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Mobile applications as aids for solving systems of linear equations with two variables using the graphical method

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ABSTRACT

This study investigated the role of mobile applications as aids in solving systems of linear equations with two variables through the graphical method. The use of mobile applications was examined in a group of primary and lower school students to evaluate their effectiveness in learning mathematics and improving their skills in solving systems of linear equations. The main goal of this scientific paper is to investigate and evaluate the role of mobile applications as aids in solving systems of linear equations, involving students in the research process. The research method included a mixed-methods design including quantitative analysis of mobile application results and qualitative analysis of students' experiences and opinions. Data collection was conducted through individual interviews and classroom observations. The results show that the use of these technological tools has a positive impact on the involvement of students, increasing the interest and efficiency of learning. The findings also highlight challenges and suggestions for improving the use of mobile applications in the mathematics teaching context. This study contributes to the understanding of the use of mobile technology for the development of mathematical skills at the lower secondary school level.

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INTRODUCTION

At a time when technology is constantly advancing, mobile applications have gained an important role in the daily use of many areas of life, including the fields of mathematics and engineering. This scientific paper aims to examine the role and value of mobile applications as aids for solving systems of linear equations with two variables using the graphical method.

Systems of linear equations are an essential part of many branches of mathematics and engineering, and often, traditional methods for solving them can be time-consuming and exact, as well as difficult to understand. In this context, mobile applications come as an innovative and efficient tool to improve the understanding and solution of these systems.

The paper will explore some of the mobile applications available that provide the tools and graphics needed to solve systems of linear equations. An in-depth analysis will be done on their ability to graph equations and provide solutions understandably and efficiently. Also, a comparison between the apps will be included to assess the quality and advantages of each.

Students face some specific challenges in understanding and solving systems of linear equations, which can be effectively addressed through mobile applications. Here are some of these challenges and ways mobile apps can help: In the abstract concept many students have difficulty understanding the abstract concepts of linear equations and solving them. For example, understanding what it means to "solve the system" and how graphical interpretation of solutions coincides with algebraic solutions. In algebraic manipulation when manipulating terms and coefficients in linear equations is often challenging, causing errors in solving systems. In graphical interpretation, understanding and interpreting graphs of linear functions and how the points of intersection represent the solutions of systems is another challenge that students often encounter. Also, during concentration and engagement, learning systems of linear equations can be monotonous for some students, leading to a lack of concentration and engagement during lessons. Therefore, these applications can help students: Visualize concepts that provide powerful tools to visualize linear equations and their systems graphically. For example, applications such as GeoGebra and Desmos can display graphs of linear equations and their point of intersection in real time, helping students better understand various concepts. In interactive manipulation, apps enable simple manipulation of equations, where students can change coefficients and see the effects of their changes on the graph. This makes the learning process more intuitive and interactive, reducing algebraic errors. During instant feedback, many applications provide instant feedback on students' solutions, helping them identify and correct their mistakes in real time, which improves the learning and understanding process. Also, increased engagement and the inclusion of technology in the learning process increases student interest and engagement. Mobile apps make learning more engaging and hold students' attention for longer periods of time, improving their concentration and academic performance.

At the end of the paper, it is intended to continue with a critical evaluation of the use of these applications, identifying advantages and potential challenges. This analysis will contribute to the understanding of the impact of mobile technology in the field of mathematics and engineering, emphasizing their role in improving the way of solving systems of linear equations with the graphical method.

There are several mobile applications designed for solving systems of linear equations using the graphical method. These applications provide a handy tool for visualizing and solving linear equations in a graphical coordinate. Some of these applications include:

Desmos: Desmos is a popular application for visualizing mathematical functions on a graph. It can be used to represent systems of linear equations and to find the point of graphical convergence (Desmos, 2014).

GeoGebra: GeoGebra provides a convenient environment for solving linear equations graphically. Users can display equations and view their graphs interactively (GeoGebra, 2014).

Wolfram Alpha: Wolfram Alpha can be used to solve systems of linear equations by displaying graphs. Users can type the equations and the application will present the corresponding graph (Wolfram, 2014).

Mathway: There are many apps named "Graphing Calculator" that offer the ability to display graphs of equations. Users can write equations and the application will visualize them in a graphical coordinate (Mathway, 2014).

Photomath: Photomath has functionality for solving linear equations by photographing them. It can be used to display graphs of equations and identify system solutions (Photomath, 2014).

Each equation in the system of linear equations involves two variables and describes a straight line on a graph. Therefore, a system of two linear equations with two variables corresponds to two lines in the plane, labeled as l_1 and l_2. Various scenarios can arise from this setup (Zejnullahu, 2022):

1. Lines l_1 and l_2 expected: The system of equations has only one solution. The solution of the system is the ordered pair (x, y) of coordinates of the intersection point. In this case, the system is possible and definite.
2. Rights l_1 and l_2 are parallel: The system has no solution. In this case, the system is impossible.
3. Rights l_1 and l_2 match: The system has infinitely many solutions. In this case, the system is called potential and indefinite.

Purpose of the Study

The primary aim of this research paper is to examine and assess how mobile applications assist students in solving systems of linear equations with two variables, actively involving them in the research process. In particular, we aim to:

- We demonstrate how the use of mobile application technology can improve student engagement in learning mathematics and solving linear equations with two variables using the graphical method.
- We evaluate the advantages and challenges of using mobile applications compared to traditional methods of solving linear equations with the graphical method, including the analysis of the accuracy and efficiency of the results.
- We demonstrate that the involvement of students in the process of solving linear equations, using mobile applications and the graphic method, can contribute to the development of their analytical, technological, and communication skills.
- We create a more motivating and hands-on environment for students, engaging them in a technology- and math-ready experience that is essential to their overall educational development.

In this way, we aim to contribute to the knowledge of the field of mathematics education, promoting an innovative and inclusive approach that can bring progress in the learning and understanding of systems of linear equations in the context of mobile applications.

Research Questions

1. How do mobile applications affect students' engagement and interest when learning to solve systems of linear equations with two variables through the graphical method?
2. What are the advantages and challenges of using mobile applications compared to traditional methods for solving systems of linear equations?
3. How do the results of solving systems of linear equations with the graphical method using mobile applications differ compared to the traditional graphical method?
4. What skills do students develop through their involvement in solving systems of linear equations using mobile applications and the graphical method?

LITERATURE REVIEW

A linear equation in variables $x_1, x_2, \dots, x_n$ is an equation of the form $a_1x_1 + a_2x_2 + \cdots + a_nx_n = b$, where$a_1, a_2, \dots, a_n$ and b are constant real or complex numbers. A system of linear equations, also known as a linear system, consists of a finite set of equations where each equation is linear and involves the same variables. For instance, a linear system with m equations in n variables $x_1, x_2, \dots, x_n$ can be written as:

$$\left.\begin{array}{c} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n = b_1 \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n = b_2 \\ \vdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n = b_m \end{array}\right\}$$

A solution to a linear system is a specific set of values $(s_1, s_2, \dots, s_n)$ that satisfy every equation in the system when these values are substituted for $s_1, s_2, \dots, s_n$ are replaced by, respectively $x_1, x_2, \dots, x_n$. The collection of all such solutions for a linear system is termed its solution set. Every system of linear equations has one of the exclusive conclusions: (a) There is no solution; (b) Unique solutions; (c) Infinitely many solutions (Chen, 2010). Equations of the form $f(x) = g(x)$ can be solved graphically by plotting the graphs of $y = f(x)$ and $y = g(x)$. The solution is then given by the coordinate x of the point where they intersect (Strand, 2013).

Therefore, digital tools for graphing functions are widespread: there are graphing apps, spreadsheet software offers graphing options, specific educational software is available for computers and mobile technology, and dedicated handheld graphing calculators are on the market. Meanwhile, we would like to emphasize that there are no intrinsic pedagogical or mathematical differences between different types of graphic tools. Students themselves can purchase graphing calculators, which guarantee permanent access independent of school facilities (Drijvers & Barzel, 2012). When students are given the opportunity to utilize technology and participate in practical activities in a mathematics classroom, they can engage directly with mathematical concepts. Technological tools in mathematics offer students chances for interaction that go beyond what is achievable through traditional paper and pencil methods alone (McCullough et. al, 2021). One such example of mathematical technology is a calculator-based ranger (CBR) which gathers and presents motion data instantly. Engaging in CBR activities enhances students' skills in interpreting and modeling "physical phenomena," thereby improving their understanding of graphical representations (Kwon, 2010), I have incorporated several CBR exercises where students walk in front of a motion sensor to generate or replicate specific graphs (Remijan, 2019). Following the involvement of students in CBR activities in my classroom, along with outdoor exercises related to crash reconstruction alongside the Illinois State Police (Remijan, 2017), I designed a supplementary activity using toys, thrusters, and a CBR to simulate a "crash" scenario within the classroom. The dynamic aspect of the technology provides a fantastic opportunity to play with mathematics as it allows users to change aspects of a situation and observe the impact on the representation (here it was graphical and algebraic, but also applies to others such as geometric or numerical). Playfulness here is not in the sense of 'let's have fun messing around', but being open to exploring a situation and then trying to explain what is happening and why (Button, 2018). Since students in the classroom are more technology-savvy, new tools and resources are available to educators, but teachers are not always prepared to integrate technology into lessons efficiently and effectively (Onal, 2016). Findings from Orhani, (2023) offer insights into enhancing teaching methods and establishing Mathematica as an effective tool for exploring quadratic functions within mathematics education. (Orhani, 2023).

METHODOLOGY

The methodology of this scientific study aims to determine and describe how they will implement the strategy of the use of mobile applications for solving systems of linear equations with two variables. For this study, mixed-methods were chosen, including the quantitative analysis of the results of mobile applications and the qualitative analysis of the experiences and thoughts of the students.

Metrics and parameters

To evaluate the performance and effectiveness of mobile applications in helping students understand and solve systems of linear equations, it is necessary to define clear metrics and parameters. These metrics can help objectively assess the impact of these apps on improving student learning and achievement. Here are some specific metrics and parameters that were used: Improvement in test scores, where comparisons were made in test scores before and after using mobile applications. With GPA parameters, percentage of students passing tests, improvement of specific questions of linear equations. Also, problem solving time shows the metric measuring the average time students take to solve systems of linear equations before and after using the app. With parameters of average time per problem and change in total solution time. On the other hand, the accuracy of the solutions is used as a metric with the percentage of correct solutions before and after using the application. And with the parameter of the number of mistakes made, the percentage of correct solutions in the tests. During engagement and participation, the metric of measuring the level of engagement and participation of students while using the application was used with the parameters of time spent in the application, the number of use sessions and the frequency of use of the application. During the feedback, the metric was treated with the evaluation of the application by students and teachers through surveys and interviews with the parameters of user satisfaction, perception of improvement of understanding and recommendation for improvement. And finally, error analysis with metric analysis of the type and frequency of errors made by students while using the application with the parameters of the most common type of errors, as well as the reduction of specific errors after using the application.

Participants

The sample of this study includes the students of the primary and lower secondary schools "Heronjtë e Lumës" and "Zef Lush Marku" from Prizren, who are involved in the teaching of mathematics and have basic knowledge of solving systems of linear equations with the graphical method. To ensure a purposive and representative selection of students from lower secondary schools, we will use the following criteria for selecting the sample:

Level of knowledge in mathematics: To ensure that selected students have at least basic knowledge in solving systems of linear equations.

Engagement in learning: To engage students who are active and interested in learning mathematics.

Use of mobile applications: Students who have experience in using mobile applications for solving systems of linear equations.

Data Collection and Analysis

Individual interviews: Using interviews to allow students to share more of their experiences and thoughts in a more informal and freer environment. Students will be encouraged to share their experiences and express themselves about the meaning and difficulties they encountered using mobile applications for solving systems of linear equations in two variables.

Observations: Use observations while using mobile applications in the classroom to capture student reactions and behavior in real time. Observations were an important tool to observe student behavior and to record changes in the use of mobile applications in solving systems of linear equations with the graphical method in a learning environment. At this stage, the tasks to be observed will be prepared, including the use of mobile devices by students and how they integrate them in solving systems of linear equations with two variables. During the observation, the time that students spend using mobile applications for solving systems of linear equations will be recorded, observing their intensity and dedication. Through these observations in the classroom, it is intended to collect accurate and detailed data about the use of mobile applications by students during mathematics learning. The observations will contribute to a deeper understanding of the impact of mobile technology in the learning environment.

RESULTS

The results chapter aims to present and analyze the main findings of the study on the use of mobile applications for solving systems of linear equations with two variables through the graphical method in mathematics classes. This section reflects on how effective these technological tools are in improving learning performance and developing students' mathematical skills. After a brief overview of the methodology and objectives of the study, this chapter will focus on some essential challenges and results achieved from the analysis of the data collected during the research phase.

Analysis of the results from the observation

In this chapter, we will analyze the results of the observations made during the use of mobile applications for solving systems of linear equations with two variables through the graphic method. The observation was carried out in several lower secondary school classes, where some important aspects and results were observed. We are analyzing the first task solved in the notebook with a pencil and the one using the GeoGebra application:

1. Solve the system of linear equations with two variables by the graphic method:(25 points)

$$\left.\begin{aligned} 4x - y = 1 \\ x + y = 4 \end{aligned}\right\}$$

In our analysis of the task of solving systems of linear equations with two variables through the graphical method, a difference is observed in the performance of students depending on how the task was solved: with a pencil or with the use of the GeoGebra application.

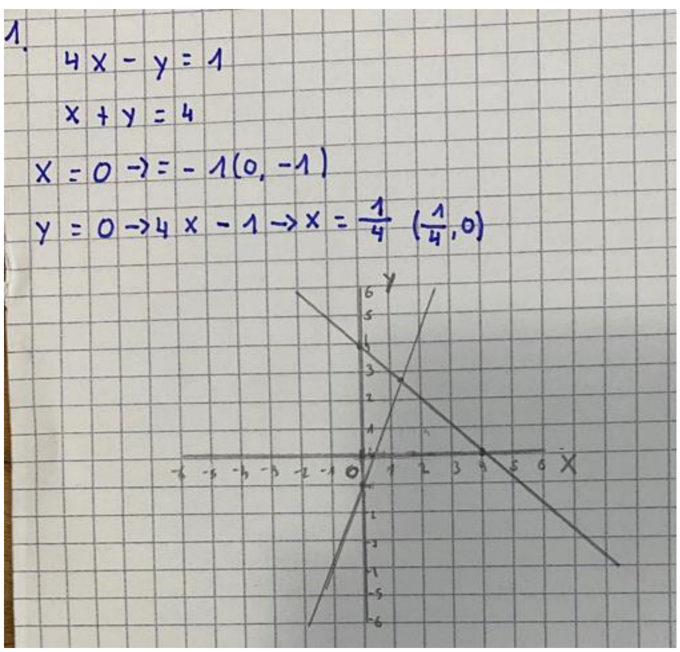

Fig. 1. Solving the system of equations by a student

When using the pencil to solve the task, some errors in the accuracy of the results were observed. The students showed some difficulties in determining the common points of two lines and in finding the correct solution to the system of linear equations. These errors often resulted in incorrect or incomplete answers.

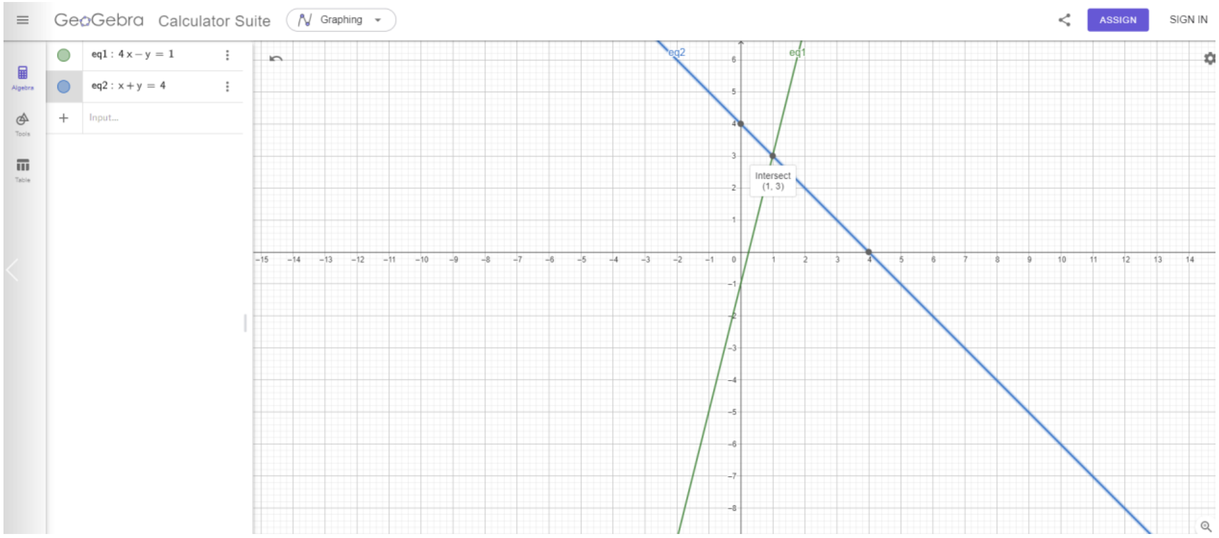

Fig. 2. Solving the system of equations with the GeoGebra application

On the other hand, students who solved the task using the GeoGebra application showed a high level of accuracy and an improved ability to find the exact solution of the system of linear equations. The use of this application facilitated the process of graphing two lines and identifying the common point, making the solution to the task clearer and more precise.

From this analysis, it appears that the use of mobile applications, such as GeoGebra, offers an advantage compared to the traditional pencil solution in similar tasks. Information and communication technology (ICT) applications can be an effective tool to improve students' understanding and performance in mathematics and in solving various problems related to this field.

We are analyzing the second task solved in the notebook with a pencil and the one using the Mathway application:

2. Solve the system of linear equations with two variables by the graphical method:(25 points)

$$\left.\begin{aligned} 2x + 2y &= 6 \\ x + y &= 2 \end{aligned}\right\}$$

In the analysis of the second task, where the solution of the system of linear equations with two variables was requested by the graphical method ($2x + 2y = 6$ and $x + y = 2$), an evident difference in the performance of the students is observed depending on how the task was solved: using a pencil or the Mathway application.

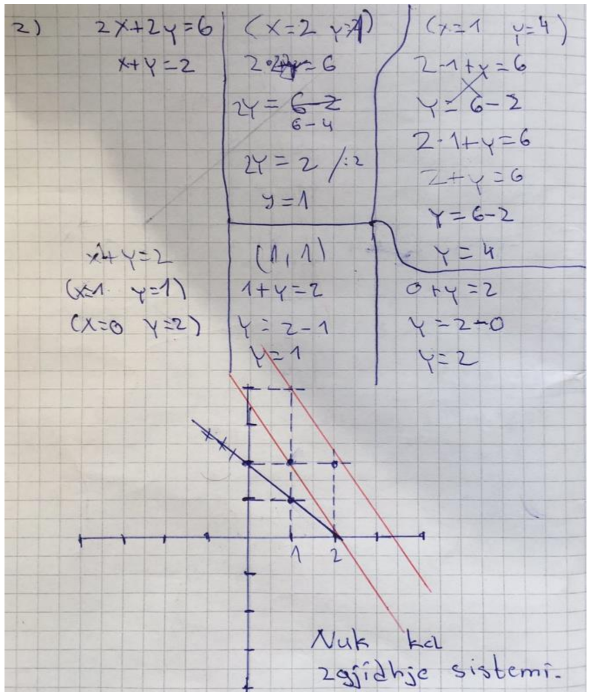

Fig. 3. Solving the system of equations by a student

Students who solved the task with a pencil showed some difficulties in drawing parallel lines in the coordinate system. This led to identification errors that the system had no solution for. In some cases, students showed difficulties in understanding the concept of parallel lines, leading to large errors in the interpretation of the graph.

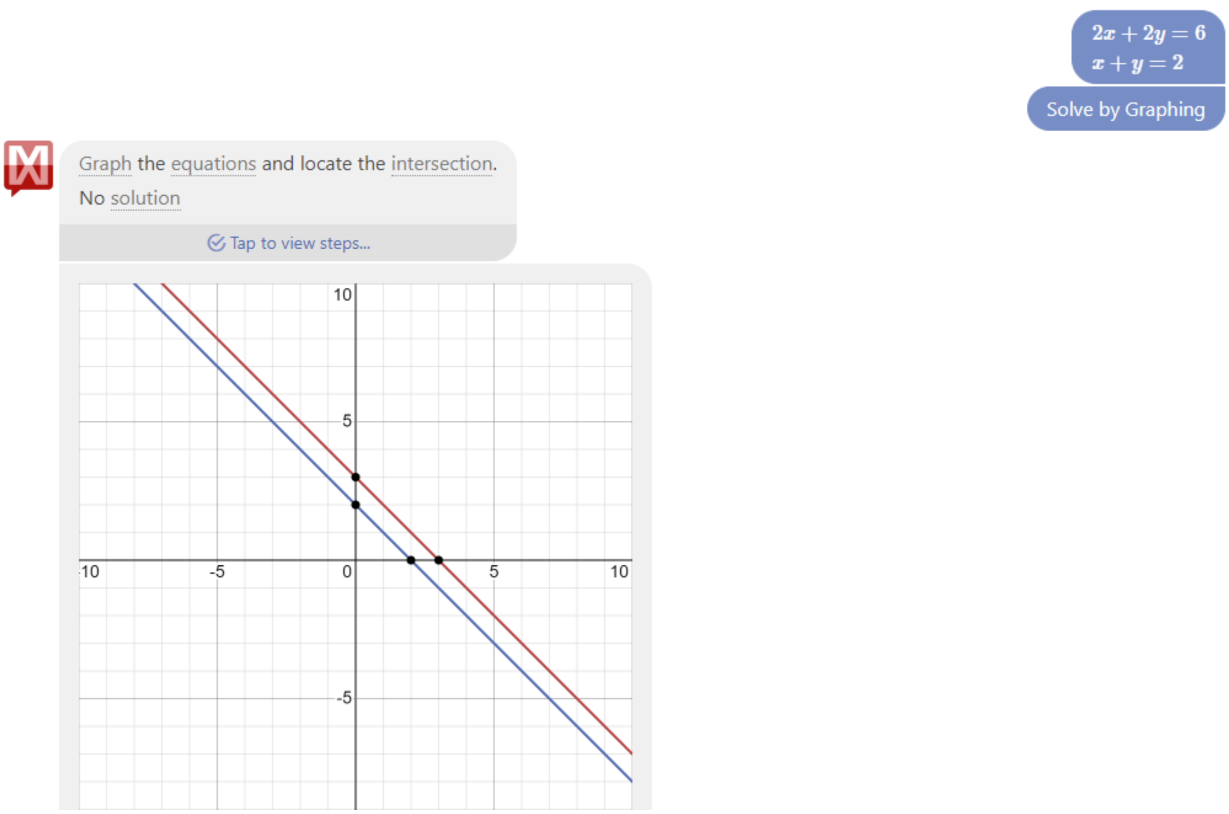

Fig. 4. Solving system of equations with Mathway app

On the other hand, students who solved the task using the Mathway application showed a high level of accuracy and efficiency in solving the system of linear equations. The application provided a fast and accurate solution using sophisticated algorithms to graph and identify parallel lines.

From this analysis, it can be seen that the use of mobile applications, such as Mathway, offers a clear advantage compared to the traditional pencil solution in similar tasks. Information and communication technology (ICT) applications can be an effective tool to improve students' understanding and performance in mathematics and in solving various problems related to this field.

We are analyzing the third task solved in the notebook with a pencil and the one using the Photomath application:

3. Solve the system of linear equations with two variables by the graphic method:(25 points)

$$\left.\begin{aligned} x + y = 3 \\ 4x + 4y = 12 \end{aligned}\right\}$$

In the analysis of the third task, which was asked to solve the system of linear equations with two variables by the graphical method ($x + y = 3$ and $4x + 4y = 12$), differences were observed in the students' performance depending on how the task was solved: with a pencil or using of the Photomath application.

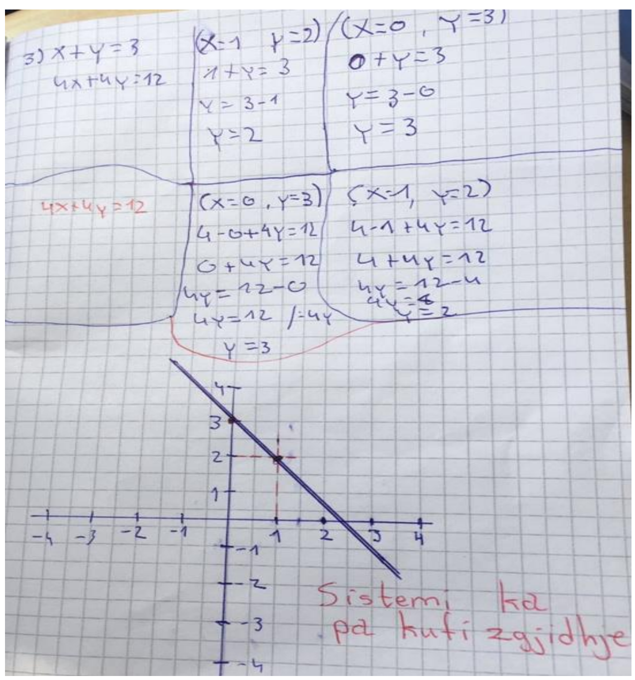

Fig. 5. Solving the system of equations by a student

Students who solved the task with a pencil showed a good effort to draw lines in the coordinate system at right angles to the plane. However, they made a mistake in understanding the system of equations and the number of lines. Some students think that the system has one line, when in fact, the two lines coincide and represent the same line.

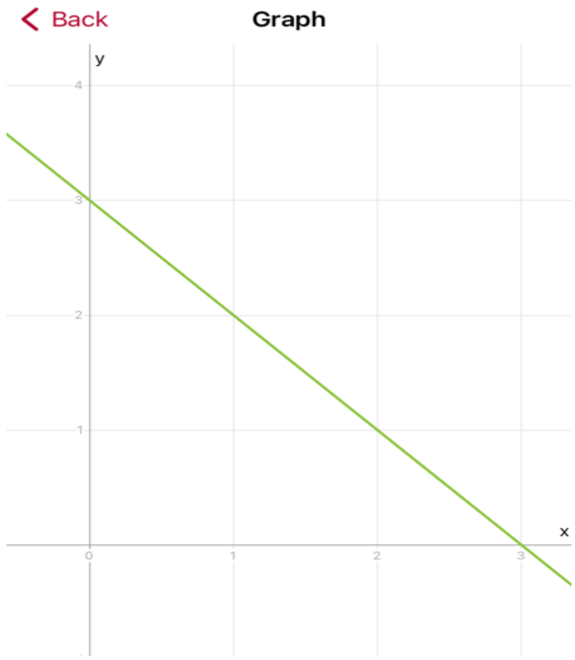

Fig. 6. Solving the system of equations with the Photomath application

On the other hand, students who solved the task using the Photomath application showed a high level of accuracy and understanding. The application provided a quick and accurate solution, identifying the lines and clearly showing that the system has infinite solutions, as the lines match.

From this analysis, it is clear that the use of mobile applications, such as Photomath, offers a clear advantage compared to the traditional pencil solution in similar tasks.

We are analyzing the fourth task presented as a problem and then solving it in a notebook with a pencil and using the Desmos application:

Artan bought several bus tickets and several train tickets for one trip. The bus ticket costs 20 euros each, while the train ticket costs 30 euros each. Artan bought a total of 5 tickets and paid 130 euros for them. How can he determine the number of bus and train tickets that Artan has bought? (Solve the system of equations by the graphical method). (25 points)

In the analysis of the fourth task, which is a mathematical problem for solving a system of linear equations with two variables, differences were observed in the students' performance depending on how the task was solved: with a pencil or with the use of the Desmos application.

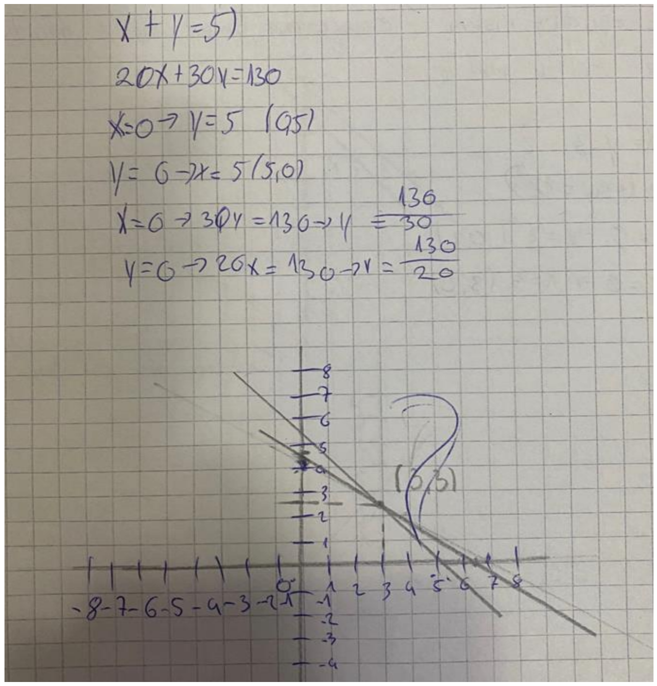

Fig. 7. Solving the system of equations by a student

Students who solved the task with a pencil showed an attempt to solve the problem through the method of systems of linear equations. They may have determined the equations for bus and train tickets, but some of them may have had difficulty finding the correct graphical solution for the system.

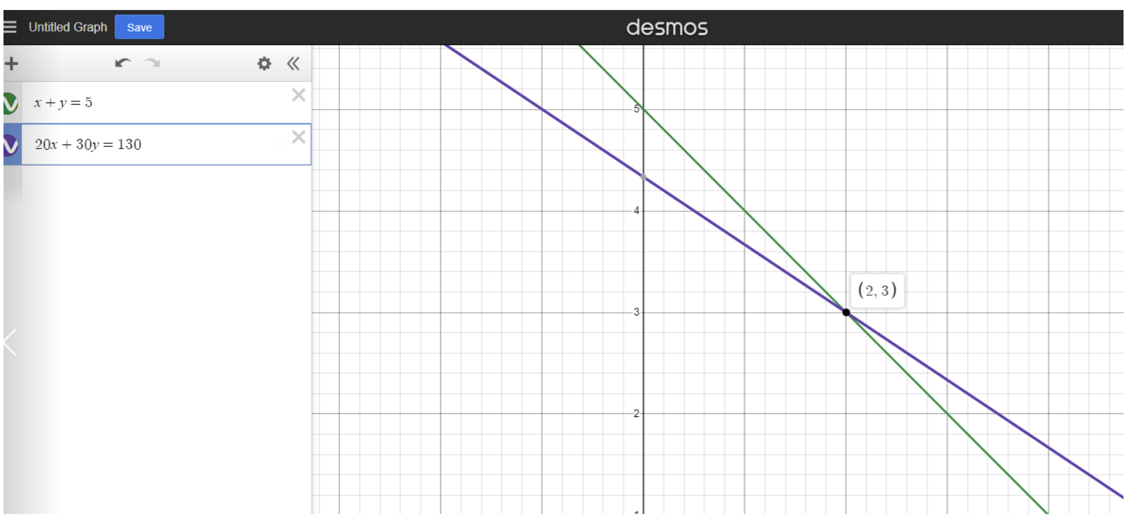

Fig. 8. Solving the system of equations with the Desmos application

On the other hand, students who solved the task using the Desmos application showed a high level of accuracy and efficiency. The application provided a fast and accurate solution to the system of linear equations, clearly identifying the number of bus and train tickets that Artan had purchased.

From this analysis, it can be seen that the use of mobile applications, such as Desmos, offers a clear advantage compared to the traditional pencil solution in similar tasks. Such applications can be useful tools to improve students' understanding and performance in mathematics and in solving mathematical problems.

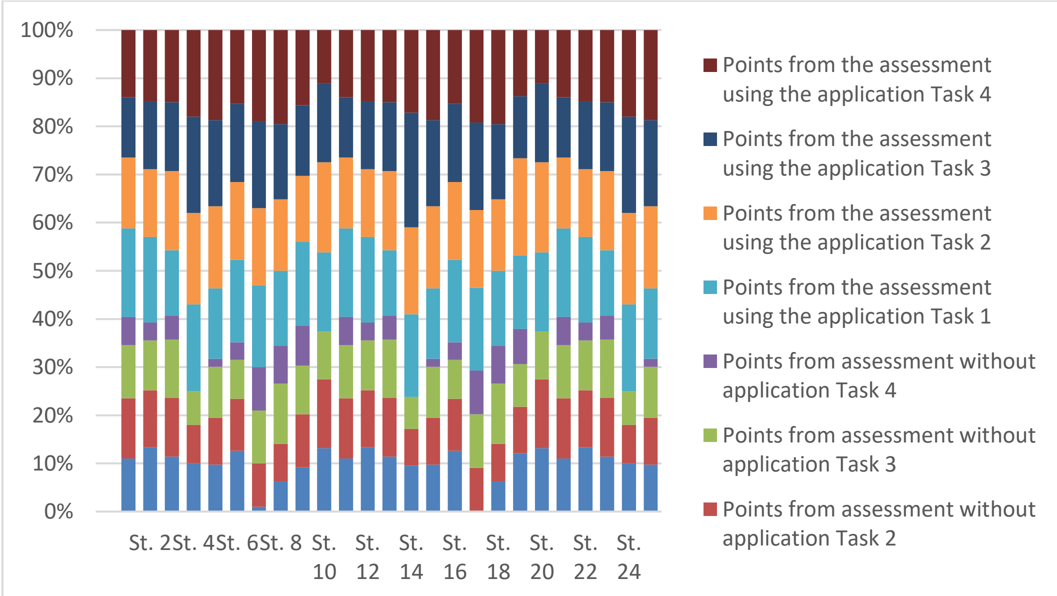

Fig. 9. Solving the system of equations with and without the application

To interpret the results from the observational assessment of the solution of systems of linear equations without application and with application, it was important to analyze the differences in the points obtained by each student for each task. In tasks 1, 2, 3, and 4, students who used the application for solving systems of linear equations had the highest scores compared to those who solved the tasks without using the application. This suggests that the use of applications positively affected the performance of students in solving these tasks. In all tasks, students who used the app managed to get more points than those who didn't. This shows that mathematics applications have helped students understand and solve tasks more successfully compared to traditional methods. In addition, it is worth noting that some students had a noticeable increase in their scores using the app, while others showed a smaller or slower increase. This shows that the impact of the application on student performance may vary depending on individual abilities and their engagement in learning. Finally, in general, the results show that the use of mobile applications for solving systems of linear equations with the graphical method has a positive effect on students' performance in mathematics. The apps provided a useful tool to solve tasks accurately and efficiently.

Table 1. The average of the points from the solution of the tasks

Student	Points from assessment without application				Points from the assessment using the application			
	Task 1	Task 2	Task 3	Task 4	Task 1	Task 2	Task 3	Task 4
Mean	12,28	12,88	12,4	5,2	19,68	19,44	18,92	19,16
Std Dev	4,614	3,257	3,291	3,571	3,024	2,399	2,379	3,625

The average score for each task is significantly increased when apps are used to solve them compared to the solution without an app. This shows that the use of applications has positively affected the performance of students in all tasks. The standard deviation of scores from the assessment with the app is lower compared to that without the app in all tasks. This fact points to a more significant level of consistency in student performance when they used the apps. For all tasks, the average score for the solution with the app is much higher than that without the app. This difference expresses a positive impact of the use of applications in achieving better results in mathematics for students. According to these results, it seems clear that the use of applications has brought about an increase in the performance of students in solving mathematical tasks at all assessment levels. Apps have provided a powerful tool to improve understanding and performance in mathematics.

Analysis of the results from the interview

This chapter provides a summary of the findings achieved during the study and marks the final step towards a more in-depth discussion and interpretation of the results revealed.

Table 2. Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	F	12	48.0	48.0	48.0
	M	13	52.0	52.0	100.0
	Total	25	100.0	100.0	

Based on the data presented in the table on gender, the study included a group of 25 subjects. Of these, 12 (48%) were female and 13 (52%) were male. These results show a greater distraction of the male participants compared to the females in the study. However, the difference between the two genders is not very large and may be important to consider when analyzing the impact of mobile applications on solving systems of linear equations in both genders. Overall, this result may suggest a need to make more efforts to obtain equal participation of both gender in such education studies. This could include strategies to increase the interest of women in the fields of technology and mathematics, as well as taking measures to involve more women in such studies.

Table 3. Knowledge about using mobile applications

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Basic	4	16.0	16.0	16.0
	Intermediate	17	68.0	68.0	84.0
	Advanced	4	16.0	16.0	100.0
	Total	25	100.0	100.0	

Based on the data presented in the table on the knowledge about the use of mobile applications, the study has identified different knowledge of the participants regarding this topic. From the group of 25 subjects: 4 (16%) subjects have a level of basic knowledge in using mobile applications. 17 (68%) subjects have an average level and 4 (16%) subjects have an advanced level of knowledge in this field. This result shows that most of the participants have average knowledge about the use of mobile applications. However, there is a distraction for participants who have basic or advanced knowledge. This may have an impact on how participants benefit from using mobile applications for solving linear equations and on their level of technological competence in general. The results suggest that the experience and knowledge of the participants regarding the use of mobile technology can influence their suitability and effectiveness in using applications for solving systems of linear equations by the graphical method with mobile applications. This information is important for understanding the context and potential impact of participants' technological knowledge on the interpretation of study results.

Table 4. I gained experience using mobile applications for solving systems of linear equations with two variables through the graphical method:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neither agree or disagree	3	12.0	12.0	12.0
	Agree	14	56.0	56.0	68.0
	Strongly agree	8	32.0	32.0	100,0
	Total	25	100,0	100,0	

Based on the data presented in the table on the experience of the participants in using mobile applications for solving systems of linear equations with two variables through the graphical method, there was a different range of attitudes of the participants. From the group of 25 subjects: 3 (12%) subjects do not have a clear attitude regarding their experience of using mobile applications for solving systems of linear equations. 14 (56%) subjects have agreed with their experience in using these applications. 8 (32%) subjects expressed full agreement with their experience. This shows that most of the participants are compatible or completely compatible with their experience in using mobile applications for finding solutions to systems of linear equations involving two variables through the graphical method. However, a small part of them do not have a clear position regarding this issue. The interpretation of these results shows that the experience of the participants in using these applications has been mostly positive. Their compliance suggests an acceptable level of effectiveness and usability of these technological tools for solving systems of linear equations, while some subjects who do not have a clear attitude may need to further devote themselves to the use of applications to achieve a deeper understanding and a better experience about the subject.

Table 5. The use of these applications in the sense of solving systems of linear equations with two variables through the graphical method was efficient:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neither agree or disagree	5	20.0	20.0	20.0
	Agree	11	44.0	44.0	64.0
	Strongly agree	9	36.0	36.0	100,0
	Total	25	100,0	100,0	

Based on the data presented in the table on the efficiency of using mobile applications for solving systems of linear equations with two variables through the graphical method, there was a different range of evaluations of the participants regarding this issue. From the group of 25 subjects: 5 (20%) subjects do not have a clear attitude regarding the efficiency of using mobile applications in terms of solving systems of linear equations. 11 (44%) subjects have expressed a general level of compliance with the efficiency of these applications. 9 (36%) subjects have expressed full compliance with the efficiency of the applications. This shows that a significant part of the participants found the use of mobile applications efficient for solving systems of linear equations. However, some entities do not have a clear position regarding this issue, while another part have expressed complete compliance with the efficiency of the applications. The interpretation of these results shows that the use of mobile applications for solving systems of linear equations has been generally efficient in the eyes of the majority of participants. A large number of them have positively evaluated this experience, while some participants may still have doubts or have not formed a clear attitude. This may be the result of various variables such as prior knowledge, technological skills, or individual perceptions regarding the use of technology in learning.

Table 6. We have benefited from the use of mobile applications for solving systems of linear equations with two variables through the graphical method:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	4.0	4.0	4.0
	Neither agree or disagree	2	8.0	8.0	12.0
	Agree	15	60.0	60.0	72.0
	Strongly agree	7	28.0	28.0	100.0
	Total	25	100.0	100.0	

Based on the data presented in the table on the benefit of using mobile applications for solving systems of linear equations with two variables through the graphical method, there was a different range of evaluations of the participants regarding this issue. From the group of 25 subjects: 1 (4%) subject does not agree with the fact that he has benefited from the use of mobile applications for solving systems of linear equations. 2 (8%) subjects do not have a clear attitude regarding their benefit from using these applications. 15 (60%) subjects have expressed a general level of compliance with their benefit from mobile applications. 7 (28%) subjects have expressed full compliance with their benefit. This shows that most of the participants have benefited from using mobile applications for solving systems of linear equations. However, there are a small number of subjects who do not agree or do not have a clear position on this issue. The interpretation of these results shows that the experience of the participants in using mobile applications has been mostly positive and they have benefited from this experience. Their compatibility suggests that mobile applications have provided a valuable contribution to solving systems of linear equations, helping to understand and apply this phenomenon. However, it is also important to understand why some participants did not benefit to the same extent and to identify factors that may have influenced this difference in perceptions.

Table 7. We had challenges and difficulties while using mobile applications for solving systems of linear equations with two variables through the graphical method:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	8.0	8.0	8.0
	Disagree	5	20.0	20.0	28.0
	Neither agree or disagree	8	32.0	32.0	60.0
	Agree	7	28.0	28.0	88.0
	Strongly agree	3	12.0	12.0	100.0
	Total	25	100.0	100.0	

Based on the data presented in the table on the challenges and difficulties when using mobile applications for solving systems of linear equations with two variables through the graphical method, there was a different range of evaluations of the participants regarding this issue. From the group of 25 subjects: 2 (8%) subjects did not agree at all with the fact that they encountered challenges and difficulties when using mobile applications for solving systems of linear equations. 5 (20%) subjects did not agree with the fact that they encountered challenges and difficulties. 8 (32%) subjects do not have a clear position regarding this issue. 7 (28%) subjects have expressed a general level of compliance with the fact that they encountered challenges and difficulties. 3 (12%) subjects expressed full agreement with the fact that they encountered challenges and difficulties while using mobile applications. This shows that the perception of the participants regarding the challenges and difficulties when using mobile applications for solving systems of linear equations is different. A significant part of the participants has encountered challenges and difficulties, while some others have not agreed or have different attitudes regarding this issue. The interpretation of these results shows that the experience of the participants in using mobile applications has been different in terms of challenges and difficulties. This may be the result of various factors such as prior knowledge, technological skills, or the complexity of the applications. Identifying specific challenges and ways to address them can be important to improve the experience and benefit of participants in the future.

Table 8. We had cooperation with friends during the use of mobile applications in mathematics lessons:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	8.0	8.0	8.0
	Disagree	1	4.0	4.0	12.0
	Neither agree or disagree	7	28.0	28.0	40.0
	Agree	6	24.0	24.0	64.0
	Strongly agree	9	36.0	36.0	100.0
	Total	25	100.0	100.0	

Based on the data presented in the table on peer collaboration during the use of mobile applications in mathematics lessons, there was a different range of participants' evaluations regarding this issue. From the group of 25 subjects: 2 (8%) subjects did not agree at all with the fact that they had collaboration with friends while using mobile applications in mathematics lessons. 1 (4%) subjects did not agree with the fact that there was cooperation. 7 (28%) subjects do not have a clear position regarding this issue. 6 (24%) subjects expressed a general level of compliance with the fact that they had cooperation with friends. 9 (36%) subjects have expressed full agreement with the fact that they had collaboration with friends while using mobile applications in mathematics lessons. This shows that most of the participants collaborate with peers while using mobile applications in mathematics lessons. However, there are a small number of subjects who disagree or have different positions on this issue. The interpretation of these results shows that cooperation with friends while using mobile applications has been generally positive. Their compliance suggests that this collaboration may have contributed to their experience in using mobile applications and may have created a more inclusive and stimulating environment for learning mathematics.

Table 9. We are motivated to learn mathematics after using mobile applications:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	4.0	4.0	4.0
	Neither agree or disagree	5	20.0	20.0	24.0
	Agree	12	48.0	48.0	72.0
	Strongly agree	7	28.0	28.0	100.0
	Total	25	100.0	100.0	

Based on the data presented in the table on the motivation for learning mathematics after using mobile applications, there was a different range of participants' evaluations regarding this issue. From the group of 25 subjects: 1 (4%) subject does not agree at all with the fact that he is motivated to learn mathematics after using mobile applications. 5 (20%) subjects do not have a clear position regarding this issue. 12 (48%) subjects have expressed a general level of agreement with the fact that they are motivated to learn mathematics after using mobile applications. 7 (28%) subjects have expressed full agreement with the fact that they are motivated to learn mathematics after using mobile applications. This shows that most of the participants are motivated to learn mathematics after using mobile applications. However, some entities have different attitudes regarding this matter. The interpretation of these results shows that the use of mobile applications has had a positive impact on the participants' motivation for learning mathematics. Their compliance suggests that this technology has provided an effective means of increasing interest and motivation for learning this area. This is an important finding that can help promote the use of mobile applications in teaching.

Table 10. We are engaged while you use these technological tools:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	14	56.0	56.0	56.0
	Strongly agree	11	44.0	44.0	100.0
	Total	25	100.0	100.0	

Based on the data presented in the table on engagement while using these technological tools, there was a consistent expression of engagement by participants. From the group of 25 subjects: 14 (56%) subjects stated that they were engaged while using these technological tools. 11 (44%) subjects stated that they were fully engaged while using these tools. This shows a high level of engagement of participants when using mobile applications for solving linear equations. Participants are committed and emotionally invested in the activity of using these technological tools. This finding suggests a successful and up-to-date use of these technologies in the context of mathematics education.

Table 11. Attitudes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	7	28,0	28,0	28,0
	Positive	18	72,0	72,0	100,0
	Total	25	100,0	100,0	

Based on the data presented in the table on the attitudes of the participants, it turns out that most of them have expressed positive attitudes towards the use of mobile applications for solving linear equations. From the group of 25 subjects: 7 (28%) subjects expressed neutral attitudes. 18 (72%) subjects expressed positive attitudes. This shows wide support for the use of these applications in the process of learning mathematics. Positive attitudes are an important indicator of the success and effectiveness of these technological tools in support of learning and solving mathematical problems. These findings confirm that the participants valued and had a favorable perception of the role and impact of mobile applications in their learning experience.

Table 12. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Attitudes	25	4	5	4,72	,458
Valid N (listwise)	25				

Descriptive statistics for participants' attitudes towards the use of mobile applications for solving systems of linear equations provide some important information on their perception. These are the results of subject evaluations for this technological tool. The interpretation of these results can be made as follows: The minimum value is 4, which indicates that the subjects have expressed an attitude of at least 4 towards the use of mobile applications for solving systems of linear equations. This can be interpreted as a low level of attitude in the most dissatisfied or less positive cases. The maximum value is 5, which indicates that some subjects have expressed a maximum attitude towards the use of mobile applications for solving systems of linear equations. This can be interpreted as a maximum favorable level of attitudes. The average is 4.72, which shows an average value of the subjects' attitudes towards the use of mobile applications. This average is high, suggesting a positive perception of the participants regarding this technological tool. The standard deviation is 0.458, which indicates that the distribution of attitude values from the mean is limited. This shows that the subjects were consistent in their assessments, indicating a high degree of consistency in their perception. In general, these results show a support and a favorable attitude towards the use of mobile applications for solving systems of linear equations. A high mean and a low standard deviation indicate a match and consistency in the perception of the participants. This suggests that mobile applications were viewed positively as an effective tool to help solve systems of linear equations, while subjects had a consistent perception regarding this topic.

Table 13. ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Gender:	Between Groups	,367	1	,367	1,437	,243
	Within Groups	5,873	23	,255		
	Total	6,240	24			
Knowledge about using mobile applications:	Between Groups	,000	1	,000	,000	1,000
	Within Groups	8,000	23	,348		
	Total	8,000	24			

The presented table contains the results of ANOVA analyses for two different factors: gender and knowledge about the use of mobile applications. For the "Gender" factor: "Sum of Squares" (Sum of Squares) is 0.367 for between groups. "df " (Degree of freedom) is 1 for between groups and 23 for within groups. "Mean Square" (Mean of Squares) is 0.367 for between groups and 0.255 for within groups. "F" (Distribution value) is 1.437. "Sig." (Significance level) is 0.243. For the factor of "Knowledge about the use of mobile applications": "Sum of Squares" (Sum of Squares) is 0.000 for between groups. "df " (Degree of freedom) is 1 for between groups and 23 for within groups. "Mean Square" (Mean of Squares) is .000 for between groups and .348 for within groups. "F" (Distribution value) is .000. "Sig." (Significance level) is 1.000. To interpret these results, we see the value of "Sig." (Significance scale level). In this case, the values of Sig. for both factors are quite high (.243 for gender and 1.000 for knowledge about the use of mobile applications). This shows that there are no statistically significant differences between groups for any factor. Therefore, there is no discernible difference in participants' attitudes regarding the use of mobile applications for solving systems of linear equations depending on gender or knowledge about them.

On the other hand, the students' answers to the open questions of the survey show these findings. Based on students' responses regarding the benefits of using mobile applications for solving two-variable systems of linear equations graphically, there are some notable benefits that students have noticed: Some students have emphasized that mobile applications have helped them learn more about technology and its use. Most of the students have mentioned that mobile applications have helped them learn more in the field of mathematics. Some students have mentioned that the apps have helped them learn how to use their phones better in the context of learning math. Several students have emphasized that the applications have helped them gain new knowledge about solving systems of linear equations with two variables through the graphical method. Some students have noted that the apps have helped them better understand the concepts of systems of linear equations in two variables and solve them graphically. However, some students have emphasized that the applications have helped them save time in solving mathematical tasks. In general, the student's responses indicate a clear benefit from the use of mobile applications in learning mathematics and solving systems of linear equations with two variables. They gain new knowledge, improve their technology skills, and better understand mathematical concepts while making more efficient use of their time.

Based on students' responses regarding the use of mobile applications in mathematics lessons, there are some additional comments that students have made: Students have noticed that using these applications has helped them solve various mathematical tasks. Some students have pointed out that the applications have helped them learn more about the subject of mathematics. Students have noticed that using these apps has helped them learn how to better use their phones to learn math. Some students have suggested that mobile applications be used more often in teaching mathematics. A student noticed that these apps have good drawings. Also, a student suggested that the applications be used by those who have little knowledge about learning mathematics. In general, students have positively evaluated the use of these mobile applications in mathematics lessons, identifying benefits such as help in solving tasks, increased knowledge in mathematics, and better use of technology in teaching this field. Some have even provided suggestions for more extensive use of apps in the classroom.

Based on the student's answers regarding the use of these tools in the future in the teaching of mathematics in their school, there are some suggestions and comments that the students have made: Students express that they wish that these tools are used more often in the teaching of mathematics in school. Some students suggest that technology should be developed more in the teaching of mathematics at school, including the use of mobile applications. In some cases, students express those mobile applications should be used only when necessary and not in an unimaginable way. Some students express their concern that an overuse of technology may lead to the neglect of traditional learning methods, such as the pencil and eraser. One student suggests that the use of these tools should be focused mainly on certain classes, such as middle school. In general, students express an interest and desire to use mobile applications and technology in mathematics learning in the future but also emphasize the need for wise and careful use of these tools to their needs and their level of development.

DISCUSSIONS

This section of the paper focuses on the interpretation of the results and their analysis in the context of the research and the aims of the study. The results show that mobile applications have a positive impact on the efficiency of solving systems of linear equations. Students who used these tools displayed a high level of engagement and simultaneously achieved a better understanding of mathematical concepts. Experiences from interviews and observations showed that the use of mobile applications increases the involvement of students in the process of solving systems of linear equations with two variables. Students reported a higher sense of responsibility for their learning, further linking technology use with positive outcomes. However, some challenges were identified during the study. One of these was the limited level of technological knowledge of some students, causing difficulties in using the applications. This suggests the need for improvements in the training and preparation of students for the use of mobile technology in mathematics learning. In conclusion, despite the challenges identified, the findings of this study show that the use of mobile applications for solving systems of linear equations with two variables through the graphical method can be well matched with the goals of modern learning. This can serve as a model for developing instructional strategies that incorporate technology in mathematics instruction at the primary and lower school levels.

According to the results of the research, we are giving answers to the first research question "How do mobile applications affect the engagement and interest of students during learning to solve systems of linear equations with two variables through the graphical method?" Therefore, mobile applications have positively influenced the engagement and interest of students when learning to solve systems of linear equations in two variables through the graphical method. This is a result of the fact that students who used the applications showed greater concentration and a higher level of engagement in their tasks. They showed more interest and motivation to solve tasks using mobile apps, while those who did not use them showed a lower level of engagement. This suggests that mobile apps can increase students' concentration and interest in mathematics by using a more interactive and innovative method for solving tasks.

According to the results of the research, we are giving answers to the second research question "What are the advantages and challenges of using mobile applications compared to traditional methods for solving systems of linear equations?" Therefore, there are several advantages and challenges of using mobile applications compared to traditional methods for solving systems of linear equations. The advantages of using mobile applications for solving systems of linear equations were: Mobile applications provided an easy tool for solving linear equations, making the process clearer and more understandable for students. Mobile applications offered a more interactive and engaging way to learn mathematics, thereby fostering student engagement and motivation. Mobile applications were easy for students to access and use, providing the opportunity to learn anywhere and anytime. While, the challenges of using mobile applications for solving systems of linear equations were: In some cases, mobile applications can bring an excessive dependence on technology and can affect the lack of direct pedagogical control by the teacher. If students use too many applications for solving linear equations, they may lose the ability to understand and solve problems with traditional methods. The quality and accuracy of mobile applications for solving linear equations may vary, introducing potential risks for errors or missing information. In summary, mobile applications offer many advantages compared to traditional methods for solving systems of linear equations, but potential challenges must also be considered to ensure their effective and sustainable use in the educational context.

According to the research results, we are giving answers to the third research question "How do the results of solving systems of linear equations with the graphical method using mobile applications differ compared to the traditional graphical method?" Therefore, the differences in the results of solving systems of linear equations with the graphical method using mobile applications compared to the traditional graphical method are clear and have a significant impact on student performance. Students who used mobile applications showed a higher level of accuracy in solving systems of linear equations compared to those who used the traditional graphical method. The applications provided a more convenient and consistent tool for drawing graphs, reducing errors, and helping to arrive at accurate solutions. The use of mobile applications helped to reduce the time required to solve systems of linear equations compared to the traditional graphical method. Apps offered a faster and easier solution, making the process more efficient. Students who used mobile applications showed a higher level of understanding of mathematical concepts related to solving systems of linear equations. Using the apps provided a more interactive and engaging experience, helping in a deeper understanding of the subject matter. In summary, the use of mobile applications in solving systems of linear equations with the graphical method brings positive changes in student performance and results, improving accuracy, solution time, and understanding of mathematical concepts.

According to the results of the research, we are giving answers to the fourth research question "What skills do students develop through their involvement in solving systems of linear equations using mobile applications and the graphic method?" Therefore, students developed some important skills through their involvement in solving systems of linear equations using mobile applications and the graphical method. The use of mobile applications gave students the ability to manipulate technology and use digital tools to solve mathematical problems. They learned how to use applications effectively to create and analyze graphs of linear equations. Students developed skills to analyze and evaluate their results by comparing their solutions with those generated through mobile applications. They learned to critique and evaluate the accuracy of their solutions, understanding the advantages and disadvantages of each method. Engaging in solving mathematical problems using mobile applications and the graphical method helps students develop critical skills to evaluate how the use of technology has affected the problem-solving process. Also, the use of mobile applications encouraged collaboration and knowledge sharing among students in a technology environment. Students learned how to work together to solve math problems using digital tools. In general, the involvement of students in solving systems of linear equations using mobile applications and the graphical method contributes to their development of technical, analytical, critical, and collaborative skills in the field of mathematics.

According to the results of the research, we are giving answers to the fifth question of the research "How do students perceive their experiences with the use of mobile applications in solving systems of linear equations with two variables and what are their recommendations for the use of these tools in teaching math?" Therefore, students perceive their experiences with using mobile applications in solving systems of linear equations with two variables as a positive and useful experience. Some of their perceptions and recommendations for the use of these tools in teaching mathematics are: Students appreciate that the use of mobile applications has helped them understand and apply mathematical concepts more easily and efficiently. They feel that this experience has made math tasks more enjoyable and interesting. Students estimate that the use of mobile applications has made the processes of solving mathematical problems simpler and more understandable. They feel that these tools give them a more intuitive way to understand and visualize linear equations. Students recommend that mobile applications be used more often in mathematics learning, especially for solving complex problems such as systems of linear equations. They also suggest that teachers ensure that all students have equal access to technology and learn how to use these tools effectively. Some students state that they would be happy to receive more training in using mobile applications for solving mathematical problems. They believe that their knowledge and skills in this area would increase further through additional training and intensive practice. In summary, students perceive their experiences with the use of mobile applications in solving systems of linear equations as positive and useful and recommend their use in teaching mathematics on the condition that they are trained and supported appropriately by teachers.

CONCLUSION

This study was devoted to exploring the role of mobile applications in solving systems of linear equations that involve two variables through the graphical method among primary and lower school students. The results have confirmed the aims of the study, revealing a positive impact of these technological tools on the involvement of students and the efficiency of mathematics learning. The use of mobile applications showed that technology has a significant impact on mathematics learning. Students displayed a deeper understanding of systems of linear equations and a higher level of motivation, highlighting the potential of these tools to improve their mathematical skills. Accomplishing learning goals encourages a responsible use of mobile technology in mathematics learning. It is important to continue to develop and use such tools carefully, preparing students for the challenges and advantages of such use. In this context, we realized that the use of mobile applications for solving systems of linear equations that involve two variables through the graphical method has great potential to increase the quality and performance of mathematics learning results. The contribution of this study is to address a space in the scientific literature, examining the concrete impact of these tools in the context of lower secondary schools.

RECOMMENDATIONS FOR THE FUTURE

The study concludes with recommendations for the use of mobile applications in the educational context. These include developing a training program for students and teachers, as well as improving applications to address identified challenges. Further research is also recommended to monitor the affective and academic impact of using mobile technology in mathematics learning. To evaluate the effectiveness of the use of mobile technology in a lower secondary school, the implementation of pilot projects is recommended. These projects should be testing grounds where the effect on mathematics learning will be monitored before measures are taken for wider-scale implementation. Encouraging collaboration between students and teachers in the use of mobile technology can increase the effectiveness of these tools. Creating a collaborative and supportive environment will contribute to the successful and sustainable use of mobile applications in mathematics education.

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REFERENCES

Button, T. (2018), Simultaneous equations: an insight from playing with technology, Digital Technologies for learning mathematics, https://digitalmathematics.blogspot.com/2018/05/simultaneous-equations-insight-from.html
Chen, B. (2010). *Systems of Linear Equations.* Hong Kong University of Science and Technology.
Desmos. (2014). *Desmos*. Retrieved from Introducing Desmos 3D: https://www.desmos.com/
Drijvers, P., & Barzel, B. (2012). *Equations With Technology: Different Tools, Different Views.* Atm. 1-19.
GeoGebra. (2014). *GeoGebra*. Retrieved from GeoGebra for Teaching and Learning Math: https://www.geogebra.org/?lang=en
Kwon, O.N. (2010). The effect of calculator-based ranger activities on students' graphing ability. School Science and Mathematics, 102(2), 57 – 67. htps://onlinelibrary.wiley.com/ doi/10.1111/j.1949-8594.2002.tb17895.x
Mathway. (2014). *Mathway*. Retrieved from Mathway: https://www.mathway.com/Graph
McCullough, A.W., Lovet, J.N., Dick, L.K. & Cayton, C. (2021). Positioning students to explore math with technology. Mathematics Teacher: Learning and Teaching PK-12, 114(10), 738 – 749. htps://doi. org/10.5951/MTLT.2021.0059
Onal, N. (2016). Development. Validity and Reliability of TPACK Scale with Pre-Service Mathematics Teachers, International Online Journal of Educational Sciences.
Orhani, S. (2023). Evaluation of the Effectiveness of the "Mathematica Application" in Examining and Graphing Quadratic Functions, Futurity Education, 3(3):164-177.
Photomath. (2014). *Photomath*. Retrieved from Photomath: https://www.mathway.com/Graph
Remijan, K.W. (2017, November 22). Building mathematical skills and community relationships through crash reconstruction. ASCD Express. htps://www.ascd.org/el/articles/ building-mathematical-skills-and-community relationships-through-crash-reconstruction
Remijan, K.W. (2019). STEAMing up linear functions. The Mathematics Teacher, 112(4), 250 – 256. htps:// doi.org/10.5951/mathteacher.112.4.0250
Strand, J. (2013). *Using Graphs to Solve Equations.* Student Text.
Wolfram. (2014). *Wolfram Alpha*. Retrieved from Wolfram Alpha: https://www.wolframalpha.com/
Zejnullahu, R. (2022). *Matematika 9.* Prishtinë: Dukagjini.