requirement to include the subject in the curriculum for pre-gradual teacher training. On the other hand, the results of processing the responses to this questionnaire item are in line with the demands made by students regarding the significance of the incorporation of teaching the issue to work with the relevant kinds of software applications and systems into the teacher training program.

As the results show, the issue of the use of *Microsoft Word*, *Microsoft PowerPoint* and *Microsoft Excel* software applications should be taught within a compulsory or compulsory optional subject (choice of the answer *a* or *b*), with software applications *FreeMind*, *Mindomo*, *Xmind*, *Prezi* and *Google Docs* within a compulsory optional or optional subject (choice of the answer *b* or *c*).

The work with the software applications *ActivInspire*, *SMART Notebook*, *Flow!Works* (of the interactive whiteboards ActivBoard, SMART Board and QOMO) should be taught as a part of a compulsory or compulsory optional subject devoted exclusively to this issue (choice of the answer *a* or *b*). This is in good agreement with the fact that the interactive learning activities and tasks performed with the support of these applications represent an up-to-date phenomenon to increase teaching efficiency at all levels of the school system.

Kind of the software application	*a* compulsory subject	*b* compulsory optional subject	*c* optional subject	*d* not to incorporate
B1.3 – *ActivInspire, SMART Notebook, Flow!Works*	53 18.93 %	151 53.93 %	67 23.93 %	9 3.21 %
B2.3 – *Prezi*	33 11.79 %	107 38.21 %	115 41.07 %	25 8.93 %
B3.3 – *FreeMind, Mindomo, Xmind*	52 18.57 %	90 32.14 %	114 40.71 %	24 8.57 %
B4.3 – *ActivExpression2, SMART Response 2, TurningPoint*	24 8.57 %	93 33.21 %	106 37.86 %	57 20.36 %
B5.3 – *Socrative 2.0*	32 11.43 %	88 31.43 %	117 41.79 %	43 15.36 %
B6.3 – *Google Docs*	36 12.86 %	97 34.64 %	107 38.21 %	40 14.29 %
B7.3 – *Microsoft PowerPoint*	98 35.00 %	120 42.86 %	46 16.40 %	16 5.71 %
B8.3 – *Microsoft Excel*	84 30.00 %	118 42.14 %	65 23.21 %	13 4.64 %
B9.3 – *Microsoft Word*	122 43.57 %	110 39.29 %	32 11.43 %	16 5.71 %

Table 3: Absolute and relative frequencies of the answers *a – d* regarding the character of the subject in frame of which issue relevant to the given SW applications B1 – B9 should be taught (source: own research)

As to the voting systems *ActivExpression2, SMART Response 2, TurningPoint, QRF700/9*00, and internet application *Socrative 2.0*, at this items the lowest level of the need to incorporate them into the teacher training curricula was recorded. And besides, these systems belong to the most up-to-date voting means of the third generation. We consider this result to be a consequence of the fact that the students (teacher trainees) have not been sufficiently familiar with the possibilities of their use, or more specifically, with the possibilities of their use in teaching practice. Therefore, we consider to be important in addition to training in voting systems, the issue of their use should be emphasized in connection with possibilities to increase the efficiency of the particular subject teaching (the use of voting systems in a subject teaching as a mean contributing to increases in pupils/students' activity, interestingness and attractiveness of the presented subject matter or teaching/learning process, etc.).

Discussion

To meet the teacher trainees' expectations related to the development of their competence to use the given means in teaching their majors presuppose two kinds of changes. It will not only be necessary to change the content of the subjects developing their didactic-technological competencies, but also to re-arrange the way in which these subjects are incorporated into the teacher training study programs. This is mainly related to the cross-curricular interconnection of these subjects with subject didactics. It is common that subject didactics are included in the study programs in higher grades (usually up to the master degree of the study), while subjects aimed at developing teacher trainees' didactic-technological competencies (but usually in practice emphasizing development of the teacher trainees' global digital literacy) are assigned to lower grades (usually in the bachelor degree).

In the current way of the study program and curricula structuralization there is basically the opposite sequence of the above-mentioned subjects to each other. So there is rather „student's" than „teacher's" viewing angle on the possibilities of using the software applications prevailing

quite naturally in the didactic-technological training. This means that consideration of the use of these means from the point of student's view predominates over the teacher's point of view. In our opinion, shift of the subjects devoted to didactic-technological training of teacher trainees to the higher grades of the study would help to eliminate this problem.

The presented results of the described research have called at the Faculty of Comenius University in Bratislava into a proposal how the bachelor and master degrees of the teacher training programs, in their parts devoted to teacher trainees' didactic-technological preparation, should be innovated for purposes of the coming reaccreditation (Záhorec, Hašková and Munk, 2020). The proposed innovations cover compulsory and compulsory optional subjects *Digital Technologies I, Digital Technologies II, ICT in Teaching Process* and *Multimedial Didactic Technology and E-learning Basis.* Beside that there are proposed also some new (compulsory/compulsory optional) subjects, specifically subjects *Design of Interactive Forms of Teaching Materials, Interactive Voting Technologies in Education* and *Didactics Software Applications in Education.*

The proposed new subject *Design of Interactive Forms of Teaching Materials* should be focused on the issue of application of innovative didactic approaches in teaching subject matter by means of *Prezi* and *Microsoft Sway.*

An important aspect of the new subject *Interactive Voting Technologies in Education* is to acquire new professional digital competencies related to the use of interactive voting systems *ActivExpression2, SMART Response 2, QRF700/QRF900, TurningPoint* and to the use of the online web applications like e.g. *Socrative 2.0.*

Curricula of the subject *Didactics Software Applications in Education* should be devoted to acquisition of principles and methodology of the work with software applications designed for creation and presentation of mind maps, which lead intact pupils and pupils with special educational needs to the more effective acquiring of new knowledge, develop their analytical skills, ability to communicate with each other, creativity, strengthen the development of their personalities and self-knowledge (i.e. with such software applications as are e.g. *FreeMind, Mindomo* or *Xmind*).

Conclusion

As the results of different researches show (Uluyol and Sahin, 2016; Shopova, 2014; Ottestad, Kelentrić and Guðmundsdóttir, 2014), success of technology use in teaching process depends mostly on the teacher's personality and his/her skills. That is why it is very important to keep sustainability quality of teachers' professional didactic technological competencies. This task includes in its also the need to innovate continuously the pre-gradual training of teacher trainees. Results of the carried out research indicates some requirements which should be currently reflected in innovation of curricula of this part of the training. In particular, besides the traditionally taught use of the software applications *Microsoft Word, Microsoft Excel* and *Microsoft PowerPoint, t*o the topics and issues which should be included or reinforced in the curricula of the pre-gradual teacher training study programs belong mainly the use of software products *ActivInspire, FreeMind, Flow!Works, Google Docs* and if possible also *FreeMind, Mindomo, XMind* and *Prezi* with accent on the methodological aspects of the use of these didactic means in teaching and learning processes.

Acknowledgement

This work has been supported by the Cultural and Educational Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic under the projects No. KEGA 021UKF-4/2018 and KEGA 041UK-4/2017.

References

Brečka, P. and Olekšáková, M. (2013) 'Implementation of Interactive Whiteboards into the Educational Systems at Primary and Secondary Schools in the Slovak Republic', *International Conference on Advanced Information and Communication Technology for Education 2013*, Hainan, Atlantis Press, pp. 126-130.

Ghavifekr, S. and Rosdy, W.A.W. (2015) 'Teaching and learning with technology: Effectiveness of ICT integration in schools', *International Journal of Research in Education and Science (IJRES)*, vol. 1, no. 2, pp. 175-191.

Gudmundsdottir, G.B. and Hatlevik, O.E. (2017) 'Newly qualified teachers' professional digital competence: implications for teacher education', *European Journal of Teacher Education*, vol. 41, no. 2, pp. 214-231. https://doi.org/10.1080/02619768.2017.1416085

Klement, M., Dostál, J., Kubrický, J. and Bártek, K. (2017) *ICT nástroje a učitelé: adorace, či rezistence?*, Olomouc: Univerzita Palackého, 321p. https://doi.org/10.5507/pdf.17.24450926

Kongsgården, K. and Krumsvik, R.J. (2016) 'Use of tablets in primary and secondary school – a case study', *Nordic Journal of Digital Literacy*, vol. 11, no. 4, pp. 248-273. https://doi.org/10.18261/issn.1891-943x-2016-04-03

Kosová, B. et al. (2012) *Vysokoškolské vzdelávanie učiteľov: vývoj, analýza, perspektívy*, Banská Bystrica: Pedagogická fakulta, Univerzita Mateja Bela v Banskej Bystrici, 143p.

Ottestad, G., Kelentrić, M. and Guðmundsdóttir, G. (2014). 'Professional Digital Competence in Teacher Education', *Nordic Journal of Digital Literacy*, vol. 9, no. 4, pp. 243-249.

Petrová, G. and Duchovičová, J. (2013) 'University Preparation of Teachers in the Context of Transformation Processes', *Lifelong Learning – celoživotní vzdělávání*, vol. 3, no. 1, pp. 8-37. http://dx.doi.org/10.11118/lifele201303018

Shopova, T. (2014) 'Digital literacy of students and its improvement at the university', *Journal on Efficiency and Responsibility in Education and Science*, vol. 7, no. 2, pp. 26-32. https://doi.org/10.7160/eriesj.2014.070201

Uluyol, C. and Sahin, S. (2016) 'Elementary school teachers' ICT use in the classroom and their motivators for using ICT', *British Journal of Educational Technology*, vol. 47, no. 1, pp. 65-75. https://doi.org/10.1111/bjet.12220

Vítečková, M., Procházka, M, Gadušová, Z. and Stranovská E. (2016) 'Identifying novice teacher needs – the basis for novices' targeted support', *ICERI 2016 Proceedings*. Valencia: IATED Academy, pp. 7731-738. https://doi.org/10.21125/iceri.2016.0772

Wastiau, P., Blamire, R., Kearney, C., Quittre, V., Van de Gaer, E. and Monseur, C. (2013) 'The Use of ICT in Education: A Survey of Schools in Europe', *European Journal of Education*, vol. 48, no.1, pp. 11-27. https://doi.org/10.1111/ejed.12020

Záhorec, J., Hašková, A. and Munk, M. (2020) *Digital literacy of teachers in the context of their professional training*. Bratislava: Comenius University, 286 p.

Záhorec, J., Nagyová, A. and Hašková, A. (2019) 'Teachers` attitudes to incorporation digital means in teaching process in relation to the subjects they teach', *International Journal of Engineering Pedagogy*, vol. 9, no. 4, pp. 101-120. https://doi.org/10.3991/ijep.v9i4.11064

Proceedings of the 17th International Conference Efficiency and Responsibility in Education 2020

Cover:	**Michal Hruška**
Technical editor:	**Jiří Fejfar**
Published by:	**Czech University of Life Sciences Prague** **Kamýcká 129, Prague 6, Czech Republic**
Printed by:	**Reprografické studio PEF ČZU v Praze** **Kamýcká 129, Prague 6, Czech Republic**

ISBN 978-80-213-3022-1
ISSN 2336-744X