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Evaluation of the Effectiveness of the "Mathematica Application" in Examining and Graphing Quadratic Functions

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Abstract: The aim of this paper was to evaluate the effectiveness of the “Mathematica Application” in examining and graphically presenting quadratic functions. This study has the potential to improve teaching and to help choose the most effective tools for examining and presenting quadratic functions. The purpose of this research was to evaluate the effectiveness of the "Mathematica Application" in examining and graphing quadratic functions. The method used to evaluate the effectiveness of the “Mathematica Application” was a combination of qualitative and quantitative analysis. In the qualitative analysis, the students' experience with the Mathematica application in examining quadratic functions and presenting them graphically was examined. The users were music school students who have used the application in order to study quadratic functions in the context of learning mathematics. Also, the quantitative analysis was used to analyse the performance of the Mathematica application in the graphical representation of quadratic functions. The sample of the study is represented by students of the tenth grade, where it is a purposive sample, since these learning units are covered in this class. The results of this evaluation are important to the community of mathematicians and users of the Mathematica application. The findings of the study show a positive assessment by the students on the efficiency and performance of the Mathematica application in examining and graphing quadratic

functions. These findings provide implications for improving teaching and establishing the Mathematica application as a suitable tool for studying quadratic functions in the context of mathematics education. By incorporating the Mathematica application into the teaching and learning process of mathematics, students' interaction and understanding of this important mathematical topic can be increased.

Keywords: Application, effectiveness, graphic presentation, Mathematica, quadratic functions, students.

Introduction

Computer applications have become an integral part of many fields of study and work today. In the field of mathematics and education, they provide powerful tools to analyse represent and review mathematical functions (Aydın, 2005). One of these outstanding computer applications is the "Mathematica Application", developed by Wolfram Research. Mathematica is a specialised mathematics and programming environment that can be used to solve a wide range of mathematical problems and create graphical representations of functions. In recent years, the integration of technology, especially computers, into the teaching and learning of mathematics has gained considerable attention in education systems around the world. The use of computers has shown a great potential able to improve the learning experiences of students at various school levels. Theoretical and empirical evidence suggests that technology-integrated tools can create a more dynamic and interactive learning environment, promoting a deeper understanding of mathematical concepts and fostering students' critical thinking and problem-solving skills (Haleem et al., 2022). One of the main advantages of using computers in mathematics education is the ability to provide visual representations and simulations. Graphics tools, dynamic geometry software, and mathematical modelling applications allow students to visualize abstract mathematical concepts, such as quadratic functions, in a tangible and meaningful way. This visual approach helps students understand complex ideas more easily and enables them to explore different scenarios, making learning math more engaging and enjoyable (Velázquez & Méndez, 2021).

This paper aimed to evaluate the effectiveness of the “Mathematica Application” in examining and graphically presenting quadratic functions. Quadratic functions are important in mathematics and the applied sciences, and graphing them is a key tool for understanding their characteristics and patterns.

This study has the potential to improve future teaching and help choose the most effective tools to examine and present quadratic functions. By incorporating the Mathematica application into the process of teaching and learning mathematics, students' interaction and understanding of this important mathematical topic can be increased.

Research Problem

Until now, the examination and graphing of quadratic functions have been accomplished mainly by traditional methods, including the use of hand-drawn graphs, mathematical tables, or some other analogous tool (Nielsen, 2015). This can have limitations in how quadratic functions can be examined and understood more interactively and visually. The problem is that in the absence of a specialised and powerful environment, in the presented experience as teachers it seems difficult to present the graphs of quadratic functions in a clear and understandable way for some students and teachers of mathematics. This can affect the inclusion and deep understanding of the concepts of quadratic functions and their applications.

Research Focus

To solve this problem, “Mathematica Application” as a potential tool to examine and graph quadratic functions was identified. However, there has not yet been a detailed evaluation of the effectiveness and performance of this application in the context of quadratic functions. So, the need to evaluate the “Mathematica Application” in examining and graphing quadratic functions is essential to understand how effective and suitable this computing environment is in fulfilling these goals. The identification and solution of this problem would enable the use of a modern and specialized tool to help in the learning and understanding of quadratic functions, thus improving the performance and experience of students and professors in teaching mathematics.

Research Aim and Research Questions

The purpose of this research was to evaluate the effectiveness of the "Mathematica Application" in examining and graphing quadratic functions. In order to achieve this goal, we aim to analyse students' experience and use of the Mathematica application in examining quadratic functions and their graphical representation. Their comments and ratings to evaluate the level of use, benefits and difficulties they encountered in using this application will be taken into account.

Research questions:

1. How effective is the “Mathematica Application” in examining and presenting quadratic functions?

2. What are the main benefits and difficulties of using Mathematica to graph quadratic functions compared to traditional methods?

3. Has the Mathematica application improved the understanding and learning of quadratic functions among mathematics students?

Research hypothesis:

H_1: “Mathematica application” is an effective tool for examining quadratic functions and their graphical representation.

H_2: The use of Mathematica to graph quadratic functions has obvious benefits and difficulties compared to traditional methods.

H_3: The use of the Mathematica application has a positive impact on the understanding and learning of quadratic functions among students.

Literature Review

Research in this studied field is lacking in our country, so this paper bases on the review of international literature as follows. Mathematica application is a powerful computer algebra system developed by Wolfram Research (Wolfram, 1999), and the lead developer is Stephen Wolfram. It is a very high-level programming language that is suitable for different types of mathematics courses. The Mathematica application is a system for doing mathematics with computers. It includes arbitrary precision and exact numerical calculations, symbolic calculations, graphics, sound, hyperlinks, and documentation in an easy-to-use software package. The computer algebra system Mathematica is an attractive medium for teaching mathematics. Several computer algebra systems exist, such as Mathematica and others, and at this level, it is largely a matter of taste which system one chooses to use. However, looking a little further, it is the opinion of the authors that (Jonassen, 2002). Mathematica is

superior to the others. The Mathematica application works with input-output logic, has a graphical interface, and is easy to use to create graphs (Ardic & Isleyen, 2017). Mathematica's ease of use and animation features provide students with an environment to discover, experiment, identify patterns, generate and test conjectures, and visualize multiple representations of the derivative concept in ways that were impossible using the whiteboard and the pencil (Shatila et al., 2016).

The results of the study by Bataineh et al. (2019) showed that the teaching method using computerised educational materials using the Mathematica application, in the experimental group was more effective in developing students' skills for solving the derivative problem and its applications. This approach provided students with multiple representations of derivative concepts, which were useful when solving different context problems, and also motivated students to think in critical and innovative ways. The author showed how to use Mathematica to quickly perform calculations that would be time-consuming and potentially time-consuming if done by hand (Baumann, 2000). Also, from the study of the author Orhani (2021), the findings reflected the high results of the participants regarding the integration of technology in mathematics lessons. Mathematica can motivate and help students develop the essential mathematical concepts and skills needed in their fields (Sholahudin, 2017). Based on previous research conducted by Musyrifah et al. (2021) in the development of learning modules, the resulting product is valid, useful, attractive, practical, and suitable for use. The Mathematica app would revitalize the learning process and encourage creativity, critical thinking, and innovation. There is a urgent need to make the teaching and learning of science, math, and engineering more hands-on, practical, and fun, says AUC (n.d.). Mathematica software provides easy and effective access to students to many representations of derivative concepts. There are few studies that have been conducted on the use of Mathematica as a tool for first year college students. Mathematica provides a powerful interactive and dynamic working environment, which when integrated in teaching and learning results in a great improvement in the effectiveness of lecturing. Mathematica is one of the most popular CAS which has positive effect on learning theoretical and applicable mathematics. It also improves students' mathematical knowledge as it motivates the student to build their mathematical concepts (Vorob'ev, 2012). Many universities were interested in improving their mathematics students' understanding and performance. Reform movements to the mathematical courses such as calculus suggested that CAS (such as Maple and Mathematica) are used in teaching calculus to increase students' conceptual understanding, improve students' ability in problem solving and develop positive attitudes towards mathematics and technology (Tall et al., 2008). The traditional teaching on mathematics subjects, based on lectures and seminar classes can be integrated with laboratory classes in which the corresponding CAS is used to reinforce the theoretical problems and solving nonstandard and practically oriented problems with tedious computations. (Tersian & Chaparova, 2020). The importance of Mathematica software in teaching Analytical Geometry is undeniable. This was observed on the development of teaching materials of Analytic Geometry using Mathematica software in the development of students' representation, and research on improving the achievement and learning independence of differential calculus students of the mathematics education program of Universitas Negeri Yogyakarta using the software Mathematica (Listyani, 2006). Strogatz (2013) in his book introduces us to quadratic functions and makes it easy to understand how they vary and how they affect graphs. It explains the use of the Mathematica application to visualise these functions and shows how this technology can help solve complex mathematical problems in a fast and accurate way. In the book "Mathematica in Action: Problem Solving Through Visualisation and Computation" by Borwein and Bailey (2009), along with the contributions of other authors, provide an in-depth perspective on the power of Mathematica in solving mathematical problems. Using the Mathematica application before moving on to manual solutions has been shown to be a powerful tool to speed up problem-solving time and better understand mathematical concepts. In addition to solving mathematical problems, they show that the Mathematica application also illustrates use in other sciences, making it attractive to students, professors and researchers of

various fields. Mathematica in Education by Dziubak et al. (2014) is an informative and inspiring book for anyone interested in the use of Mathematica in mathematics education and other sciences. The authors provide examples of the successful use of Mathematica in teaching and research, showing how this technology can help improve the teaching and understanding of mathematics and solve complex problems in other fields of knowledge. In the future, this research may pave the way for further development of mathematics teaching and technology integration in a more intentional and conscious way.

Research Methodology

General Background

This research was exploratory and combined, using a mixed methodology that included elements of qualitative and quantitative research. Exploratory research is a type of research that aims exploring and better understanding a certain topic or problem, fulfilling the defined purpose and bringing new knowledge and new perspectives on the research subject (George, 2021). In this case, our research aims to explore the effectiveness of the "Mathematica Application" in examining and graphing quadratic functions.

Mixed Methods Research involved the use of combined methods in a study, including data obtained from qualitative and quantitative research. The combination of these two methods helped in a more complete understanding of the research subject and provides a broad and detailed perspective on the topic of study (George, 2021).

So, our research was of an exploratory type, aiming to understand and discover how the "Mathematica Application" helps in examining and graphing quadratic functions. Also, the research was with combined data, including first the graphical analysis produced by the Mathematica application (quantitative data) and then the data obtained from the interviews (qualitative data). Combining these data allows us to achieve a more detailed understanding and provide affordable and reliable results for evaluating the effectiveness of the Mathematica application.

Sample / Participants / Group

In this research, the main included participants were high school students from the tenth grade with a total of 25 students. The samples were selected purposively, in a specific group of mathematics students since quadratic functions are elaborated in these classes. The selection of the sample was made taking into account the necessary criteria, such as experience in using the "Mathematica Application" and knowledge of quadratic functions. Throughout the selection process, it has been ensured that the subjects are motivated and suitable to give their contribution to the evaluation of the effectiveness of the Mathematica application in the examination and graphical presentation of quadratic functions. In the research, first with all the participating students, the traditional approach was used, and then with all the students, the alternative approach was used using the Mathematica application. The issue of sensitisation was carefully and responsibly handled in order to ensure that all study participants had a clear perception and felt involved and informed about both methods used the traditional one and the alternative one using the Mathematica application.

Instrument and Procedures

Data collection methods included two main aspects: qualitative data collection and quantitative data collection.

Qualitative data were obtained through individual and group interviews with students. These

interviews were used to obtain information about their experience with the Mathematica application, its use for examining quadratic functions, and their assessment of the performance and benefits of this application. The interviews were structured with open and closed questions to ensure a wide range of responses. The purpose of the questions for this research was to explore the effectiveness of Mathematica in examining and graphing quadratic functions, and to evaluate the benefits and difficulties of using Mathematica compared to traditional methods. The questions aimed to reveal users' perceptions, experiences and feelings towards the Mathematica application and its impact on the understanding and learning of quadratic functions. The survey was used to gather student perceptions and measure a subjective assessment of the effectiveness of the Mathematica application. On the other hand, the observation allowed evaluating the practical use and performance of the Mathematica application by students during the presentation of quadratic functions in class.

Quantitative data included the examining and graphing quadratic functions through the Mathematica application. A data set of known quadratic functions and use the Mathematica application to display their graphs was selected. The tools provided by the Mathematica application to determine the significant points of the functions, analyse the shape of the functions, and compare the graphs produced with the appropriate graphs of the functions were used. This data was important to evaluate the level of conformity and the quality of the graphical representation of the Mathematica application.

Data Analysis

The data analysis sub-chapter for this study aimed to explore and find out how "Mathematica Application" helps examining and graphing the quadratic functions. The analysis process was carried out with appropriate methods to handle the data collected from interviews with focus groups and observations in a detailed and systematized manner. After transcribing the focus group interviews and analysing the observations, coding techniques were used to identify the themes covered and group student responses into specific categories. Part of the data analysis was also carried out with quantitative methods, using statistical software to measure the distribution of responses and to calculate the different percentages of students in the codified categories. The results of the analysis are interpreted critically and carefully to arrive at accurate conclusions supported by the collected data.

Methodology validation

To ensure the validity and reliability of the research results, several strategies were implemented. For the validation of qualitative data, the triangulation technique to confirm and verify the results by comparing them with data collected from other entities and alternative sources were used. For quantitative data validation, replication and independent testing techniques to verify the results and ensure the accuracy of our analyses were used. We also ensured that all ethical issues and necessary standards of data protection and confidentiality were respected throughout the research process. Through these research methodology methods and strategies, accurate and reliable results to evaluate the effectiveness of "Mathematica App" in examining and graphing quadratic functions were provided. Since the application was available on the Wolfram Mathematica open-source web page, there was no reason to ask for permission from the author to use the Mathematica application. To check the accuracy of the examination and graphical presentation of the quadratic function, we as mathematics teachers were ready to take care of this process. To achieve the triangulation technique in this study several alternative sources of data were used, such as previous studies on the use of Mathematica in teaching and mathematics, observations and discussions with teachers and students, review of student papers, and interviews with students.

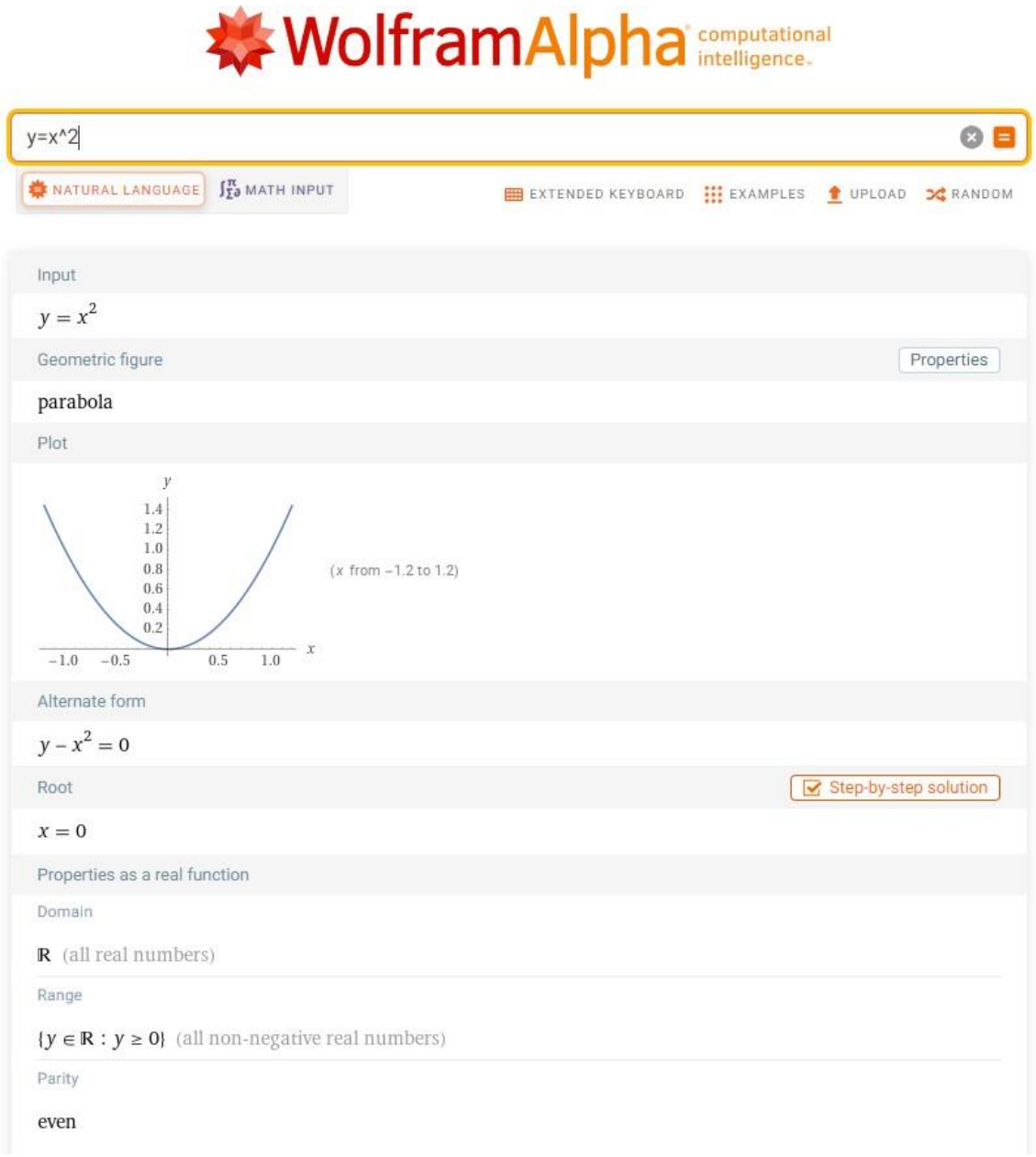
Research Results

In this chapter, the results of the given research on evaluating the effectiveness of the "Mathematica Application" in examining and graphing quadratic functions were presented and analysed. This chapter includes a summary of data collected from qualitative and quantitative research methods, providing a clear and detailed overview of the perceptions and experiences of users of the Mathematica application.

The results collected from the observation of the use of the "Mathematica Application" in the examination and graphical presentation of quadratic functions by the students are as follows. The ease of creating graphs Through the Mathematica application, great ease of creating graphs of quadratic functions was noticed. Students were able to quickly visualise the shape and characteristics of functions. The Mathematica application provided valuable assistance in identifying critical points of quadratic functions, such as extremum points and inflection points. Students used the Mathematica application's available tools to easily find critical point values. Also, the Mathematica application provided a detailed representation of graphs of quadratic functions. Students discovered important points such as zeros of the function, and monotonicity of the function through graphing. An important advantage that was observed in the Mathematica application was the ability to change the parameters of the quadratic functions and display the changes on the graph. Students experimented with coefficient values and assessed their influence on the shape and motion of the function. Also, the Mathematica application provided accurate results in the graphical representation of quadratic functions. The produced graphs are fully adequate and accurate in representing the shape and characteristics of the functions. Therefore, the results of the observation show that the Mathematica application was a powerful and effective tool for examining and graphically presenting quadratic functions. Students benefit from the ease of use, help in identifying critical points, detailed graphing, the ability to change parameters, and accurate graphing results. Below we present a part of the examination and graphical representation of the quadratic function $y = x^2$:

Figure 1

Mathematica Application



The results table shows the percentage of examples that students worked on in class, comparing the traditional method of solving quadratic functions with the use of the Mathematica application to solve them. The percentages shown represent the distribution of responses according to three categories: complete solution, partial solution, and lack of solution.

The analysis of the quantitative results allows us to evaluate the performance of the Mathematica application in presenting complete and partial solutions of quadratic functions, as well as identifying cases when the Mathematica application does not provide solutions. This gives us a clear impression of whether the application is efficient in handling quadratic functions compared to traditional methods. Below we present these results:

Table 1

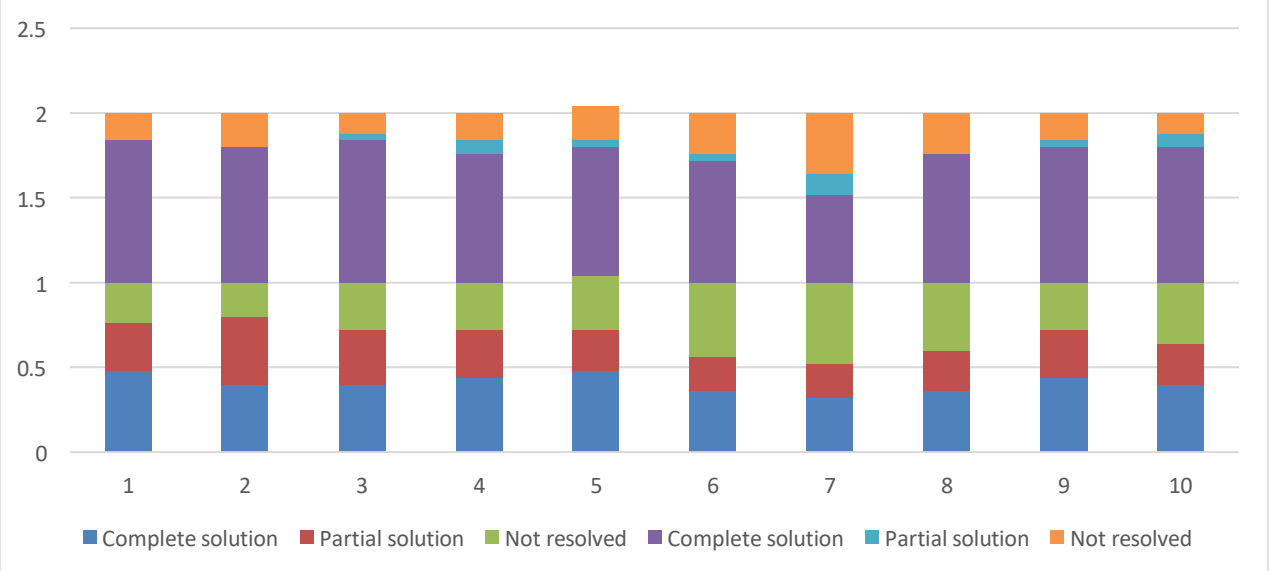
The Results from the Assessment of the Students During the Examination and Graphical Presentation of Quadratic Functions

No.	Quadratic functions	Traditional method (solution in a notebook)			Alternative method (solution with Mathematica application)		
		Complete solution	Partial solution	Not resolved	Complete solution	Partial solution	Not resolved
1	$y = x^2$	48%	28%	24%	84%	0%	16%
2	$y = -x^2$	40%	40%	20%	80%	0%	20%
3	$y = x^2 + 1$	40%	32%	28%	84%	4%	12%
4	$y = x^2 - 2$	44%	28%	28%	76%	8%	16%
5	$y = -x^2 + 3$	48%	24%	32%	76%	4%	20%
6	$y = -x^2 + 2x + 2$	36%	20%	44%	72%	4%	24%
7	$y = (x - 3)^2 - 2$	32%	20%	48%	52%	12%	36%
8	$y = x^2 + 2x - 15$	36%	24%	40%	76%	0%	24%
9	$y = x^2 - 3x - 4$	44%	28%	28%	80%	4%	16%
10	$y = 2x^2 + x + 5$	40%	24%	36%	80%	8%	12%

The diagram below provides a detailed overview of the results of this research and sheds light on the role and benefits of the "Mathematica Application" in examining and graphing quadratic functions. In the following, these results will be discussed and evaluated, linking them to the research hypotheses and the main goals of the study:

Figure 2

The Results from the Assessment of the Students During the Examination and the Graphical Presentation of Quadratic Functions



Through traditional methods (solving in a notebook), the percentage of complete solutions for quadratic functions it ranged from 32% to 48%. The percentage of partial solutions varied from 20% to 40%, while the percentage of cases where the solution of the quadratic function was not achieved it ranges from 24% to 48%.

Through the alternative method (solving with the Mathematica application), the percentage of complete solutions for quadratic functions was higher and ranged from 72% to 84%. The percentage of partial solutions varied from 0% to 8%, while the percentage of cases where the solution of the quadratic function was not reached it ranges from 12% to 36%.

The results showed that the use of the Mathematica application has provided a significant benefit in the complete solution of quadratic functions, achieving high percentages of complete solutions for most of the tested cases. The alternative method has also offered a considerable advantage in the graphical presentation of quadratic functions, offering clear and understandable solutions for most cases.

Data collected from the focus group interviews with students to assess their experience with Mathematica in examining and graphing quadratic functions yield these findings. A student said he used the Mathematica app to examine quadratic functions for a class project. He noted that the Mathematica application made easier the understanding and graph of the quadratic function and to identify critical points such as extremum points and turning points. Another student expressed that the Mathematica application helped visualising quadratic functions interactively. He pointed out that this gives them a deeper understanding of the relationship between the shape of a function and its graph. Likewise, a student expressed that the use of the Mathematica application in the graphical presentation of quadratic functions makes them more attractive and understandable for students. He observed that graphs drawn by the Mathematica application give a better sense of the shape of the function and help in evaluating their trends and characteristics. The results showed that the Mathematica application also provided options to display multiple graphs in one coordinate, making it easier for students to compare quadratic functions and evaluate the differences between them. Some students report that using Mathematica to review quadratic functions helped them solve large problems more easily and complete their math assignments with more confidence. The data collected from focus group interviews provide us with a clear perspective on the user experience with the Mathematica application in examining and graphing quadratic functions. Most users have positively evaluated Mathematica's ability to help understand and present quadratic functions interactively and engagingly.

Discussion

Based on the results of the interviews and observations collected, it can be assessed that the “Mathematica Application” was an effective tool for examining and graphically presenting quadratic functions. Students have positively evaluated the benefits and performance of the Mathematica application in solving quadratic functions and their graphical presentation. The use of the Mathematica application has provided obvious benefits in the context of examining and graphing quadratic functions. Students have identified the ease of creating graphs, the help in identifying critical points, and the detailed presentation of graphs, the possibility of changing parameters, and the correct results of the graph presentation as the main advantages of the Mathematica application. The results of the study by Bataineh et al. (2019) were consistent with the given study showing that the teaching method using the Mathematica application was more effective in developing students' problem-solving skills. The results of the study showed that the use of the Mathematica application has brought about a significant improvement compared to the traditional methods of solving quadratic functions and their graphical representation. The percentage of complete and partial solutions of quadratic functions through the Mathematica application has been much higher than with traditional methods. This suggests that the Mathematica application provided a more efficient and accurate tool for solving quadratic functions and creating graphs. Therefore, it is possible to give answer to the first question of the research that the

“Mathematica Application” is very effective in examining and graphing quadratic functions,

providing a powerful and useful tool for students in understanding and learning these functions. According to our findings and the study of Kinlay (n.d.) it is possible to give answer to the second research question that the benefits of using the Mathematica application were: Ease in creating graphs; Identification of critical points; Detailed presentation of graphics; The possibility of changing the parameters; Motivating students to complete the task, etc. However, the difficulties of using the Mathematica application were: The requirement for technical knowledge; Lack of wide access; its use may be limited due to financial constraints; Difficulty in recognising syntax, etc. The results of the research provided answers to the third research question that students have evaluated the performance of the Mathematica application in creating graphs of quadratic functions. The app has provided an improved and easier experience, helping them better understand quadratic functions and improve their graphing skills. Interactivity, the visualisation of many graphs, and ease of use were important aspects that have contributed to the positive assessment of students on the performance of the Mathematica application. Also, from the findings of this research and from the study of Dziubak et al. (2014), it is also possible to give answer to the last question of the research by saying that the Mathematica application has influenced the improvement of the understanding and learning of quadratic functions among students of mathematics. Improving the understanding of concepts, improving skills in graphic representation, facilitating experimentation, and increasing motivation and engagement are the main factors that have contributed to this positive impact. The Mathematica application has created a suitable and stimulating environment for students to learn and better understand quadratic functions.

On the other hand, according to the given findings, the hypotheses presented for this research can be confirmed. The results of the research and the study by Bataineh et al. (2019) showed to confirm the hypothesis H_1: The use of "Mathematica Application" was evaluated as an effective tool for examining quadratic functions and their graphical representation. Users reported significant benefits in using Mathematica for solving quadratic functions and creating their graphs. The results of the presented research and the study by Shatila et al. (2016) support the hypothesis H_2: The students appreciated that the “Mathematica Application” provides graphical representations of quadratic functions understandably and clearly. The graphs produced by the Mathematica application were evaluated as detailed and perfect in presenting the shape and characteristics of quadratic functions. The results of our research and research by Vorob’ev (2012) supported the hypothesis H_3: The use of the Mathematica application showed obvious benefits compared to traditional methods for the graphical presentation of quadratic functions. The Mathematica app helped students better understanding the concepts of quadratic functions and improving their graphing skills. Also, the use of the Mathematica application increased the motivation and engagement of students in learning this subject. Students rated the performance of the Mathematica application in examining and presenting quadratic functions as satisfactory and adequate. The application provided an improved and easier experience in creating graphs, help in understanding quadratic functions, and the ability to experiment with changing parameters.

One of the main limitations of the research was the sample size used in the survey and observation. The limited sample may not be fully representative of the entire population of interest, thus reducing the generalisability of the results to a wider group. The use of surveys may involve a degree of subjectivity, as students may respond in a manner influenced by their individual perceptions, personal experiences and preferences. This may affect the objectivity of the results. The research is based on the context of a particular school of students and users of the Mathematica application. The results may differ if the research is conducted in a different context or with a different group of participants. The limited time for conducting the research may have affected the detail of the analysis and the collection of more data. In some cases, a longer duration could provide more information and depth to the study.

The research focused on using the Mathematica application before traditional methods, but it is

possible that using another graphics application or other technology tools would provide different results.

Based on the conducted research, there are some suggestions for future research that could expand knowledge and address some of the limitations of the current study. In order to have a wider and more complete representation of the population of interest, it is suggested to choose the sample size. The use of large samples will increase the statistical certainty and reliability of the research results. The current research was conducted in the context of a particular school of mathematics students. Future studies may consider using the Mathematica application in different settings. Additional research could use a control group to compare the effectiveness of the Mathematica application with other methods of representing quadratic functions. Future research could deepen the assessment of students' attitudes and expressions towards the Mathematica application. Future research could also compare the effectiveness of the Mathematica application with other technological tools used for graphing quadratic functions.

Conclusions and Implications

In conclusion, the given research aimed to evaluate the effectiveness of the “Mathematica Application” in examining and graphically presenting quadratic functions. Based on the results of the data analysis and their interpretation, it can be concluded that the “Mathematica Application” was a very effective tool for examining and graphically presenting quadratic functions. Students have appreciated the ease of use of the Mathematica application and the help it provided in solving quadratic functions. The Mathematica application provided graphical representations of quadratic functions understandably and clearly. Using the Mathematica application had obvious benefits compared to traditional methods of solving quadratic functions. The Mathematica application provided more accurate solutions and perfect graphics, bringing a better user experience. However, the use of the Mathematica application had some potential difficulties, such as a lack of technical knowledge and access limitations. Nevertheless, students rated the performance of the Mathematica application as satisfactory and fulfilling. The application has positively influenced the understanding and learning of quadratic functions among students.

Overall, it can be confirmed that the "Mathematica Application" is an effective tool for examining and graphing quadratic functions, providing clear benefits to users. The results of the research showed that the Mathematica application has a positive impact on the understanding and learning of quadratic functions among students. These conclusions can serve as a basis for using Mathematica in the context of quadratic functions and can encourage more research and use of this application in the field of mathematics.

As the landscape of Mathematics education continues to evolve, incorporating the "Mathematica Application" into quadratic function learning offers promising prospects for the future. The results of the research highlighted its effectiveness in enhancing students' understanding and graphical representation of quadratic functions, making it a valuable resource to be integrated into curricula. Embracing the potential of innovative technologies like the "Mathematica Application" will foster a dynamic and engaging mathematics learning environment in the future perspective. Continual research and adaptation, considering the ever-evolving educational landscape, will ensure that quadratic function education remains relevant, effective, and impactful for future generations of learners.

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References

Ardic, M. A., & Isleyen, T. (2017). Secondary school mathematics teachers' and students' views on computer assisted mathematics Mathematica example. *Malaysian Online Journal of Educational Technology, 5*(1), 46–64. https://mojet.net/index.php/mojet/article/view/92

AUC. (n.d.). *Mathematica software revolutionizes science, engineering education. Retrieved* July 9, 2023, from https://www.aucegypt.edu/news/stories/mathematica-software-revolutionizes-science-engineering-education

Aydın, E. (2005). The use of computers in mathematics education: A paradigm shift from "Computer assisted instruction" towards "Student programming". *The Turkish Online Journal of Educational Technology, 4*(2), Article 4. https://files.eric.ed.gov/fulltext/ED502604.pdf

Bataineh, H., Zoubi, A., & Khataybeh, A. (2019). Utilizing MATHEMATICA software to improve students' problem solving skills of derivative and its applications. *International Journal of Education and Research, 7,* 57–70. https://www.ijern.com/journal/2019/November-2019/05.pdf

Baumann, G. (2000). *Symmetry analysis of differential equations with Mathematica.* Springer New York. https://doi.org/10.1007/978-1-4612-2110-4

Borwein, J., & Bailey, D. H. (2009). *Mathematica in action: Problem solving through visualization and computation*. Springer New York. https://doi.org/10.1007/978-0-387-75477-2

Dziubak, S., Sobotka, T., & Suchánek, P. (2014). *Mathematica in education*. World Scientific.

George, T. (2021, December 6). *Exploratory research | Definition, guide, & examples.* Scribbr. https://www.scribbr.com/methodology/exploratory-research/

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3,* 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Jonassen, T. M. (2002). *Mathematica as a teaching tool for a large audience of students* [Conference presentation]. International Arctic Seminar 2002, Murmansk, Russia.

Kinlay, J. (n.d.). *What are some real-world applications of Mathematica?.* Wolfram Community. Retrieved July 9, 2023, from https://community.wolfram.com/groups/-/m/t/774416

Listyani, E. (2006). *Efforts to increase achievement and independence learning differential calculus with mathematica software on mathematics study program students*. FMIPA UNY.

Musyrifah, E., Rabbani, H., Sobiruddin, D., & Khairunnisa, K. (2021). Development of wolfram mathematica application-assisted learning module on derivative in high school. *Journal of Physics: Conference Series, 1836*, Article 012076. https://doi.org/10.1088/1742-6596/1836/1/012076

Nielsen, L. E. (2015). *Understanding quadratic functions and solving quadratic equations: An analysis of student thinking and reasoning* [PhD dissertation]. University of Washington. http://hdl.handle.net/1773/33799

Orhani, S. (2021). Integration technology in math lessons. In Yu. B. Melnyk, & L. M. Georgieva (Eds.), *Current issues of education and science. 9th international conference, CIES-2021, Riga, Latvia – Kharkiv, Ukraine, November* 10–13, 2021, Conference proceedings (pp. 25-32). https://doi.org/10.26697/9786177089147.2021.04

Strogatz, S. (2013). *The joy of x: A guided tour of math, from one to infinity*. Mariner Books.

Shatila, H., Habre, S., & Osta, I. (2016). Effects of technology-aided multiple-representations approach on students' understanding of derivatives. In *Proceedings of 28th International Conference on Technology in Collegiate Mathematics* (pp. 221–225). https://laur.lau.edu.lb:8443/xmlui/bitstream/handle/10725/8057/Effects.pdf

Sholahudin, U. (2017). Pemanfaatan perangkat lunak mathematica dalam perkuliahan kalkulus materi limit fungsi. In *Seminar Nasional Riset Terapan* 2017 (pp. 247–250). https://e-jurnal.lppmunsera.org/index.php/senasset/article/view/456

Tall, D., Smith, D., & Piez, C. (2008). Technology and calculus. In M. K. Heid & G. M. Blume (Eds.), *Research on technology and the teaching and learning of mathematics* (volume I: research syntheses, pp. 207–258). Information Age Publishing.

Tersian, S., & Chaparova, J. (2020). *About using "Mathematica" in teaching of diferential calculus. University of Ruse Angel Kanchev.* https://www.researchgate.net/publication/228993636_ABOUT_USING_MATHEMATICA_IN_TEACHING_OF_DIFFERENTIAL_CALCULUS

Velázquez, F. D., & Méndez, G. M. (2021). Application in augmented reality for learning mathematical functions: A study for the development of spatial intelligence in secondary education students. *Mathematics, 9*(4), Article 369. https://doi.org/10.3390/math9040369

Vorob'ev, E. (2012). Online teaching of calculus using webmathematica [Conference presentation]. First International Conference. Globalization: Business, Finance and Education (ITERB-2012), Larnaca, Cyprus.

Wolfram, S. (1999). *The Mathematica book* (4th ed.). Cambridge University Press.