A Model for Effective Mathematics Teaching With an Emphasis on the Development of Transversal Competencies in Technical and Economic Study Programs

Mária Mišútová [1], Martin Mišút [2]

[1]Slovak University of Technology, Faculty of Materials Science and Technology, Bottova 25, Trnava, Slovakia
[2]University of Economics, Faculty of Economic Informatics, Dolnozemská cesta 1/b, Bratislava, Slovakia

***Abstract* – The research results published so far have shown that success in mathematics positively affects the retention rate at technical and economic universities. Various studies have explored different forms, methods, and tools in mathematics teaching to improve student success, but an effective teaching model is yet to be identified. Based on previous experience and published results, a model of effective teaching was proposed with an emphasis on developing selected cross-sectional competencies to increase student retention. A recent study aimed to verify the effectiveness of this model in the pilot subject Mathematics I. The study included 211 first-year students of 7 bachelor's technical-economic study programs. Results showed significant improvement in the group of students who struggled with mathematics. The study confirmed that an appropriately chosen intervention in mathematics can increase the success rate of completing technical and economic study programs, and this approach can also be applied at other universities.**

***Keywords* – Efficiency, teaching, mathematics, transversal competencies, technical and economic study programs.**

DOI: 10.18421/TEM124-37
https://doi.org/10.18421/TEM124-37

Corresponding author: Mária Mišútová,
Slovak University of Technology, Faculty of Materials Science and Technology, Trnava, Slovakia
Email: maria.misutova@stuba.sk

Received: 29 May 2023.
Revised: 15 August 2023.
Accepted: 11 September 2023.
Published: 27 November 2023.

1. Introduction

Teaching mathematics in engineering studies has been reported worldwide as problematic due to the low student retention rate [1], [2]. High dropout rates, especially in the STEM disciplines (science, technology, engineering and mathematics) [3], have proved intractable despite offering supplemental instruction [4]. High failure rates in mathematics subjects and lower retention in disciplines with mathematics-intensive subjects have prompted tertiary institutions to set up some form of mathematics support to prevent these students from failing [2].

Success or failure in mathematics strongly influences the choice of study orientation and completion [5], [6]. Therefore, studies have been undertaken to identify how to increase student's success rate in mathematics and thus improve the success rate of completing engineering studies [7], [8], [9], [10], [11].

As Drijvers [12] points out, many university students are not sufficiently prepared to study mathematics at the university level. In addition, in recent years, there has been a negative trend (decline) in the preparedness of secondary school graduates in mathematics for university studies [13]. Only 10% of students complete their studies without intervention, while 40% obtain a bachelor's degree with additional help [14].

Among the traditional causes of insufficient mathematical preparation of students for engineering education are mainly inadequate preparation in secondary schools, a lack of dedicated hours to mathematical education and a weak connection between the requirements of engineering disciplines and the mathematical curriculum [15]. Bargagliotti *et al.* [16] also mention students' characteristics, lack of effort and motivation, or low study skills.

Luhan, Novotná and Križ [17] further add to this the inhomogeneity of the study groups in terms of diverse levels of mathematical knowledge.

To overcome the shortcomings mentioned above in the mathematical preparation of students for engineering education, teachers complement the traditional teaching model with strategies that emphasise conceptual understanding, active learning, and relevant applications and actively investigate the implementation of educational technologies [18], [19]. Several studies have been published that point to the fact that only the development of mathematical skills is not sufficient [20]. It is also necessary to address the fear of mathematics, negative attitudes, insufficient study skills and lack of responsibility in the approach to study [21]. As Merrill and Comerford [22] showed, through an integrated approach, students more easily "see" the connections connecting different areas of learning. This contributes to the quality of their education through a more profound, multidimensional understanding of the problems being addressed. Leppävirta [23] suggests an increasing emphasis on conceptual understanding of mathematics, increasing diversity in student assessment, and promoting individualisation of learning styles and strategies. Also, numerous research studies have shown that using educational technologies helps improve the processes of teaching and learning mathematics [24], [25].

The motivation of students to study mathematics is essential because knowledge of mathematics forms the knowledge basis for computer science, technical and economic subjects. Moreover, increased math anxiety and the need for math remediation correlate with a decreased chance of completing a STEM degree, particularly for female students [26], [27].

In light of the above, as well as the current situation affected by the pandemic, when designing the teaching model, we focused on choosing a sequence of methods supporting the development of selected transversal competencies, in particular mathematical competencies, essential competencies in science and technology, competence to learn and digital competences. As Epuran *et al.* [28] and Wagenaar [29] pointed out, modernising higher education and minimising early graduation studies is essential. One of the possible solutions is to introduce additional support to improve the prerequisites for proper graduation, apply the education focused on the needs of the student and support the development of such transferable competencies of university students that allow them flexibility in the labour market. On the other hand, implementing online and offline hybrid teaching models of university mathematics implies a change to the traditional teaching models. It is still a topic many university mathematics teachers face [30].

Most published studies primarily examine the small impact of factors on educational outcomes, such as mathematical software application factor [31], different teaching methods [9], [32], and math tutoring factor [10], [11]. Alternatively, they investigate one or more dimensions of the multidimensional issue of teaching mathematics at the university. For the curriculum from the perspective of future engineers' competencies [7], problems of online mathematics courses [8], [33], defining problems and finding different ways to solve them [34]. Only some studies deal with the systematic analysis of factors in stem education [35]. However, this study only analysed published empirical studies on using learning analytics for student retention in STEM education. Some studies focus more on the context, environment, and mentoring of students than on improving the results in subjects [36].

Consequently, it is still necessary to define a complex model of teaching mathematics, which improves results in the current environment, especially for technical students who have a problem with passing mathematical subjects and thus increases the number of successful graduates and economic study programs.

Our project aims to enhance the success rate of technical and economic study programs by improving students' performance in mathematical subjects. One approach is to cultivate interest in studying mathematical subjects [37], [38], [39], [40].

Therefore, this study aims to contribute to this research gap by reviewing the empirical evidence on implementing the innovative teaching model to learn mathematical and informatics subjects to increase the quality of graduates and reduce student decline during studies, especially at technical and economic universities.

2. Methodology

The goal of the study was to create a teaching model so that it has the highest possible didactic effectiveness. Therefore, we first surveyed students about the state of knowledge in secondary school mathematics. Students who formed a set of respondents completed part of their secondary studies during the pandemic. We identified the state of mathematical education results from secondary school in three ways. 1. By analysis of student-written papers from the previous two academic years. 2. By using a questionnaire. 3. By evaluating the entrance test from the secondary mathematics curriculum [41].

Fig.1 shows a graph of the relative number of students who made mistakes in a given thematic area.

The chart shows that students make the most mistakes in editing algebraic expressions. We were surprised that 21% of students made mistakes in the area of fraction operations.

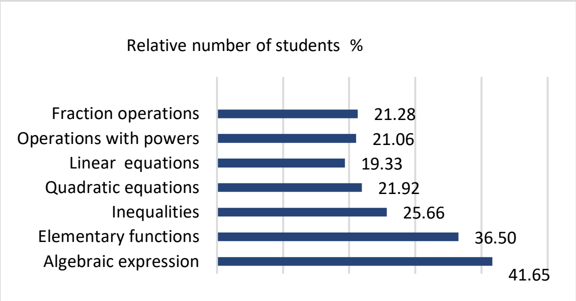

Figure 1. Test analysis results

Fig. 2 shows a graph of the relative number of responses from students per questionnaire item: Which of the areas of secondary school mathematics most often caused you difficulties in solving tasks in the subjects Mathematics 1 and Mathematics 2? Most often, students marked geometric areas. Almost 54% of students have problems with geometric shapes, 50% with vectors, and nearly 41% with 2D and 3D Cartesian coordinate systems.

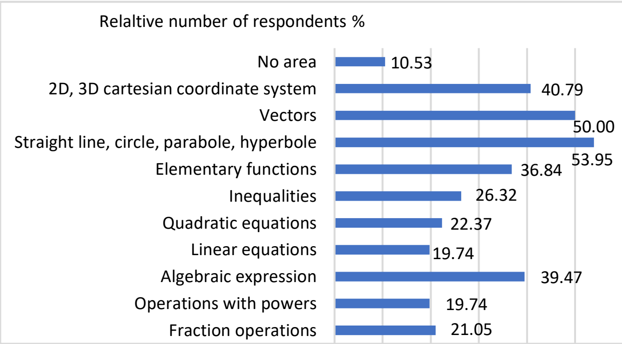

Figure 2. Questionnaire results

Fig.3 shows a graph of the relative success of solving the tasks of the entrance test. Students achieved the lowest success rate of only 28% in solving the Vectors task. Up to 50% of students identified this topic as problematic in the questionnaire. On the other hand, although almost 41% of students identified Cartesian coordinate systems as a problem area of 2D and 3D, in the entrance test, this task had the highest success rate, up to 55.26%.

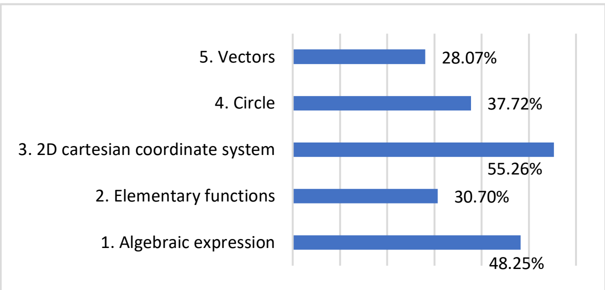

Figure 3. Entrance test results

The success rate of solving other tasks was low. The entrance test results confirmed that solving tasks in thematic areas of mathematics, as we identified them by analysing written papers and using a questionnaire, causes significant problems for students in the 1st year of bachelor studies.

Based on the results, in addition to designing and creating an e-learning module suitable for self-study, additional seminars in mathematics in the field of content and methods and forms used are innovated. When innovating the content, we considered the state of knowledge of students in high school mathematics. The main criteria in the selection of methods and forms of teaching were to develop selected transversal competencies in students. In the described part of the research, we focused on verifying the didactic effectiveness of one of the components of a complex teaching model – the innovation of additional seminars in mathematics. In order to find the answer to the research question of whether our proposed model of additional seminars is didactically effective, we conducted a natural pedagogical experiment. We were looking for an answer to the research questions below.

•Is there a statistically significant difference in the average success rate of the experimental group in whose teaching the proposed model of teaching additional seminars and the control group was applied, taught using the original methods, forms, and content?

•Is there a statistically significant difference in average success in the experimental and control group of men? I.e., were the men of the experimental group more successful in the subject Mathematics I than the men of the control group?

•Is there a statistically significant difference in average success in the experimental and control group of women? I.e., were the women in the experimental group more successful in Mathematics I than those in the control group?

We were also interested in questions about possible differences in the success rates of men and women in the whole set of respondents and the experimental and control groups. We formulated the following research questions.

•Is there a statistically significant difference in the average success rates of men and women across the respondent group?

•Is there a statistically significant difference in the average success rates of men and women in the experimental group?

•Is there a statistically significant difference in the average success rates of men and women in the control group?

The effective teaching model of additional seminars has been verified in teaching Mathematics I at the Faculty of Materials Science and Technology in Trnava Slovak University of Technology in Bratislava in the winter semester of the academic year 2022/2023. The process of creating a model still needs to be completed. We are constantly continuing its development and modifying it based on the results of pedagogical experiments. The teaching model has been designed to develop in students the transversal competencies needed in their studies and technical practice. The proposed model of teaching supplementary seminars differs from the original teaching in content, methods, and forms. In addition to university mathematics topics, the content of teaching the experimental group is extended by the repetition of thematic units of secondary school mathematics, identified within the previous part of the research [41]. In teaching the control group, repetition of selected units of secondary school mathematics is absent. The content is only practising the topics of the university subject Mathematics I. Passive methods have a considerable predominance in teaching the control group. The teacher solves the tasks on the board, and the students describe them. The reason for choosing this interpretative method is the effort of the teacher to impart as much ready-made knowledge as possible to students. The teacher of the experimental group solves the tasks with the help of students. The experimental group solves fewer tasks than the control group. However, the goal is to develop students' activity, independence, ability to creative, critical and technical thinking, and ability to communicate effectively and solve problems. In addition to frontal teaching, the teacher of an experimental ensemble often uses group lessons, where students try to solve a given task in groups, thereby developing their ability to work in a team. There are also differences in teaching in the designation of variables. To designate dependent and independent variables, students of the experimental group use the usual designations y and x and the variable designations used in physics, mechanics, automation and other subjects that students take during their studies. In this way, the teacher promotes the development of student flexibility. Moreover, students taught in this way will more easily apply the knowledge acquired in mathematics to technical subjects. In supplementary study literature, experimental group students also had presentations from lectures available and used freely available mathematical software (wxMaxima, Winplot, Desmos, Geogebra 3D, WolframAlpha). Mathematical software can significantly increase understanding [42] and reduce concerns about math. Reducing fears about mathematics significantly increases academic success in mathematics [43]. Students also used Matlab's commercial software to address topics such as algebraic equations. Math software allowed students to control task-solving and graphical representations of solutions, which promoted a deeper understanding of the curriculum. By using different types of software, student flexibility was also trained. In addition, using the software can increase students' interest in studying and motivation, which is no less important [44], [45]. A detailed description of the model is given in the study [41]. According to the university's study regulations, students can take the final assessment during the exam period on proper or two correction dates. We monitored the students' success in the regular attempt (1st attempt), in the first corrective attempt (2nd attempt) and in overall success, where we no longer recorded whether the student completed the subject on the first, second or third attempt. We only observed with what final evaluation the subject ended. We established the following working hypotheses based on the above research questions, the results of the previous part of the research [46], and experience.

Hypothesis 1a: The application of the proposed teaching model has a statistically significant impact on the overall success of students in mathematics.

Hypothesis 1b: Applying the proposed teaching model statistically significantly impacts students' success on the first attempt at the mathematics exam.

Hypothesis 1c: Applying the proposed teaching model statistically significantly affects students' success on the second attempt at the mathematics exam.

Hypothesis 2a: Applying the proposed teaching model has a statistically significant impact on men's overall success rate in mathematics.

Hypothesis 2b: The application of the proposed teaching model has a statistically significant impact on the success of men on the first attempt at the mathematics exam.

Hypothesis 2c: The application of the proposed teaching model has a statistically significant impact on the success of men on the second attempt of the mathematics exam.

Hypothesis 3a: Applying the proposed teaching model statistically significantly impacts women's overall success in mathematics.

Hypothesis 3b: Applying the proposed teaching model statistically significantly impacts women's success at the first attempt at the mathematics exam.

Hypothesis 3c: Applying the proposed teaching model statistically significantly impacts women's success at the second attempt at the mathematics exam.

Hypothesis 4a: There is no statistically significant difference in men's and women's overall average success rate in the respondent group.

Hypothesis 4b: There is no statistically significant difference in the overall average success rates of men and women in the experimental group.

Hypothesis 4c: No statistically significant difference exists in the overall average success rates of men and women in the control group.

We used the T-test using the statistical software Minitab to verify the working hypotheses. The data consisted of the resulting evaluations of students at the exam in the subject Mathematics I. We assigned numerical values to grades: A - 5, B - 4, C - 3, D - 2, E - 1, FX/FN - 0. The respondents consisted of 211 first-year students of 7 bachelor study programs. Before the beginning of the semester, the study department divided students into two groups. The first group consisted of students of the study programs Industrial Management, Manufacturing Technologies, and Production Devices and Systems. The second group consisted of students of the study programs Integrated Safety, Materials Engineering, Applied Informatics and Automation in Industry and Mechatronics in Technological Equipment. We conducted a natural pedagogical experiment and chose the experimental group according to a teacher willing to teach experimentally.

3. Results and Discussion

Results are presented according to two aspects: firstly, descriptions of differences in results between experimental and control groups and then the comparison of results between and within groups of men and women.

a. Results for the Whole Group of Respondents

Table 1 shows that in the whole group of respondents, the overall pass rate of students of the experimental set (1.70) on the exam is 0.15 lower than that of the students of the control set (1.85). However, the two-sample T-test using Minitab software showed that the difference was insignificant ($p=0.541$), at a significance level $\alpha=0.05$, since $p>\alpha$. We got the same result on the first attempt of the exam. The success rate of the control group students (1.43) is 0.22 higher than that of the experimental group students (1.21), but again, the difference was not statistically significant ($p=0.388$). The opposite situation is in the second attempt of the exam, where the students of the experimental group achieved a higher average pass rate (0.78) than those of the control group (0.364), and the difference in average success rates was statistically significant. ($p=0.025$)

Table 1. The average success rate in the whole group of respondents

	Descriptive Statistics				
	Group	N	Mean	StDev	SE Mean
Overall	Con.	113	1.85	1.73	0.16
	Exp.	98	1.70	1.71	0.17
1st attempt	Con.	113	1.43	1.89	0.18
	Exp.	98	1.21	1.78	0.18
2nd attempt	Con.	55	0.364	0.649	0.087
	Exp.	50	0.78	1.13	0.16

Based on the above results, hypothesis 1c, in which we assumed a statistically significant influence of the proposed teaching model on students' success in the second attempt of the exam in mathematics, has been confirmed. The fact that the research results did not confirm hypotheses 1a and 1b, where we assumed a statistically significant influence of the proposed teaching model on students' success in the first exam attempt and overall success, may have several causes. One of them may be the fact that students who had good knowledge of secondary school mathematics also easily mastered the university curriculum. They did not participate in additional seminars in mathematics, and they took the exam on the first attempt. Another possible reason may be that in the control group, there were students from study programs such as Applied Informatics and Automation in Industry and Mechatronics in Technological Equipment, who have a closer relationship to mathematics than students from the experimental group who study programs such as Industrial Management, Manufacturing Technologies. It can be assumed that students whose knowledge of secondary school mathematics did not reach an excellent level understood less of the studied curriculum in lectures and exercises, so they attended additional seminars. With their help, they successfully passed the exam on the second attempt, where they already had experience with solving tasks on the first attempt. Further research is needed to establish the proposed teaching model's didactic effectiveness. However, it is clear from student feedback that the proposed teaching model of additional seminars in mathematics helped many students with lower levels of knowledge from high school to complete the subject successfully.

b. Results for the Men's and Women's Groups

The results in the male group match those in the entire respondent group. Table 2 shows that in the male group, the overall success rate of the experimental group students (1.68) was higher than that of the control group students (1.65).

The two-sample T-test via Minitab software showed that the difference is insignificant (p=0.894) at the significance level α=0.05. We got a similar result in success rate on the first attempt. The men in the experimental group finished Mathematics I with worse results (1.18) than those in the control set (1.21). However, the difference in average success rates was not statistically significant (p=0.919). Hypotheses 2a and 2b have not been confirmed. The results confirmed the validity of hypothesis 2c, in which we assumed that applying the proposed teaching model has a statistically significant impact on the success rate in the group of men at the second attempt. The men in the experimental group achieved a higher average success rate (0.84) on the second attempt than those of the control set (0.36). The difference in average success rates was statistically significant, confirmed by the results of the Two–Sample T-test using Minitab software (p=0.032). It can be assumed that the causes of the above condition are the same as in the previous section in the whole group of respondents.

Table 2. The average success rate in the men's group overall and on the first and second attempt

	Descriptive Statistics				
	Group	N	Mean	StDev	SE Mean
Overall	Con.	96	1.65	1.60	0.16
	Exp.	72	1.68	1.72	0.20
1st attempt	Con.	96	1.21	1.73	0.18
	Exp.	72	1.18	1.75	0.21
2nd attempt	Con.	50	0.360	0.663	0.094
	Exp.	37	0.84	1.19	0.20

Unexpected were the results in the group of women. Table 3 shows that in the female group, the overall average success rate of the experimental group (1.77) was lower than that of the control group (3.00). The two-sample T-test via Minitab software showed that the difference was statistically significant (p=0.046). We received a similar result on the first exam attempt. The success rate of the women in the experimental group (1.31) was lower than those in the control set (2.71). The difference was also statistically significant (p=0.047). We assume that there needed to be more interest in mathematics among the women from the experimental ensemble, which affected their results and could also cause their poor participation in additional seminars in mathematics. At the second attempt, women in the experimental group achieved a higher average success rate (0.615) than women in the control group (0.400). However, the difference in average success rates was not statistically significant (p=0.562).

Table 3. The average success rate in the women's group overall and on first and second attempt

	Descriptive Statistics				
	Group	N	Mean	StDev	SE Mean
Overall	Con.	17	3.00	2.00	0.49
	Exp.	26	1.77	1.73	0.34
1st attempt	Con.	17	2.71	2.31	0.56
	Exp.	26	1.31	1.89	0.37
2nd attempt	Con.	5	0.360	0.548	0.24
	Exp.	13	0.615	0.961	0.27

The research did not confirm any of hypotheses 3a, 3b and 3c, in which we hypothesised that the application of the proposed teaching model had a statistically significant impact on the overall success and success rate of the first and second attempts in the group of women. One possible explanation is the fact, verified by previous research [47] that women are more comfortable with face-to-face teaching, and the online module available to the experimental group did not affect the positive results of women. Moreover, face-to-face teaching, which, according to previous research results, is more suited to women, needed more time in the additional seminars to influence women's outcomes. Possible causes may have included an unexpected statistically significant difference between the overall mean success rates of men and women in the control group, as shown below.

c.Results for Men and Women in the Control Group

A statistically significant difference between men's and women's overall average success rates was found in the control group. As seen from Table 4, the women in the control group achieved a much higher overall average pass rate (3.00) than the control group of men. The two-sample T-test showed that the difference was statistically significant. (p=0.016). The 4c hypothesis, in which we assumed that there was no statistically significant difference in the overall average success rates of men and women in the control group, was not confirmed. One possible reason may be that women who study programs such as Applied Informatics and Automation in Industry and Mechatronics in Technological Equipment are not only interested in mathematics but also have excellent knowledge of mathematics compared to men who are more interested only in professional subjects of study programs. Further planned research is still needed to verify this assumption.

Table 4. The overall average success rate for men and women from the control group

	Descriptive Statistics				
	Sex	N	Mean	StDev	SE Mean
Overall	M.	96	1.65	1.60	0.16
	W.	17	3.00	2.00	0.49

d. Results for Men and Women in the Experimental Group

The research results confirmed hypothesis 4b, where we assumed no statistically significant difference in the overall average success of men and women in the experimental group. As seen from Table 5, the women in the experimental set achieved a higher overall average pass rate (1.77) than men (1.68). However, the two-sample T-test showed that the difference was not statistically significant. (p=0.823).

Table 5. The overall average success rates of men and women from the experimental group

	Descriptive Statistics				
	Sex	N	Mean	StDev	SE Mean
Overall	M.	72	1.68	1.72	0.20
	W.	26	1.77	1.73	0.34

e. Results for Men and Women Across the Respondent Group

The research results confirmed the validity of hypothesis 4a, where we assumed that there was no statistically significant difference in the average success rate of men and women in the whole group of respondents. Although women achieved a higher overall average success rate (2.26) than men (1.66), as shown in Table 6, the difference was not statistically significant. (p=0.067)

Table 6. The overall average success rate of men and women from the respondent's group

	Descriptive Statistics				
	Sex	N	Mean	StDev	SE Mean
Overall	M.	168	1.66	1.65	0.13
	W.	43	2.26	1.92	0.29

The above findings for the whole group of respondents and the experimental group regarding the same overall average success rate of men and women in Mathematics agree with our previous researches [48], [41], and other researchers' results [49], [50], [51], [52].

4. Conclusion

Although more research is needed to say with certainty that the proposed teaching model emphasising the development of transversal competencies is didactically effective, the presented research has revealed several significant findings.

The research results confirmed our assumption (hypothesis 1c) that applying the proposed model of teaching in additional seminars has a statistically significant impact on students' success on the second attempt (first attempt repeated) of the exam in mathematics.

We saw the same result in the men's group. Our assumption (hypothesis 2c) that the application of the proposed teaching model has a statistically significant impact on the success of men in mathematics on the second attempt at the mathematics exam was confirmed.

Unexpected for us were the results in the group of women. We were surprised by the non-confirmation of any of hypotheses 3a, b, c, in which we assumed that the application of the proposed teaching model has a statistically significant impact on the overall success rate and also on the success rate at the 1st, second attempt in the group of women.

Although in the second attempt, the women in the experimental group finished Mathematics I with better results than those in the control group, the difference in average success rates was not statistically significant. This discrepancy deserves further investigation, but one possible explanation is that women are more comfortable with face-to-face teaching. The second one is related to the sample size of women (17 + 26) being analysed. The obtained results' validity is limited and will be investigated more.

Nevertheless, research has confirmed that the proposed teaching model can be used in teaching mathematical subjects and, after some modification, in teaching computer science subjects. Obtained results also prove that the proposed teaching model substantially improves the success ratio of the most threatened students in the second attempt. Those students mainly impact retention in the first year of university study.

The described research results will be used in creating a model for teaching mathematical and informatics subjects using digital technologies and emphasising the development of transversal competencies to increase its didactic effectiveness.

Acknowledgements

This contribution was funded by the project KEGA 004STU-4/2022 "Model of online teaching with an emphasis on increasing the quality of education of engineers in a period of a possible pandemic."

References:

[1]. Reisel, J. R., Jablonski, M., Hosseini, H., & Munson, E. (2012). Assessment of factors impacting success for incoming college engineering students in a summer bridge program. *International Journal of Mathematical Education in Science and Technology, 43*(4), 421-433.

[2]. Faridhan, Y.E., Loch, B. & Walker, L. (2013). Improving retention in first-year mathematics using learning analytics. In Proceedings of Electric Dreams. Proceedings ascilite 2013 Sydney (pp. 278-282). Australasian Society for Computers in Learning in Tertiary Education.

[3]. Belser, C., Shillingford, A., Daire, A., Prescod, D., & Dagley, M. (2018). Factors Influencing Undergraduate Student Retention in STEM Majors: Career Development, Math Ability, and Demographics. *The Professional Counselor*, *8*, 262-276.

[4]. Hardy, P., & Aruguete, M. (2014). Needs assessment in STEM disciplines: reliability, validity and factor structure of the Student Support Needs Scale (SSNS). *Assessment & Evaluation in Higher Education, 39*(5), 553-562.

[5]. Bahr, P. R. (2008). Does mathematics remediation work?: A comparative analysis of academic attainment among community college students. *Research in Higher Education 49*(5), 420-450.

[6]. Kortesi, P., Simonka, Z., Szabo, Z. K., Guncaga, J., & Neag, R. (2022). Challenging Examples of the Wise Use of Computer Tools for the Sustainability of Knowledge and Developing Active and Innovative Methods in STEAM and Mathematics Education. *Sustainability*, *14*(20).

[7]. Pepin, B., Biehler, R., & Gueudet, G. (2021). Mathematics in engineering education: A review of the recent literature with a view towards innovative practices. *International Journal of Research in Undergraduate Mathematics Education*, *7*(2), 163-188.

[8]. Law, Y. K., Tobin, R. W., Wilson, N. R., & Brandon, L. A. (2020). Improving student success by incorporating instant-feedback questions and increased proctoring in online science and mathematics courses. *Journal of Teaching and Learning with Technology, 9*(1).

[9]. Bas, G., & Kivilcim, Z. S. (2021). Traditional, Cooperative, Constructivist, and Computer-Assisted Mathematics Teaching: A Meta-Analytic Comparison Regarding Student Success. *International Journal of Technology in Education, 4*(3), 464-490.

[10]. Navarra-Madsen, J., & Ingram, P. (2010). Mathematics tutoring and student success. *Procedia-Social and Behavioral Sciences, 8*, 207-212.

[11]. Nawaz, A., & Rehman, Z. U. (2017). Strategy of peer tutoring and students success in mathematics: An analysis. *Journal of Research and Reflections in Education, 11*(1), 15-30.

[12]. Drijvers, P. (2013). Digital technology in mathematics education: Why it works (or doesn't). *PNA, 8*(1), 1-20.

[13]. Asshaari, I., Tawil, N. M., Othman, H., Ismail, N. A., Nopiah, Z. M., & Zaharim, A. (2012). The Importance of Mathematical Pre-University in First Year Engineering Students. *Procedia - Social and Behavioral Sciences, 60*, 372-377.

[14]. Brittenham, R., Cook, R., Hall, J. B., Moore-Whitesell, P., Ruhl-Smith, C., Shafii-Mousavi, M., & White, K. (2003). Connections: An integrated community of learners. *Journal of Developmental Education, 27*(1), 18-25.

[15]. Shershneva, V. A., Noskov, M. V. (2007). The Mathematics Education of an Engineer: Traditions and Innovations. *Russian Education & Society, 49*(11), 70-84. Doi:10.2753/res1060-9393491104

[16]. Bargagliotti, A., Botelho, F., Gleason, J., Haddock, J., & Windsor, A. (2012). The Effectiveness of Blended Instruction in Core Postsecondary Mathematics Courses. *The International Journal for Technology in Mathematics Education, 19*(3), 83-94.

[17]. Luhan, J., Novotna, V., & Kriz, J. (2013). ICT Support for Creative Teaching of Mathematic Disciplines. *Interdisciplinary Studies Journal, 2*(3), 89-100.

[18]. Phuong, T. T. T., Danh, N. N., Le, T. T. T., Phuong, T. N., Thanh, T. N. T., & Minh, C. L. (2022). Research on the application of ICT in Mathematics education: Bibliometric analysis of scientific bibliography from the Scopus database. *Cogent Education, 9*(1).

[19]. Rahman, R. A., Yusof, Y. M., & Baharun, S. (2012). Improving the Teaching of Engineering Mathematics using Action Research. *Procedia - Social and Behavioral Sciences, 56*, 483-493.

[20]. Higbee, J. L., & Thomas, P. V. (1999). Affective and cognitive factors related to mathematics achievement. *Journal of Developmental Education*, *23*(1), 8-24.

[21]. Lima, P. D. S. N., das Almas Silva, L., Félix, I. M., & de Oliveira Brandão, L. (2019, October). Difficulties in basic concepts of mathematics in higher education: A systematic review. In *2019 IEEE Frontiers in Education Conference (FIE)*, 1-7. IEEE.

[22]. Merrill, C., & Comerford, M. (2004). Technology and mathematics standards: An integrated approach. *The Technology Teacher*, *64*(2), 8-12.

[23]. Leppävirta, J. (2011). The Impact of Mathematics Anxiety on the Performance of Students of Electromagnetics. *Journal of Engineering Education, 100*(3), 424-443.

[24]. Andrade-Aréchiga, M., López, G., & López-Morteo, G. (2012). Assessing effectiveness of learning units under the teaching unit model in an undergraduate mathematics course. *Computers & Education*, *59*(2), 594-606. Doi:10.1016/j.compedu.2012.03.010

[25]. Figueroa-Canas, J., & Sancho-Vinuesa, T. (2021). Investigating the relationship between optional quizzes and final exam performance in a fully asynchronous online calculus module. *Interactive Learning Environments, 29*(1), 33-43.

[26]. Cundiff, J. L., Vescio, T. K., Loken, E., & Lo, L. (2013). Do gender-science stereotypes predict science identification and science career aspirations among undergraduate science majors? *Social Psychology of Education*, 16, 541-554. Doi:10.1007/s11218-013-9232-8

[27]. Nosek, B. A., & Smyth, F. L. (2011). Implicit social cognitions predict sex differences in math engagement and achievement. *American Education Research Journal, 48*(5), 1125-1156.

[28]. Epuran, G., Gârdan, I. P., Gârdan D. A. & Tescașiu B. (2016). Modernisation of Higher Education in the Context of European Integration? A Comparative Analysis. *Amfiteatru Economic Journal, 18,* 42, 351-368.

[29]. Wagenaar, R. (2019). *Reform! Tuning the Modernisation Process of Higher Education in Europe: A blueprint for student-centred learning.* International Tuning Academy.

[30]. Zeng, X. (2023). Application of BOPPPS teaching model in online and offline blended teaching of college Public Basic Mathematics. *Applied Mathematics and Nonlinear Sciences*. Doi:10.2478/amns.2023.1.00185

[31]. Majerek, D. (2014). Application of Geogebra for teaching mathematics. *Advances in science and technology research journal, 8*(24), 51-54.

[32]. Voskoglou, M. (2019). Comparing teaching methods of mathematics at university level. *Education Sciences, 9*(3), 204.

[33]. Cassibba, R., Ferrarello, D., Mammana, M. F., Musso, P., Pennisi, M., & Taranto, E. (2020). Teaching mathematics at distance: A challenge for universities. *Education Sciences, 11*(1), 1.

[34]. Santos-Trigo, M. (2020). Problem-solving in mathematics education. *Encyclopedia of mathematics education*, 686-693.

[35]. Li, C., Herbert, N., Yeom, S., & Montgomery, J. (2022). Retention Factors in STEM Education Identified Using Learning Analytics: A Systematic Review. *Education Sciences, 12*, 781. Doi: 10.3390/educsci12110781.

[36]. Santangelo, J., Elijah, R., Filippi, L., Mammo, B., Mundorff, E., & Weingartner, K. (2022). An Integrated Achievement and Mentoring (iAM) Model to Promote STEM Student Retention and Success. *Education Sciences, 12*, 843. Doi: 10.3390/educsci12120843.

[37]. Teoh, S. H., Koo, A. C. & Singh, P. (2010). Extracting factors for students' motivation in studying mathematics. *International Journal of Mathematical Education in Science and Technology, 41*(6), 711-724.

[38]. Azmidar, A. Darhim, D. & Dahlan, J. (2017). Enhancing students' interest through mathematics learning. *Journal of Physics: Conference Series, 895*(1). IOP Publishing.

[39]. Kosiol, T., Rach, S., & Ufer, S. (2019). (Which) mathematics interest is important for a successful transition to a university study program?. *International Journal of Science and Mathematics Education, 17,* 1359-1380.

[40]. Országhová, D. (2018). E-learning approach in mathematical training of future economists. *E-learning and Smart Learning Environment for the Preparation of New Generation Specialists, 10*, 664.

[41]. Mišútová, M., Mišút, M. & Stúpalová, H. (2022). The state of the initial mathematical knowledge of engineering students in the post-pandemic period as a starting point for the development of e-courses. *Trends and Innovations in e-Business, Education and Security (TIEES 2022): 10th international scientific web-conference of scientists and PhD. students or candidates.* Budapest: The Slovak Society for Economic Informatics, 134-144.

[42]. Muminovic, A. J., Hadziabdic, V., Musanovic, S., Pervan N. & Delic, M. (2023). Improvement of Mathematical Teaching Through the Development of Virtual CAD Models and Physical Prototypes for Real Visualisation Using 3D Printing. *TEM Journal, 12*(1), 13-21.

[43]. Furner, J. M., & Berman, B. T. (2003). Review of research: math anxiety: overcoming a major obstacle to the improvement of student math performance. *Childhood education, 79*(3), 170-174.

[44]. Jawthari, M., Stoffa, V. (2022). Relation between Student Engagement and Demographic Characteristics in Distance Learning Using Association Rules. *Electronics, 11*(5), 724.

[45]. Stoffa, V. (2003). Computer-aided learning of programming. *International Conference on Computer Systems and Technologies – ComSysTech'2003*, 727-732.

[46]. Mišútová, M., Mišút, M. (2021). Students' attitudes to the use of MS Teams/G-meet in university mathematics teaching., in *XXXIV. DidMatTech 2021 Conference: New Methods and Technologies in Education, Research and Practice.* Budapest: Eötvös Loránd University (ELTE), Faculty of Informatics, 325-335.

[47]. Mišút, M., Mišútová, M. (2021). How Students Perceive Online Teaching IT Subjects within the MS TEAMS Environment, *Central-European Journal of New Technologies in Research, Education and Practice, 3*(1), 15-22, Doi: 10.36427/CEJNTREP.3.1.1192.

[48]. Misutova, M., Misut, M. (2019). Improving Teaching of Mathematics Through Data Mining and Learning Analytics. *13th International Technology, Education and Development Conference*, INTED Proceedings. Valencia: Iated-Int Assoc Technology Education & Development, 786-791.

[49]. Ethington, C. A., Wolfle, L. M. (1986). A structural model of mathematics achievement for men and women. *American Educational Research Journal, 23*(1), 65-75.

[50]. York, R., Clark, B. (2007). Gender and mathematical ability. *Monthly Review: An Independent Socialist Magazine, 59*(6), 7-15.

[51]. Udousoro, U. (2011). The effects of gender and mathematics ability on academic performance of students in chemistry. *African Research Review, 5*(4).

[52]. Sainz, M., Eccles, J. (2012). Self-concept of computer and math ability: Gender implications across time and within ICT studies. *Journal of Vocational Behavior, 80*(2), 486-499.