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ENHANCING STUDENT MOTIVATION AND ACHIEVEMENT THROUGH DIGITAL MIND MAPPING

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Abstract. The established mind mapping technique can be effectively applied in various digital contexts. In this research, tasks related to ellipses were integrated into quizzes on the Moodle platform. Each task was designed using the mind mapping technique, enabling students to receive feedback and assistance at each step when they provided incorrect answers. The primary objective of this study was to evaluate improvements in student motivation and achievement through the digital implementation of mind maps. The experimental results showed that students who used this technique performed significantly better on tests compared to those who completed tasks using traditional methods. Additionally, a survey conducted among participants confirmed the effectiveness of digital mind maps in enhancing both student motivation and learning outcomes.

Keywords: mind maps; quizzes; Moodle; ellipse

1. Introduction

In the contemporary era, technological advancements have assumed an indispensable role in our lives. From computers and smartphones to the internet and artificial intelligence, technological innovations are perpetually engendering new possibilities and exerting a substantial influence on all aspects of human existence. This progress encompasses a wide range of innovations that have made life easier and more convenient. By introducing new ways of communication, we have created a present that was unimaginable at the start of the second millennium. These changes have also influenced education, transforming how students learn and teachers teach. Online learning platforms and interactive software enable more personalized and tailored education, which can lead to greater student engagement and improved performance. When used effectively, these tools can foster critical thinking, collaboration, and creativity among students. Innovations in the education system have the potential not only to equip students with relevant knowledge and skills for the 21st century but also to create a dynamic and adaptive learning environment that supports continuous progress for each student.

The Moodle platform (Modular Object-Oriented Dynamic Learning Environment) is one of the most widely used learning management systems, providing interactive, flexible, and personalized education. It enables educators to create and manage quizzes, assignments, discussion forums, and other digital learning activities, fostering an engaging and adaptive learning environment (Nash & Rice, 2018).

At the same time, mind mapping is a powerful visual learning technique that helps students organize information, understand complex concepts, and develop problem-solving skills (Subur, 2023). By structuring knowledge in a hierarchical, interconnected format, mind maps allow learners to see relationships between ideas, improving comprehension, retention, and critical thinking (Yan, Lee, Hu, & Lao, 2022). The combination of Moodle and mind mapping presents significant advantages in digital education, particularly in STEM disciplines such as mathematics.

This study explores the integration of mind mapping techniques within Moodle-based quizzes, specifically in the context of teaching ellipses in mathematics. Students were given tasks designed with a step-by-step mapping approach, allowing them to work independently while receiving detailed feedback at each stage. This interactive method fosters active learning, where students construct their own understanding rather than passively absorbing information. The benefits of this approach are multifaceted:

– Enhanced problem-solving: Mind maps help students break down complex mathematical concepts into structured steps.

– Personalized learning: Adaptive feedback in Moodle allows students to progress at their own pace, reinforcing their understanding.
– Increased engagement: The visual and interactive nature of mind mapping makes learning more stimulating and dynamic.
– Better knowledge retention: Structuring concepts through mind maps deepens understanding and improves recall.

To evaluate the effectiveness of this approach, this study employed quantitative statistical methods to compare student performance, alongside a qualitative analysis based on student feedback. The results provide insight into how Moodle and mind mapping can be effectively combined to improve student motivation, engagement, and academic achievement.

By leveraging Moodle's digital learning capabilities and the cognitive benefits of mind mapping, educators can create more effective and interactive learning experiences. This research contributes to the growing body of work on technology-enhanced learning, highlighting the potential of digital tools to transform mathematics education.

This manuscript is structured into six chapters. After the Introduction, Chapter 2 outlines the theoretical foundation of the research. Chapter 3 details the methodology used in the study, while Chapter 4 presents the statistical analysis of the results. Chapter 5 explores participant feedback, providing insights into their experiences with the approach. Finally, Chapter 6 offers the conclusion and discussion, summarizing key findings and potential directions for future research.

2. Theoretical background

During our research, we utilized mind mapping techniques and Moodle quizzes as integral components of the learning process. Both of these methods played a crucial role in structuring and enhancing students' understanding of mathematical concepts. This section provides a detailed overview of these approaches, their theoretical foundations, and their practical applications in the educational setting.

2.1. Quiz on the Moodle – tool for teaching and learning

In the contemporary digital era, technology has become an indispensable component of the educational process, facilitating access to educational resources in novel ways for both educators and learners. The Moodle platform is one of the most widely used learning management systems globally. Moodle was first launched in August 2002 with the intention of enhancing collaborative interaction among students as a supplement to traditional classroom teaching. However, over time it has evolved into an independent e-learning platform (Brandl, 2005). As a resource centre, the platform acts as an agora where teachers and students can interact – one can organise teaching sessions, share all types of materials, create quizzes, and even collect and evaluate students' work on it (Colombero & Dal Zotto, 2023).

Moodle is widely adopted in educational institutions due to its adaptability and the broad selection of functions and tools, which often surpass those offered by other systems (Robb, 2004). Recent research has highlighted the benefits of online quizzes as one of the tools available on the Moodle platform, as well as students' positive attitudes toward them (Cohen & Sasson, 2016); (Amer & Daher, 2019). The incorporation of carefully designed questions, combined with the option of repetition and the provision of tailored, automated feedback in the form of guidance on intermediate steps, facilitates the achievement of learning objectives and the development of the anticipated competencies in students. Additionally, once questions are created, they can be continuously refined with minimal effort from the instructor (Gamage, Ayres, Behrend, & Smith, 2019).

Furthermore, students receive prompt feedback on their performance, which enhances their understanding of the subject matter (Gamage, Ayres, Behrend, & Smith, 2019). Developing Moodle quizzes requires time and effort, in particular with regard to navigating quiz design settings and understanding Moodle-specific and often counterintuitive language use (Fernando, 2020). The quality and detail of the feedback provided in quizzes is therefore crucial. Research shows that students demonstrate better learning outcomes and more effective knowledge retention when they receive detailed feedback on online tests (Wojcikowski & Kirk, 2013)

Moodle's advantages make it a popular choice for implementing quizzes that aim to collect real-time feedback from students. Moodle quizzes, with their capability to integrate multimedia elements, support interaction and provide instant feedback, effectively assessing students' comprehension levels. Moreover, the platform's statistical features allow teachers to analyze patterns in students' responses and track the overall success of the course (Gamage, Ayres, Behrend, & Smith, 2019).

While Moodle quizzes are commonly used for knowledge assessment, their potential for enhancing conceptual learning and critical thinking is still being explored. Integrating mind maps into Moodle quizzes represents an innovative pedagogical approach that merges structured learning with visual representation, fostering deeper cognitive processing and self-regulated learning (Anggreani, Prahani, & Jatmiko, 2024).

2.2. Mind mapping

Humans are innately visual creatures, which is why mind mapping has become a popular tool for acquiring new knowledge. A mind map can be defined as a visual representation of knowledge, ideas, and concepts, as well as the relationships between them, within an individual's cognitive framework on a two-dimensional plane (Balim, 2013). Developed by Tony Buzan, a mathematician, psychologist, and brain researcher, mind mapping was initially created as a technique for taking notes briefly while being visually engaging (Buzan, 1974). Over time, it has evolved to serve a wide range of purposes, from studying and project planning to idea generation and organizing information.

Mind maps illustrate the structure, hierarchy, and connections between concepts, enhancing the efficiency of knowledge acquisition and stimulating creativity (Vanko, 2018). By engaging both sides of the brain, mind mapping utilizes the logical, analytical functions of the left hemisphere and the creative, spatial, and imaginative qualities of the right hemisphere. The left side handles logic, words, sequences, and analysis, while the right side is responsible for emotion, color, rhythm, and multidimensional thinking. This synergy between both hemispheres promotes productivity, creativity, and memory retention (Buzan, 1976).

These tools not only improve recall and retention of conceptual information but also help students establish connections between ideas, view problems from multiple perspectives, and enhance problem-solving abilities (Liu, Zhao, Ma, & Bo, 2014). Mind maps allow individuals to making them effective for identifying inconsistencies, sparking new questions, and fostering creative thinking (Vanko, 2018), (Svantesson, 1992). In this way, mind maps can be described as hierarchical structures, graphical representations, instructional tools, and methods for establishing correlations between information (Pullu & Kan, 2022). Through their ability to visually organize and stimulate both cognitive hemispheres, mind maps are an invaluable tool for learning, brainstorming, and creative processes.

Studies indicate that the combination of mind maps with interactive digital tools enhances student engagement and promotes active learning (Eppler, 2006). Given the adaptability of mind mapping to different learning styles, its integration into Moodle's interactive environment can further support knowledge structuring and metacognitive skills development (Budd, 2004).

2.3. Research question

The objective of this study was to improve students' understanding of the concept of ellipses. The research aimed to determine whether the integration of mind maps with quizzes on the Moodle platform could enhance cognitive effectiveness. Considering the benefits of both Moodle quizzes and mind mapping in fostering active learning, this study investigates whether combining these two techniques leads to a more effective learning process. Specifically, the research examines whether structured mind-mapped tasks within a digital quiz format can encourage independent problem-solving, improve conceptual understanding, and enhance student motivation compared to traditional learning methods. The research question was: "Does integrating mind maps into the quiz-based Moodle platform influence students' motivation to solve tasks independently, and is this learning method more effective than the conventional approach to learning with mind maps?"

3. Methodology

3.1. Participants

The study was conducted with students from eight classes at Gymnasium "Jovan Jovanović Zmaj" and two classes at the

Electrotechnical School "Mihajlo Pupin" in Novi Sad, Serbia, with a total sample of 202 students. The research took place during the second semester of the 2023/2024 academic year across six mathematics classes. Three professors, the first three authors of this paper, conducted all lectures in a coordinated and uniform manner. By mutual agreement, they utilized identical schematic representations on the board, assigned the same tasks, and maintained consistency in all other instructional elements. This standardized approach was implemented to ensure the validity of the experiment. In the Serbian secondary education system, the topic of ellipses is introduced in the third year. At the beginning of the study, students completed a preliminary test (Appendix 1) designed to assess their prior knowledge in key areas necessary for solving ellipse-related problems, including the equation of a line, quadratic equations, and systems of linear equations. The test consisted of five tasks, each worth a maximum of four points, with a total possible score of 20 points.

Following the preliminary test, students were divided into two groups: a control group and an experimental group. A paired-matching approach was used, ensuring that each student in one group had a counterpart in the other group with a pre-test score differing by no more than two points. This method ensured equal average pre-test scores across both groups. The final sample comprised 101 students in each group. Both groups received the same instructional content, including the same introductory material (Figure 1), theoretical explanations, and problem sets (Appendix 2). However, the mode of implementation differed between the groups. The control group followed a traditional instructional approach, in which students solved problems using mind mapping techniques with paper and pencil.

In contrast, the experimental group engaged in a digital learning approach facilitated by the Moodle platform. During the lessons, students accessed Moodle quizzes via their mobile devices and, under the teacher's guidance, worked through assigned tasks, familiarizing themselves with the platform environment. Subsequently, students in the experimental group received their homework assignments exclusively on Moodle. These assignments were designed as interactive quizzes, allowing students to progress through problem-solving steps with immediate feedback (see the next subsection). All tasks, whether completed during class or assigned as homework, were identical for both groups (Appendix 3). The sole distinction was the medium through which they were completed: students in the control group used traditional paper-based methods, while those in the experimental group completed a portion of their work digitally via Moodle quizzes. After five lessons covering the topic of ellipses in depth, students from both groups took a post-test (Appendix 4) in the following class to assess their acquired knowledge. The post-test consisted of five tasks, each worth a maximum of 10 points, with a total possible score of 50 points.

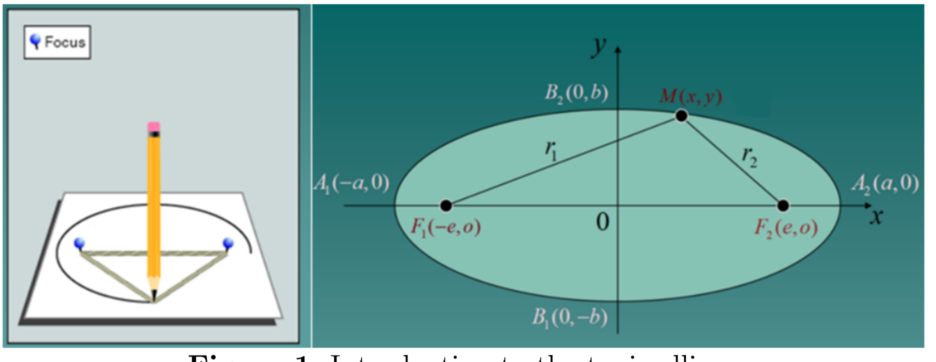

Figure 1. Introduction to the topic ellipse

Finally, following the post-test, students were invited to provide anonymous feedback regarding their experience with the learning process. The feedback aimed to evaluate their motivation and engagement with the digital approach, as well as to assess their interest in utilizing Moodle quizzes for other mathematics topics.

3.2. Mind maps integrated in Moodle quizzes

On the Moodle platform, we designed a series of illustrative tasks related to the topic of ellipses, each accompanied by comprehensive solutions structured using mind maps. These tasks were systematically deconstructed within the maps, clearly outlining the given data, the central problem, the sequential steps leading to the solution, and ultimately, the final result.

Each problem was broken down into multiple steps, represented as branches of the mind map. At each stage, students were required to respond to a specific question. In some cases, they needed to provide a numerical answer, while in others, they had to select the correct option from multiple choices. Immediate feedback was given for every response, informing students whether their answer was correct. If an incorrect answer was submitted, a visual prompt appeared, reinforcing the problem statement by emphasizing the given information and the task requirements.

Additionally, students were encouraged to attempt the problem again, with progressive hints provided for more complex questions. If, after multiple attempts, the correct answer was still not given, the full solution, accompanied by a step-by-step explanation, was displayed on the screen.

A homework assignment was used to demonstrate how students engaged with these tasks on the Moodle platform. The complete solution for a sample problem, utilizing the mind mapping technique, is illustrated in Figure 2.

The student is first prompted to identify the key value that must be determined in order to derive the equation of the tangent to the ellipse. Multiple answer choices are provided, but only one is correct (option b), as illustrated in Figure 3. If the student selects an incorrect answer, they receive immediate feedback indicating the mistake, accompanied by a visual representation highlighting the necessary calculation. This feedback not only clarifies the correct approach but also provides valuable guidance, enabling the student to make another attempt with a better understanding of the problem.

In one of the steps, the student is required to input the coordinates of the intersection point between a given line and the ellipse as an ordered pair. If the provided answer is incorrect, an on-screen prompt will guide the student to solve the corresponding system of equations, as illustrated in Figure 4. The student is then given the opportunity to re-enter their response.

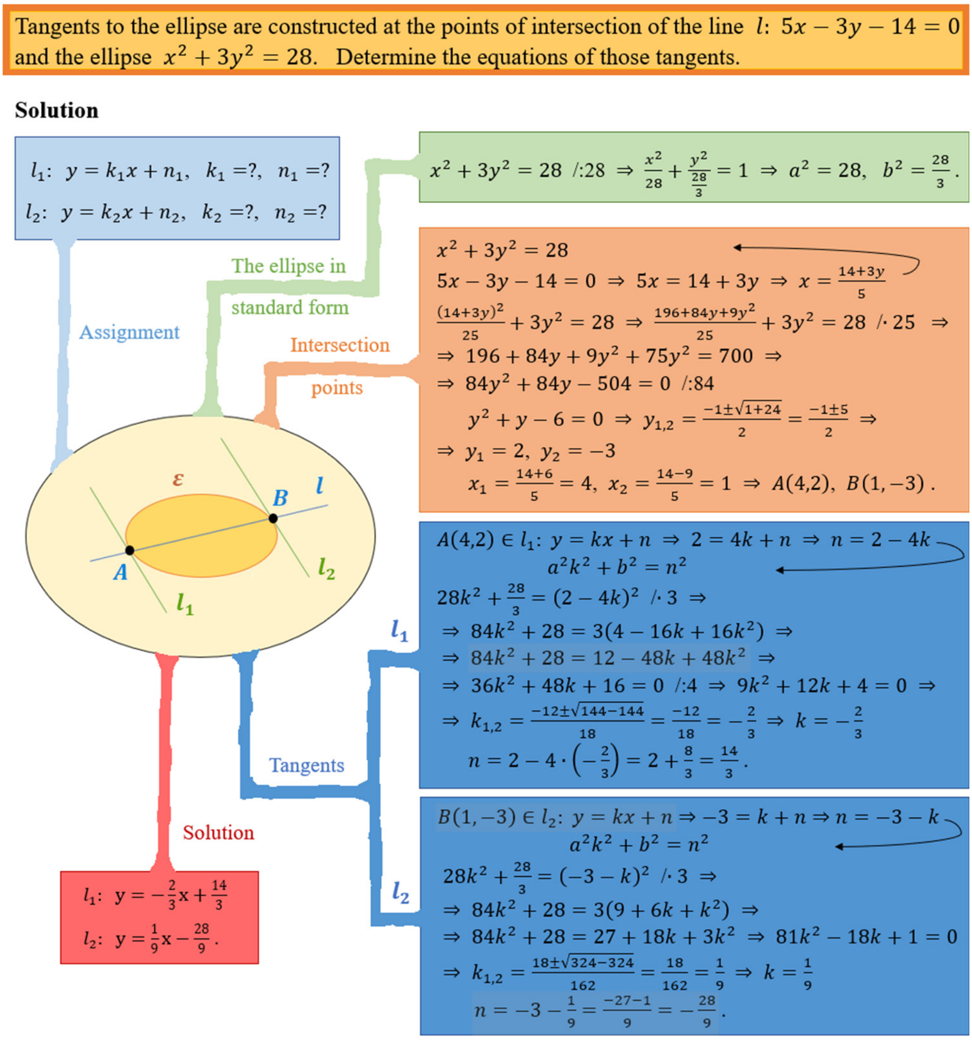

Figure 2. Mind map

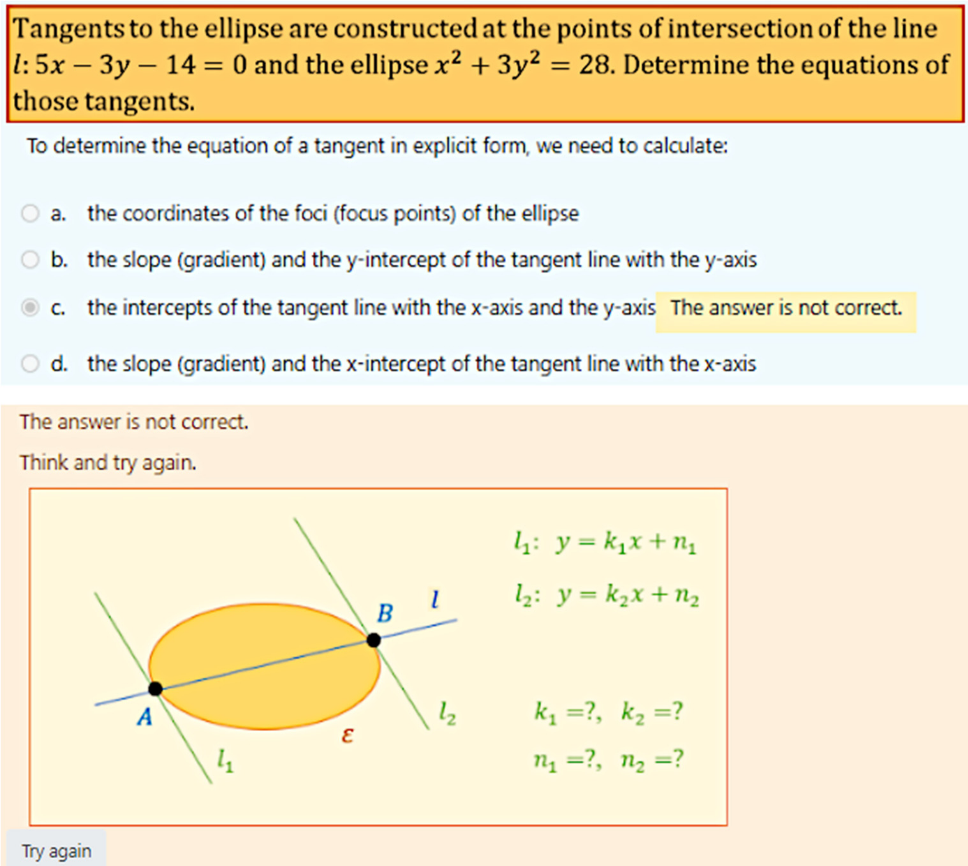

Figure 3. Quiz – multiple choice (one answer only)

If the student provides an incorrect answer a second time, the correct solution will be displayed on the screen along with a detailed explanation of how to solve the system of equations, as shown in Figure 5.

In the final step, the student must select the correct answer from multiple given options, as depicted in Figure 6. Since the problem has two valid solutions (two tangents that satisfy the problem's conditions), if the student selects one correct and one incorrect response, they will receive feedback indicating that their answer is only partially correct. The system will then allow them to attempt the question again.

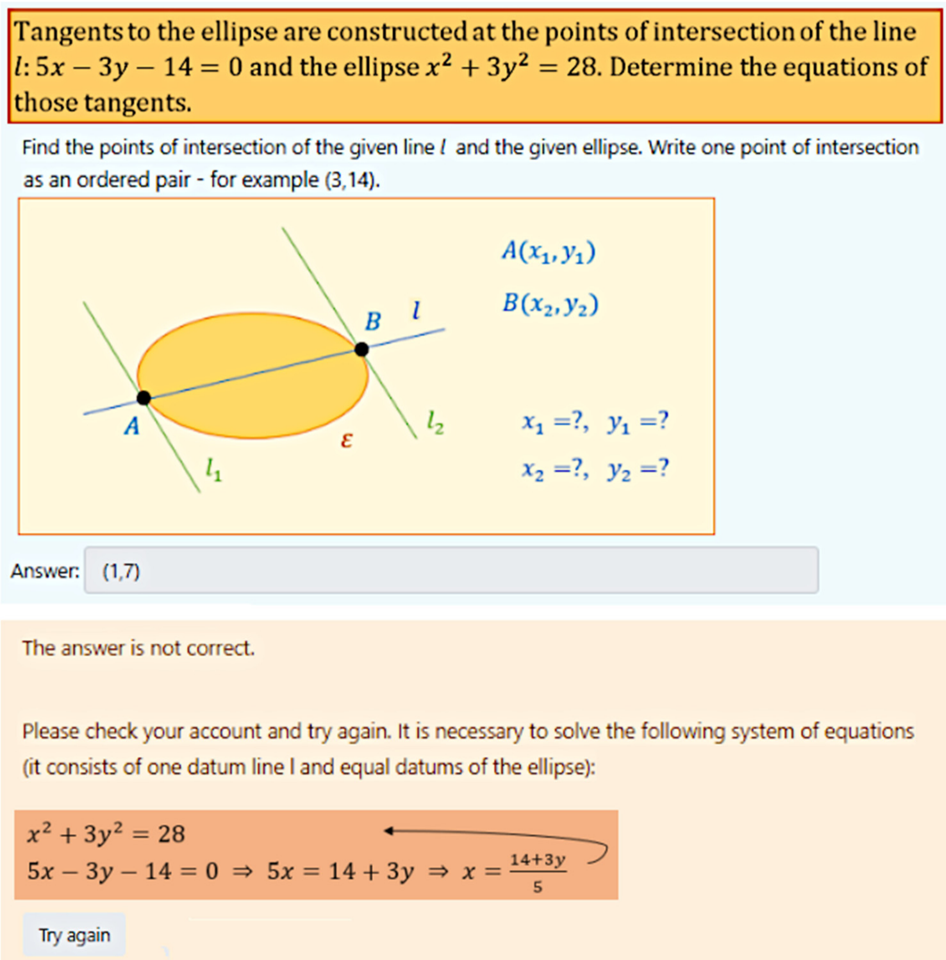

Figure 4. Quiz – short answer

All eight homework assignments for the experimental group were developed on the Moodle platform following this structured approach, incorporating the mind mapping technique to enhance problem-solving and conceptual understanding.

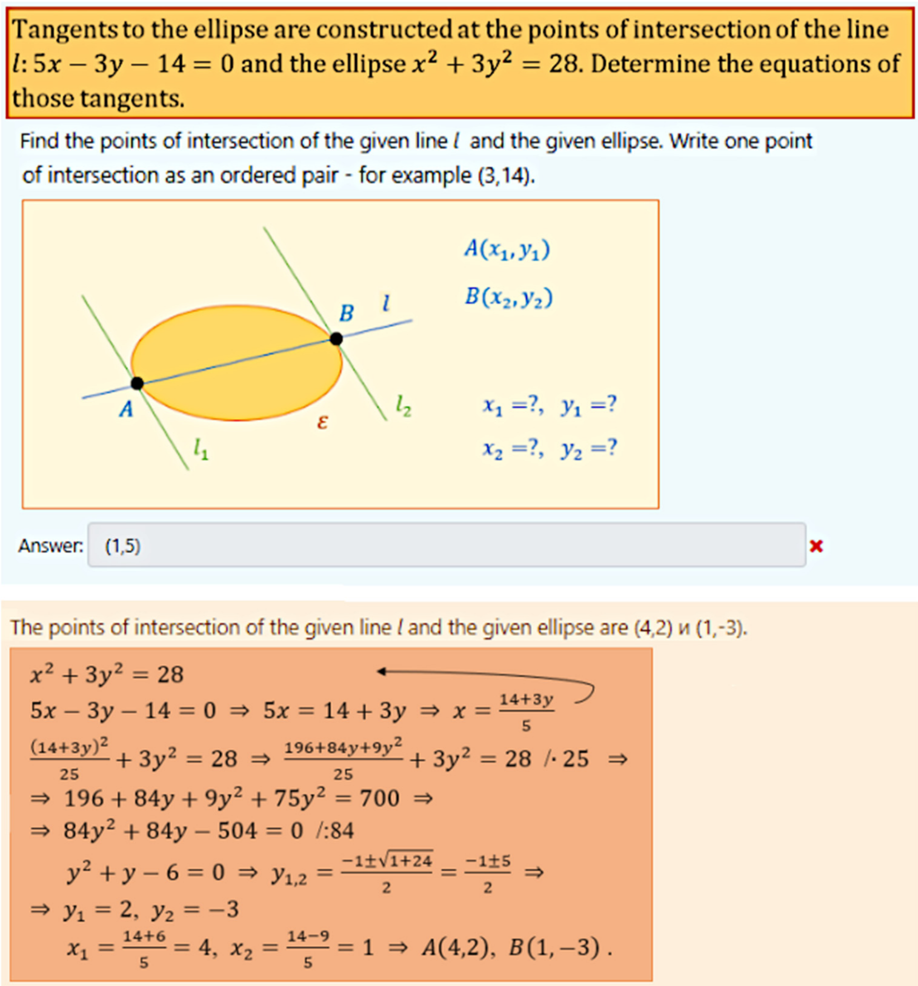

Figure 5. Quiz – second unsuccessful attempt

The use of mind maps in lectures proved to be highly engaging and motivating for students. Many expressed that this approach not only enhanced their understanding of the material but also encouraged them to actively engage in problem-solving.

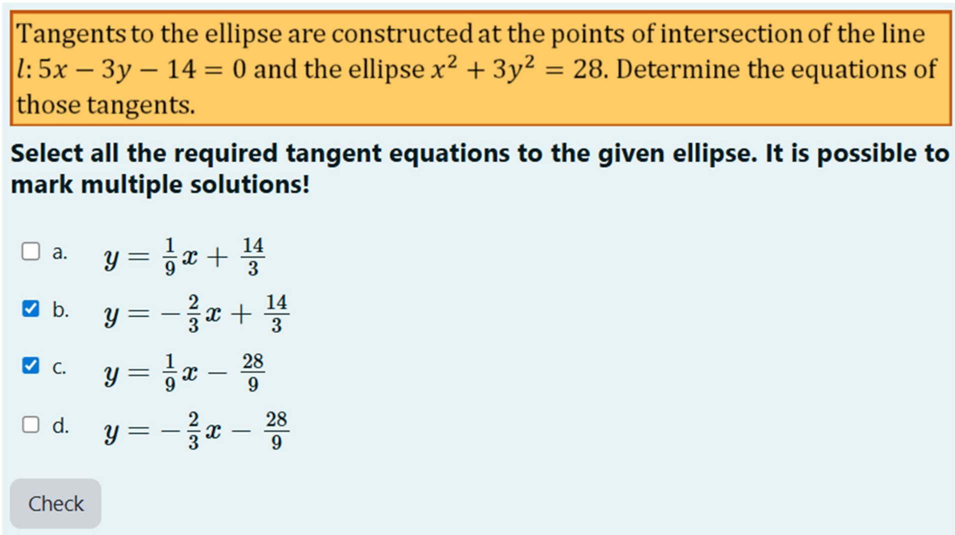

Figure 6. Quiz – multiple choice (multiple answers allowed)

The structured visualization of concepts allowed students to grasp complex ideas more intuitively, making the learning process more accessible and enjoyable.

Furthermore, the integration of the Moodle platform with mind mapping techniques for explaining tasks was particularly well received. Students found this method both interactive and intellectually stimulating, as it provided step-by-step guidance while allowing them to track their own progress. The immediate feedback and structured breakdown of problems within the Moodle quizzes fostered a deeper understanding and reinforced their learning.

Overall, the combination of digital learning tools and visual organization strategies proved to be an effective and fruitful approach, significantly contributing to student motivation and engagement in problem-solving activities.

4. Analysis of achievements

In this chapter, we present a statistical analysis of the pre-test and post-test results obtained in our research. The goal of this analysis is to determine whether the applied teaching methodology had a statistically significant impact on students' performance and to assess the effectiveness of using mind maps in combination with Moodle quizzes compared to traditional teaching methods.

4.1. Statistical analysis of the pre-test results

Before implementing the experimental intervention, a pre-test was conducted to evaluate students' prior knowledge of the topic. The pre-test included tasks assessing essential mathematical skills necessary for solving problems related to ellipses, such as solving quadratic equations, finding the equation of a line, and solving systems of equations. A total of 202 students participated in the pre-test, with 101 assigned to the experimental group and 101 to the control group. The selection of groups was carried out to ensure that both had equivalent prior knowledge, which was assessed through their pre-test scores. The results of the pre-test, presented in Table 1, show that there was no statistically significant difference between the two groups.

Table 1. Statistical results of the pre-test

	Number of students	Arithmetic means	Standard deviation	Test of difference between arithmetic means	
Group	N	M	SD	*t*	*p* (2-tailed)
Experimental	101	7.485	5.653	0.000	1.000
Control	101	7.485	5.500		

The arithmetic means of the scores in both groups were identical, confirming that the groups were well-balanced at the beginning of the experiment. This balance was crucial for ensuring the validity of the study, as it allowed us to attribute any differences in post-test performance solely to the teaching methodology rather than differences in students' initial knowledge. Additionally, the standard deviation values indicate a similar distribution of scores within both groups, further supporting the assumption that the experimental and control groups were comparable in terms of prior knowledge. The t-test results confirm that the observed difference between the groups is not statistically significant (t=0.000, p=1.000), reinforcing the reliability of our grouping strategy. By establishing that both groups had equivalent baseline knowledge, we created conditions for a fair comparison of the effectiveness of the two teaching approaches. This ensures that any differences in post-test performance can be directly attributed to the instructional methodology rather than pre-existing differences in students' mathematical abilities.

4.2. Statistical analysis of the post-test results

The analysis of the post-test results revealed a statistically significant improvement in the performance of the experimental group when compared to the control group. The experimental group achieved an average score of 34.535, while the control group scored an average of 25.663, a difference of nearly 9 points. This corresponds to a 34.57% higher achievement in the experimental group, showcasing a substantial improvement due to the intervention. A breakdown of task performance further highlights the superiority of the experimental group. As shown in Table 2, the experimental group outperformed the control group on every individual task. The most notable disparities were observed in tasks 4 and 5, which were the most complex in the post-test. This outcome aligns with the expectations that the experimental intervention would have a more pronounced impact on tasks requiring higher cognitive load.

Table 2. Average number of points per task on the post-test

Group \ Tasks	1	2	3	4	5	Total
Experimental	7.277	8.030	7.782	7.162	4.277	**34.535**
Control	5.663	6.257	6.762	4.703	2.227	**25.663**

To verify the statistical significance of the difference in post-test scores, a Student's t-test was conducted (Campbell & Stanley, 1963). The results, presented in Table 3, demonstrate a significant difference between the experimental and control groups ($p = 8.570 \cdot 10^{-6}$), indicating that the improvement in the experimental group is not due to random chance.

In addition to the t-test, Cohen's d was calculated to assess the effect size. The result of Cohen's d = 0.647 suggests a medium effect size, which further supports the practical significance of the intervention.

Table 3. Statistical results of the post-test

	Number of students	Arithmetic means	Standard deviation	Test of difference between arithmetic means	
Group	N	M	SD	t	p (2-tailed)
Experimental	101	34.535	12.128	4.574	$8.570 \cdot 10^{-6}$
Control	101	25.663	15.185		

5. Feedback

After the research was completed, students received feedback on their performance in the post-test. The students in the experimental group were given the opportunity to complete an online survey posted on the Moodle platform, where they could express their opinions about the new learning and teaching method used during the experiment.

A total of 62 participants from the experimental group completed the survey, and the results are presented in Table 4.

Table 4. Results of feedback

Questions	**Answers**				
	1	**2**	**3**	**4**	**5**
Tasks in the form of quizzes motivated me to do them independently.	8.1%	16.1%	19.4%	27.4%	29.0%
I believe that the quizzes posted on Moodle had a positive effect on my test grade.	16.1%	9.7%	17.8%	27.4%	29.0%
I think better exam success can be achieved by solving tasks in the form of quizzes rather than solving them in the traditional way.	12.9%	14.5%	25.8%	24.2%	22.6%
I think solving tasks using quizzes is a waste of time.	22.6%	27.4%	17.7%	16.1%	14.5%

I would like to use Moodle quizzes to cover other topics in mathematics.	19.4%	11.3%	29.0%	19.4%	21.0%
I prefer traditional teaching methods (such as blackboard and chalk) over the use of digital technologies like the Moodle platform.	4.8%	21.0%	24.2%	24.2%	25.8%
The feedback on correct and incorrect intermediate solutions from the quizzes was very helpful to me while solving the tasks.	3.2%	4.8%	12.9%	37.1%	41.9%

In the questionnaire within this survey, students used a scale with five possible responses ranging from 1 to 5: 1 – Totally disagree, 2 – Mostly disagree, 3 – I don't know, 4 – Mostly agree, 5 – Totally agree.

According to the survey results:

– **56.4%** of students believe that quiz-style assignments on Moodle motivate them to work independently, while **24.2%** do not think such quizzes significantly enhance their motivation.

– **56.4%** also feel that this method of learning and teaching has led to better results on the test, whereas **25.8%** feel that the quizzes did not significantly impact their post-test performance.

– **30.6%** of students consider quizzes a waste of time, while exactly **50%** disagree with this view.

– A large majority, **79%**, found the feedback on correct and incorrect answers during different steps of solving assignments very helpful, while only **8%** disagreed.

– Just over **40%** of students would like other math topics to be covered in the same way, **29%** have no opinion on the matter, and about **30%** are not interested in further use of quizzes.

– Finally, exactly **50%** of the participants prefer traditional learning methods over digital technologies, while only **25.8%** prefer learning through digital technologies rather than traditional methods, such as using a blackboard and chalk. This preference might also reflect negative experiences with remote teaching during the COVID-19 pandemic.

Overall, the survey indicates that most students find learning and teaching through mind maps integrated into quizzes on the Moodle platform useful in terms of motivation and performance on knowledge tests.

6. Discussion and conclusion

The findings of this study suggest that integrating mind maps with quizzes on the Moodle platform leads to a deeper understanding of ellipses compared to using mind maps alone in a conventional learning setting.

To examine this, students were divided into two equal groups (control and experimental), both possessing a similar level of prior knowledge necessary for understanding ellipses. The experimental group, which completed homework using mind maps integrated into Moodle quizzes, demonstrated significantly better performance on the post-test than the control group, which followed a traditional learning approach. This outcome was statistically validated.

Furthermore, a survey conducted after the study reinforced the effectiveness of the applied teaching and learning methods. More than half of the surveyed students reported that quizzes integrated into the Moodle platform positively influenced their motivation to solve tasks independently. Additionally, the majority expressed a preference for using this approach to study other mathematical topics as well.

As a result, our research question—whether the use of digital mind maps enhances comprehension—was answered affirmatively.

Future studies could explore the effectiveness of this method in other areas of mathematics, where similarly positive outcomes are expected. Moreover, it is essential to integrate the systematic use of mind mapping in Moodle-based quizzes into regular teaching practices. Mind mapping can also be applied across different digital platforms and learning environments, warranting further investigation into its effectiveness. Given its potential to enhance learning quality and improve student achievement, rigorous examination of these techniques is necessary.

Finally, while most students acknowledge the benefits of digital mind mapping for learning, half of the respondents still prefer traditional teaching methods, such as chalk and blackboard, over digital platforms.

This reluctance may stem from negative experiences with remote learning during the COVID-19 pandemic (Tzafilkou, Perifanou, & Economides, 2021). Future research should focus on identifying the most effective ways to integrate digital platforms into mathematics education while addressing students' concerns and preferences.

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Appendix 1. Pre-test

1. Solve the equation

$$\frac{3x}{x-1} - \frac{2x}{x+2} = \frac{3x-6}{x^2+x-2}.$$

2. For what values of the real parameter m, the equation $x^2 - (m+1)x + 2m - 1 = 0$ has unique solution?
3. Find the angle between the line $2x\sqrt{3} - 2y - 1 = 0$ and the positive part of x-axis as well as the intersection point of this line with the x-axis.
4. Find A and B in the linear function $Ax + By - 12 = 0$ such that the x-intercept is -2 and y-intercept is 6.
5. Find a linear function l in explicit form that is normal to the line $l_1: 3x - 2y + 8 = 0$ and contains the point which is the intersection of the lines $x + y - 3 = 0$ and $x - 2y = 0$.

Appendix 2. Tasks that were done during classes

1. Determine the semi-axes and foci of the ellipse $16x^2 + 25y^2 = 400$.
2. Determine the equation of the ellipse, knowing that points $M(6,4)$ and $K(-8,3)$ lie on the ellipse.
3. Find the value of the parameter A such that the line $Ax + y - 5 = 0$ is tangent to the ellipse $9x^2 + 16y^2 = 144$.

4. Determine the equation of the tangent line l_2 to the ellipse $x^2 + 2y^2 = 54$ that is normal to the line l_1: $x + y - 4 = 0$.
5. Given the tangents to the ellipse $x + 2y - 27 = 0$ and $7x - 4y - 81 = 0$, write the equation of the ellipse.
6. For the ellipses $9x^2 + 16y^2 = 144$ and $16x^2 + 9y^2 = 144$, determine their common tangents.
7. From the point $A(-4,2)$, construct the tangents to the ellipse $4x^2 + 25y^2 = 100$. Find the equations of these tangents.
8. Determine the equation of the ellipse if it contains the point $M(3, \sqrt{2})$, and its major axis is $2a = 2 \cdot \sqrt{15}$.
9. Determine the equation of the tangent to the ellipse $x^2 + 4y^2 = 100$ at its intersection points with the line $7x + 2y = 50$.
10. Determine the angle at which the ellipse $3x^2 + y^2 = 48$ is viewed from the point $P(8,0)$.
11. Determine the equation of the tangent to the ellipse $x^2 + 3y^2 = 28$ that forms an angle of $45°$ with the line $l: x - 5y - 20 = 0$.
12. In the ellipse $x^2 + 4y^2 = 4$, an equilateral triangle is inscribed. One vertex of this triangle is at the right vertex on the major axis of the ellipse. Determine the coordinates of the other vertices of the triangle.
13. In the ellipse $x^2 + 4y^2 = 36$, a square is inscribed. Determine its area.

Appendix 3. Homework

1. Determine the equation of the ellipse in canonical form if the distance between the foci is 6 and the length of the minor axis is 8.
2. Determine the equation of the ellipse in canonical form if the ellipse passes through the points $M(1,3)$ and $K(4,1)$.
3. For the ellipse $2x^2 + 3y^2 = 35$ and the line l_1: $3x - 8y - 24 = 0$, find the equation of the line l_2 that is tangent to the given ellipse and normal to the given line.
4. From the point $M(2,7)$, tangents are constructed to the ellipse $x^2 + 4y^2 = 100$. Determine the equations of these tangents in explicit form.

5. At the intersection points of the line $l: 5x - 3y - 14 = 0$ and the ellipse $x^2 + 3y^2 = 28$, tangents to the ellipse are constructed. Determine the equations of these tangents.
6. Determine the equation of the ellipse in canonical form if two of its tangents are known: l_1: $x + y - 8 = 0$ and l_2: $x + 3y + 16 = 0$.
7. Given the ellipse $x^2 + 4y^2 = 20$ and the line $l: y = -x + n$. Determine the parameter n such that the given line:
   a) touches the ellipse,
   b) intersects the ellipse,
   c) has no common points with the ellipse.
8. Which point on the ellipse $x^2 + 4y^2 = 20$ is closest to the line l: $x + y = 7$?

Appendix 4. Post-test

1. Find the equation of the ellipse, knowing that the points $M(2\sqrt{2}, 6\sqrt{2})$ and $K(-4, 3\sqrt{5})$ are on the ellipse.
2. Find the common tangents of the ellipses $x^2 + 6y^2 = 6$ and $9x^2 + 4y^2 = 36$.
3. Find the equation of the tangent line l_2 to the ellipse $3x^2 + 4y^2 = 120$, which is normal to the line $l_1: 2x - y + 7 = 0$.
4. Find the value of the parameter M such that the line $Mx + 5y - 15 = 0$ is tangent to the ellipse $2x^2 + 3y^2 = 18$.
5. The chord of the ellipse $x^2 + 3y^2 = 36$ on the line $x - y = 6$ is the base of an isosceles triangle whose vertex lies on the y-axis. Find the area of that triangle.

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