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Original Paper

On activating methods in mathematics education at university

Dana Országhová[1*], **Júlia Tomanová**[2]

[1] Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Institute of Statistics, Operation Research and Mathematics, Slovak Republic
[2] Constantine the Philosopher University in Nitra, Faculty of Natural Sciences and Informatics, Department of Informatics, Slovak Republic

ABSTRACT

Activating teaching methods focus on student engagement, meaning that learning takes place through students' own cognitive activity, independent thinking, and problem-solving. The aim of this research paper was to examine how additional mathematics tasks contribute to activating students in the acquisition of knowledge and skills, as well as to improving their study outcomes. The research data were collected during a pedagogical experiment conducted in the course "Information Coding and Displaying" during the 2023/2024 academic year. The research methodology was based on analysing the test scores of a control and an experimental group. Students' activation in the experimental group was promoted through additional mathematics tasks. Students in the control group were taught using the traditional method without activation tasks. The collected test data were analysed using selected methods of mathematical statistics (t-test). Findings indicate a positive impact of additional tasks on student activity in experimental group. The effectiveness of the implemented intervention was confirmed by t-test within the experimental group, where students achieved significant improvement in solving tasks in the post-test. In addition, the t-test confirmed statistically significant differences between the control and experimental groups, where the control group without additional tasks achieved better results in the post-test. Thus, the significant effect of additional tasks was not confirmed between the groups.

KEYWORDS: activating methods, university education, mathematics, additional tasks, t-test

JEL CLASSIFICATION: C50, D40, M10

INTRODUCTION

The teacher is an important factor in the process of developing students' knowledge. Factors influencing student outcomes include the level of teacher professional preparation, represented by the coverage of educational content, certification and creativity [7], [16]. In the educational process, teachers play the role of tutors who help students acquire competencies for working

* Corresponding author: doc. RNDr. Dana Országhová, CSc., Faculty of Economics and Management, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, e-mail: dana.orszaghova@uniag.sk

with information, they know how to motivate them in discovering solutions and guide them in interpreting the results and formulating conclusions to solve the problem [5].

Various studies have been conducted to investigate the impact of creative elements in mathematics teaching in primary, secondary and higher education. The results of the study showed that creative teaching has an impact on students' achievement, their attitude towards mathematics and reduces stress from this subject [1], [18]. Educational process is under the influence of many factors that have positive or negative impact on study outcomes. The use of activating methods creates opportunities for an individual approach to students and the development of their educational competencies. Talent search and development is an important goal of educational priorities that reflect the characteristics of mathematical creativity, the use of specific teaching techniques, and then analyze the impact of creative elements on mathematical knowledge [11].

Graduates of university studies with new competencies are an important basis for research and innovation development in practical fields. The low interest of high school graduates in studying technical programs, which include subjects from mathematics, physics and technical disciplines, also forces employers to actively search for talented students [8]. Information technologies have an impact on the educational process as a whole, in which the forms, methods and content of education are interconnected. As stated by English and Halford [6], the progress in the development of information technology changes the standards and requirements for future workers, thus creating a demand for modifications and adaptations in mathematical study programs. Rapid progress in the field of artificial intelligence (AI) opens up new possibilities for implementation in education at all levels of education, from elementary to higher education. The availability of IT tools modifies access to knowledge and information, which also changes the cognitive process and acquisition of knowledge of the young generation. It is important for current mathematical, technical and natural science education to be in line with new trends in preparation for lifelong learning. Students of technical universities should have knowledge of mathematics and physics. Innovative teaching models are aimed at developing the necessary skills through the implementation of mathematical software in education [13].

The changing labor market requires people who will be able to adapt to the changed conditions in the professions. Didactic games belong to activating methods of teaching. Via games teachers stimulate students' activity, support their creativity and intensify their performance in solving problems. Main intention is to engage students, to increase students' motivation and interest in the studied topic [9], [10]. Prídavková and Štefková [15] say that students do not have sufficiently developed mathematical competences at the level of connection and reflection, which is reflected in the approach to solving problems based on systematicity. As Boonen et al. [3] specify, both mental representation and reading comprehension abilities are required to solve word-mathematical problems, while presentation abilities are increasingly developed in the educational process. In another study authors recommend that reading comprehension skills should play a more important role in teaching mathematical word problems [12]. Samková et al. [17] declare that inquiry-based mathematics teaching is one of the possibilities to enrich education in science subjects and mathematics. It is assumed that this will increase students' interest in science subjects and improve the quality of their learning. The success in solving mathematical tasks is determined by understanding of terminology, particular mathematical methods and mastery of calculation skills and competences [14]. Mathematical literacy goes beyond simple counting and involves understanding mathematical ideas, using them in real-life contexts, interpreting information, thinking analytically, and making informed decisions based on numerical data [19]. The goal is for students to understand the meaning and importance of the subject matter in mathematics.

The influence of activating elements in mathematics teaching is the subject of research in many professional studies. Using active teaching methodologies (Figure 1) helps enhance students' cognitive, social, and motivational development, which in turn improves their study performance and contributes positively to the overall quality of the educational system [4].

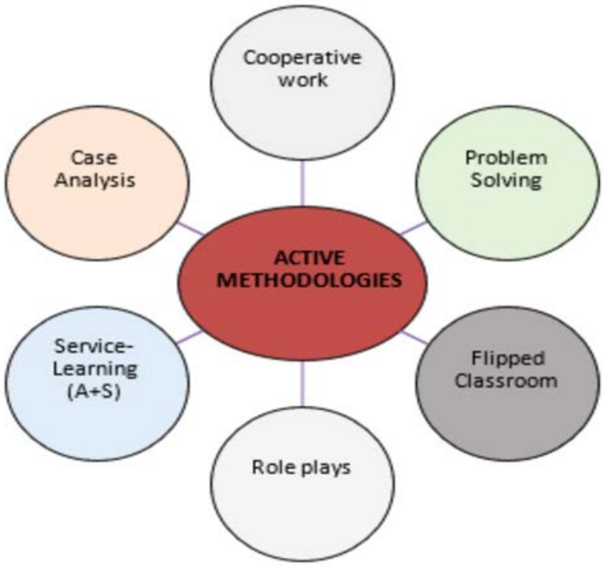

Figure 1 Active methodologies suitable for mathematics teaching
Source: [4]

Many study habits and behaviors were changed during the COVID-19 pandemic, which affected not only the field of education at all levels during the two whole years 2020-2021 [2]. The impact of the changes was also reflected in the work process and requirements for professional application.

MATERIAL AND METHODS

The main objective of this study was to analyse the possibilities of implementing activating teaching methods in university-level mathematics education. During academic year 2023/2024, a pedagogical experiment was conducted at the Faculty of Natural Sciences and Informatics of Constantine the Philosopher University in Nitra. The aim of the experiment was to integrate additional mathematics tasks into the instruction of the course *Information Coding and Displaying* and to examine their impact on students' learning outcomes. The course is taught in the first year of the *Applied Informatics* study program.

Data sample was collected from an experimental group and a control group of students, both of whom completed a pre-test and post-test. The experimental group consisted of 56 students who solved additional mathematics tasks regularly throughout the semester. The control group included 71 students who were instructed using traditional teaching methods without additional tasks.

In the contact form of education, the term traditional teaching methods refers to a set of proven educational procedures, into which progressive solutions and innovations are gradually incorporated. In both research groups, the basis of teaching in exercises in the subject *Information Coding and Displaying* was the information-receptive method (known as traditional method), which also used data projection, simulation and modeling software. Students solved tasks at school, while the correctness of the solution procedure was directly discussed. In the experimental group, where the selected activation method was applied, students received additional tasks that they solved at home and consulted obtained results with the teacher at the next exercise. The result of this activity was included in the overall assessment of the student in the subject.

The additional tasks were designed to reinforce foundational mathematical concepts required for successful completion of the course. Their purpose was to activate students through independent problem solving, encourage deeper cognitive engagement, and reduce difficulties commonly associated with the level of mathematical knowledge in first year study. Tasks were focused on algebraic operations, logical reasoning, numerical computation, and basic applications of mathematical tools relevant to information processing.

The curriculum of the course *Information Coding and Displaying* includes topics which students often find challenging. These difficulties relate to the specific nature of mathematics tasks and high cognitive demands on memory, knowledge of basic mathematical relations, logical reasoning, computational precision, and procedural accuracy. Teaching experience in this study program, together with persistent problems of students provided an important motivation for conducting this research.

Information Coding and Displaying covers the following fundamental thematic areas:

1. Logical Foundations of Information
2. Boolean Algebra and Digital Logic
3. Number Systems and Basic Encoding
4. Representation of Integers and Real Numbers
5. Coding of Text and Audio Information
6. Mathematical Tools for Information Processing

Both groups completed a pre-test and post-test composed of identical task types. Each test included multiple tasks with a defined distribution of points. The test focused on verifying basic mathematical competencies necessary for the course. Students solved 12 problems and could receive 12 points for solving a problem correctly.

Task types were selected from these categories:

1. Types of Equations and Algebraic Expressions
2. Factorials and Basic Numerical Operations
3. Solving Quadratic Equations
4. Geometry
5. Numbers Systems
6. Division and Remainders

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As a part of the research, we sought answers to these research questions:

Q1. What was the engagement rate of students in solving the additional tasks?
Q2. Do additional tasks improve the performance of students in the experimental group compared to the control group?
Q3. Do additional tasks improve the ability of experimental group students to solve specific types of problems?

Selected quantitative methods of mathematical statistics were applied to evaluate student performance in both tests. Analysis via statistical *t*-test examined differences in test success rates between the control and experimental groups and assessed the effectiveness of the implemented activating method.

RESULTS

This paper explores the activation of students through additional mathematics tasks. The aim of the research is to examine whether these tasks influence student engagement, motivation, and academic performance in mathematics.

The basic prerequisites for successfully completing the study include:
- Students' interest in the given subject and its issues,
- Understanding the meaning of the subject matter in mathematics,
- Study discipline and awareness of students,
- Quality prepared study materials in printed and electronic form (texts, audio and video programs, computer programs, etc.).

In the following section, we present the analysis of the obtained data, and answers to the research questions.

Question Q1 concerned the level of student engagement in solving additional tasks. Surprisingly, all students solved additional tasks, the level of engagement was 100%.

Question Q2 concerned the impact of additional tasks on the results of students in the experimental group compared to the results of students in the control group. We analyzed the scores achieved by students in the pre-test and post-test and obtained these results.

The boxplot (Figure 2) visually confirms that there are no meaningful differences between the control and experimental groups in the pre-test phase. This suggests that both groups started from a comparable level of initial knowledge or skill, which strengthens the methodological validity of subsequent comparisons in the post-test.

The purpose of the pre-test was to verify that both groups started at the same initial level of knowledge. A two-sample *t*-test assuming unequal variances was conducted to determine whether there is a statistically significant difference between the mean scores of the control group and the experimental group in the pre-test.

Hypotheses were formulated as follows:
Null hypothesis: There is no statistically significant difference between the mean pre-test scores of the control group and the experimental group.
Alternative hypothesis: There is a statistically significant difference between the mean pre-test scores of the control group and the experimental group.

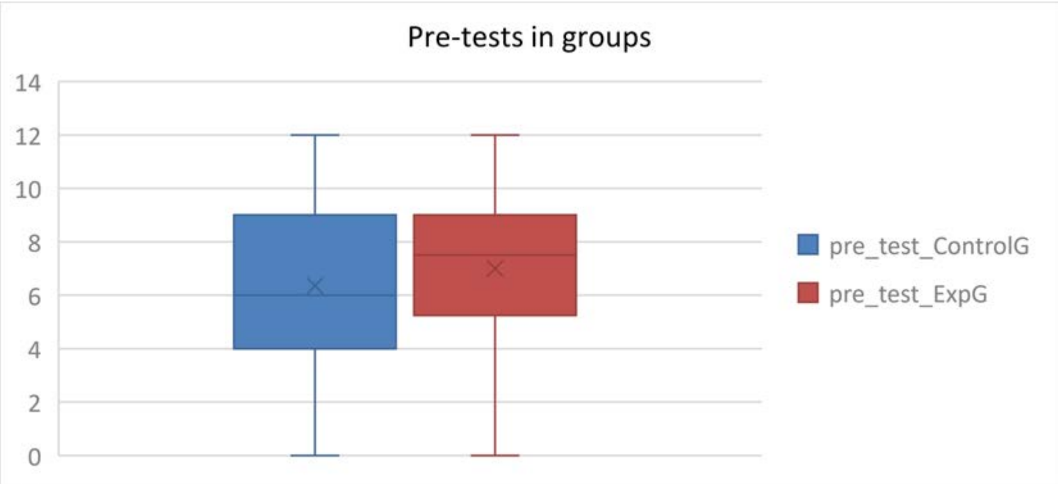

Figure 2 Pre-tests of control and experimental groups
Source: authors

The obtained *t*-statistic is *t* = –1.152, with 124 degrees of freedom. The associated two-tailed p-value is 0.251, which is greater than the conventional significance level of α = 0.05. Therefore, the null hypothesis of equal means cannot be rejected. This further confirms that the difference between the groups is statistically non-significant. Groups can be considered equivalent, which supports the validity of subsequent comparisons in the study (Table 1).

Table 1 Pre-tests: Two-Sample T-Test Assuming Unequal Variances

	pre_test_ControlG	*pre_test_ExpG*
Mean	6.352	7
Variance	11.374	8.727
Observations	71	56
Hypothesized Mean Difference	0	
df	124	
t Stat	-1.152	
P(T<=t) one-tail	0.126	
t Critical one-tail	1.657	
P(T<=t) two-tail	0.251	
t Critical two-tail	1.979	

Source: authors

In the following section, the post-test scores of students in the experimental and control groups are analyzed.

The boxplot (Figure 3) visually compares the distribution of post-test scores between the control group and the experimental group. The median score of the control group appears slightly higher than that of the experimental group. The interquartile range (IQR) of the control group is narrower, indicating that their results were more consistent and less variable. Both groups show outliers, but the experimental group includes a notably low outlier, which visually

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illustrates the larger variability within this group. The boxplot confirms that the control group not only achieved higher post-test scores on average but also demonstrated more stable performance, whereas the experimental group had a wider range of results and lower central tendency. This graphical evidence supports the statistically significant difference found in the *t*-test (see below).

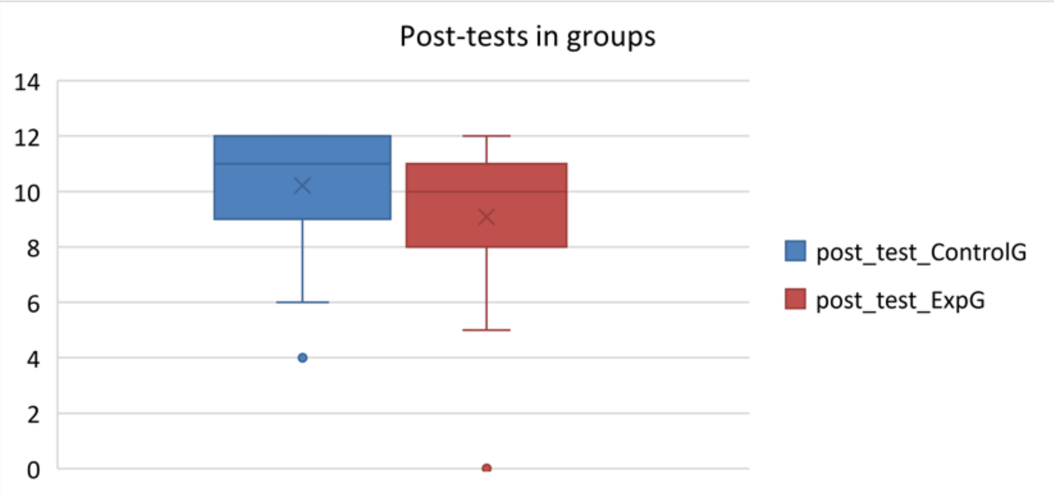

Figure 3 Post-tests of control and experimental groups
Source: authors

A two-sample *t*-test assuming unequal variances was conducted to evaluate whether there is a statistically significant difference between the control group and the experimental group in the post-test (Table 2).

Table 2 Post-tests: Two-Sample T-Test Assuming Unequal Variances

	post_test_ControlG	*post_test_ExpG*
Mean	10.211	9.089
Variance	3.398	11.210
Observations	71	56
Hypothesized Mean Difference	0	
df	81	
t Stat	2.253	
P(T<=t) one-tail	0.014	
t Critical one-tail	1.664	
P(T<=t) two-tail	0.027	
t Critical two-tail	1.989	

Source: authors

We tested the following hypotheses:
Null hypothesis: There is no statistically significant difference in the mean post-test scores between the experimental group and the control group.

Alternative hypothesis: There is a statistically significant difference in the mean post-test scores between the two groups.

The test produced a t-statistic of 2.253 with 81 degrees of freedom. The corresponding two tailed *p*-value is 0.027, which is below the conventional significance level of $\alpha = 0.05$. Therefore, the null hypothesis of equal post-test means is rejected, indicating a statistically significant difference between the groups.

Findings to the research question Q2 indicate that two groups performed differently in the post-test, with the control group achieving significantly higher results than the experimental group. Since no statistically significant difference was observed in the pre-test, this post-test difference suggests that the intervention applied to the experimental group did not lead to an improvement, and the control group ultimately outperformed the experimental group.

In this part we present findings to the research question Q3. Now we will analyze pre-test and post-test results in the experimental group to evaluate the effectiveness of the intervention from a different point of view. The descriptive and inferential statistics, together with the visual representation in the boxplot (Figure 4), provide consistent evidence of significant improvement.

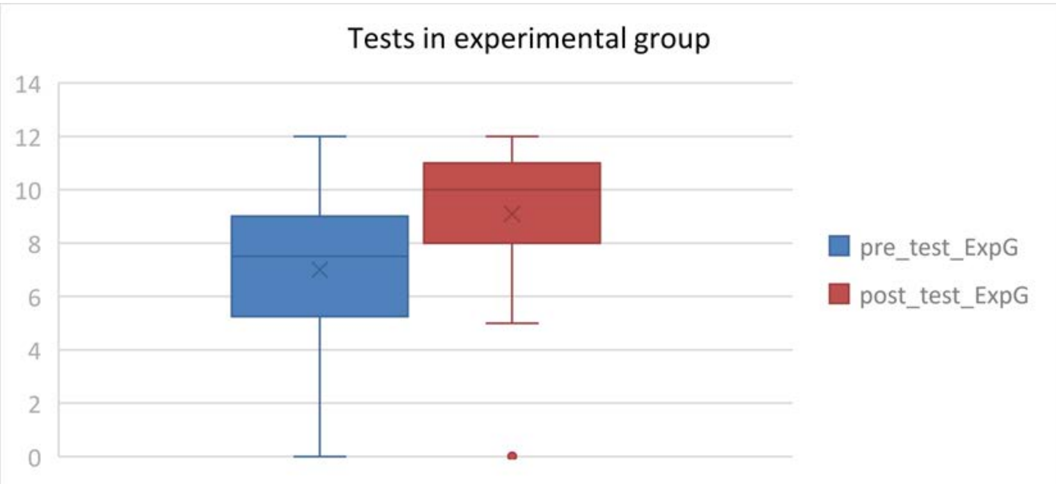

Figure 4 Comparison of pre-test and post-test in experimental group
Source: authors

We tested the following hypotheses (pre-test vs. post-test in experimental group):
Null hypothesis: There is no statistically significant difference between the mean pre-test and post-test scores of the experimental group.
Alternative hypothesis: There is a statistically significant difference between the mean pre-test and post-test scores of the experimental group.

The two-sample *t*-test assuming unequal variances produced a t-statistic of –3.502 with 108 degrees of freedom, corresponding to a two-tailed p-value of 0.0006. Since this value falls below the standard significance threshold of $\alpha = 0.05$, the null hypothesis of equal means is rejected. This confirms that the difference between the pre-test and post-test scores is statistically significant and not attributable to random variation (Table 3).

Table 3 Two-Sample T-Test Assuming Unequal Variances in experimental group

	pre_test_ExpG	*post_test_ExpG*
Mean	7	9.089
Variance	8.727	11.210
Observations	56	56
Hypothesized Mean Difference	0	
df	108	
t Stat	-3.502	
P(T<=t) one-tail	0.0003	
t Critical one-tail	1.659	
P(T<=t) two-tail	0.0006	
t Critical two-tail	1.982	

Source: authors

Obtained results demonstrate that the intervention applied to the experimental group led to significant and measurable improvement in performance from pre-test to post-test. This confirms the effectiveness of the educational plan in enhancing the targeted skills or knowledge among participants. Based on results, it can be stated that we received a positive answer to the research question Q3.

According to the outcomes of this study, several positive recommendations can be mentioned for more effective instructional practice:

First, the improvement observed in both groups suggests that the core teaching methods were effective, and these approaches should continue to be used and further refined. The structured testing phases appear to have supported learning progression, indicating that regular assessment and feedback cycles can be a valuable tool for monitoring student development.

Second, the additional tasks used in the experimental group show potential as a learning resource; with careful adjustment of complexity and clearer scaffolding, these tasks could become a powerful tool for deepening understanding and encouraging active engagement.

Third, both groups benefitted from consistent instructional routines, suggesting that maintaining a stable and supportive learning environment contributes positively to student outcomes. Finally, future instruction could build on the strengths demonstrated in this study by incorporating flexible or differentiated tasks that allow students to work at appropriate challenge levels while still benefiting from enriched learning opportunities.

CONCLUSIONS

Activating teaching methods place students at the center of the learning process by encouraging active participation, collaboration, and independent thinking. Activating teaching methods contribute to more effective, inclusive, and dynamic education systems.

The presented pedagogical experiment on the application of additional tasks in student activation brought these findings. In the pre-test, both groups displayed nearly identical median and mean values, and the boxplots showed overlapping interquartile ranges, indicating the absence of meaningful differences between the groups prior to the intervention. This aligns with the statistical results, confirming that both groups started from a comparable initial level.

The control group and the experimental group showed differences in the post-test phase. The post-test revealed a divergence, with the control group outperforming the experimental group by a significant margin. This suggests that although the intervention applied to the experimental group led to some improvement, it did not produce stronger outcomes than those observed in the control group. The consistent upward shift in the control group's performance, combined with reduced variability in the post-test, indicates that this group experienced the most substantial and reliable improvement over the course of the study.

Findings suggest that the additional tasks assigned to the experimental group did not translate into superior post-test performance in comparison with the control group. The control group demonstrated better knowledge in tests over the duration of the study. However, the experimental group showed significant improvement in knowledge in the post-test. These results point to the need for further examination of the design, difficulty, or cognitive demands of the additional tasks, as these factors may have influenced their effectiveness.

The impact of additional tasks on mathematics knowledge at university can vary and depends on the specific situation and the student's abilities and approach to learning. It is important that additional tasks are appropriate to the level of students and help them improve their knowledge and skills in mathematics. If they are properly designed and used regularly, they can help students better understand the topics, achieve better results and higher grades. The main benefit is that by solving additional tasks, students acquire new knowledge, abilities, skills and habits through their own activities.

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CONFLICT OF INTEREST
The authors declare no conflict of interests or competing interests.

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