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Power of GeoGebra in Igniting the Interest in Learning Quadratic Functions

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Abstract. This study investigated the perceived relationship between students' interest in learning quadratic functions after utilizing GeoGebra and their perceived usefulness. The study used a quasi-experimental design, specifically the one-group pretest-posttest design using a single-stage cluster sampling technique, to identify Grade 9 students' interest levels before and after using GeoGebra software in the school year 2023-2024 at Demetrio L. Alviola National (Memorial) High School. It also used the weighted mean, Wilcoxon test, and Spearman rank correlation coefficient to compare pre- and post-evaluation interest in learning quadratic functions. The results showed that GeoGebra effectively increased students' interest in quadratic functions, igniting a greater passion for the subject matter. Furthermore, using GeoGebra tools increased students' interest in learning, leading to greater confidence, participation, and motivation to understand quadratic functions. This encompassed tasks such as graphing, solving equations, and applying their knowledge to real-world scenarios, representing a significant shift before and after incorporating geometry into the learning process. Certainly, GeoGebra's engaging and vibrant components help students to relax and stay engaged, enhancing the enjoyment and collaboration aspects of education. The findings also showed that students' substantial progress in three areas—understanding concepts, engaging with teachers, and assessment results—is closely associated with their interest in learning more about quadratic functions. Students more enthusiastic about quadratic functions are more likely to comprehend these topics using GeoGebra.

Keywords: Education; ICT; GeoGebra; Mathematics; Quadratic functions.

1.0 Introduction

On a global scale, one of the major issues or concerns in learning mathematics is the lack of interest among students. Mathematics is often seen as difficult not due to students' lack of capability but because it is perceived as uninteresting or irrelevant, leading to a lack of focus and engagement (Fletcher, 2018). According to the PISA-D (PISA for Development 2018) data, two countries, Panama and the Dominican Republic, scored extremely low in mathematics, resulting in the introduction of a new proficiency level termed "below level 1" to represent the lowest level of math proficiency. When using technology to enhance interest in learning math, students may face challenges if their teachers lack the skills to create effective learning opportunities. Additionally, the lack of resources can make it difficult to implement GeoGebra on a large scale (Birgin & Topuz, 2021).

The latest results from the Programme for International Student Assessment (PISA) highlight significant challenges faced by Filipino students in numeracy (Descartin et al., 2023; Trinidad, 2020), indicating that their performance is below that of their international peers (Bernardo et al., 2023). The 2019 Trends in International Mathematics and Science Study (TIMSS) also revealed that the Philippines scored 297 in mathematics and 249 in science, placing last among the 58 countries surveyed. Romantico (2019) also emphasized that the struggles with mathematics are evident not only in international assessments but also at national, regional, and school levels. To address these issues, improvements should be implemented at the school level by integrating new technologies, as technology-based methods have proven successful in addressing various educational challenges.

Although existing literature points out how GeoGebra improves mathematical understanding, problem-solving, and student participation, its adoption and influence on math education passion require additional research (Uwurukundo et al., 2022). No study has yet delved into GeoGebra's effect on students' interest in mathematics, specifically quadratic functions. Most studies primarily concentrated on the advantages and effects of using technology on mathematical disciplines and educational contexts (Wijaya et al., 2020), while other scholars examined GeoGebra mathematics instruction's benefits to students based on their academic aptitude, cultural heritage, preferred learning approach, and special education needs (Yatim et al., 2022; Zulnaidi et al., 2020). However, the current inquiry is different because it focuses on the student's interest level before and after using GeoGebra in learning quadratic functions. This study concentrates on quadratic functions, as students often lack interest in this topic, particularly in grasping and graphing concepts. The research investigates using GeoGebra software in teaching quadratic functions, which is important for teachers and students. The goal is to improve teaching methods by equipping educators with innovative strategies to make lessons more engaging and interactive. Specifically, the study aims to enhance personalized instruction and student participation by examining the factors influencing students' selection of GeoGebra and its effects on their learning experience.

2.0 Methodology

2.1 Research Design

The study utilized the quasi-experimental design, specifically the one-group pretest-posttest design. In this type of research, there was no control group, and the subjects in the experimental group were assessed before and after the treatment. Additionally, the level of students' interest was identified before and after using the GeoGebra software.

2.2 Research Locale

This study was done at Demetrio L. Alviola National High School-Junior High School Campus located in Barangay Tinaogan, Municipality of Bindoy, Negros Oriental. The school is the second-largest secondary school in the Division of Negros Oriental, with a total number of 1,842 students and 105 teaching and non-teaching personnel in the school year 2023-2024. In this institution, flat-screen TVs are used to aid learning in classrooms. Science, library, and ICT labs are also available at the school. Moreover, the campus is equipped with Wi-Fi for teachers and students. The typical Junior High School average class size is 35 students per class, with 13 sections per year level.

2.3 Research Participants

The study participants were 238 Grade 9 students enrolled in Demetrio L. Alviola National (Memorial) High School for the school year 2023-2024. They were chosen using the single-stage cluster sampling technique, wherein seven sections were randomly selected out of 13.

2.4 Research Instrument

The self-made questionnaire used in this study consists of four parts. Part I displays the disclosure statement and the consent form. It also contains the purpose of the study. Part II assesses the student's interest in learning quadratic functions before utilizing the GeoGebra software. In contrast, Part III gauges the student's interest in learning quadratic functions after utilizing the GeoGebra software. Part IV assesses the perceived usefulness of the GeoGebra software. A dry run of the questionnaire was done with students from the randomly selected 13 sections as the respondents to ensure item reliability. The Cronbach's alpha test assessed the items' reliability, revealing how closely the items were related as a group. The questionnaire underwent a rigorous assessment to ensure the reliability and validity of its contents. It was initially validated by four experts in the field, followed by a dry run to verify its effectiveness. All coefficients obtained from the dry run exceeded 0.70, confirming the reliability of the questionnaire. Consequently, the researcher proceeded with the final data collection phase.

2.5 Data Gathering Procedure

After the design hearing, the researcher incorporated the corrections and suggestions of the panel members. A letter asking permission to conduct the study was sent first to the office of the Schools Division Superintendent of Negros Oriental requesting permission to allow the researcher to conduct the study on the targeted Grade 9 Students of Demetrio L. Alviola National High School. The signed and approved request was presented to the school principal and the randomly selected advisers of the grade 9 students. Before conducting the experiment and distributing the test questionnaires, the researcher explained to the students the purpose and importance of the research. A specific schedule was followed during the two-day pre-test and post-test experiment: two hours on the first day and another two hours on the second day. On the first day, the researcher thoroughly discussed the concepts of quadratic functions and administered a pretest using a questionnaire. On the second day, the researcher used GeoGebra Software to explore the lesson on quadratic functions further. Following the discussion, students completed a post-test questionnaire. Subsequently, questionnaires aimed at measuring the usefulness of GeoGebra were distributed. Both sets of results were analyzed and interpreted.

2.6 Data Analysis Procedure

Appropriate statistical tools were used to answer the research questions. Appropriate descriptive research rating interpretation was also applied. Weighed Mean was used to identify the level of students' interest in using GeoGebra software and the extent of usefulness of GeoGebra in terms of understanding the concepts, visual presentation, student-teacher interaction, and evaluation/assessment. Wilcoxon test was used to identify the significant difference between the pre-evaluation and post-evaluation of the student's interest in learning quadratic functions. The Spearman rank correlation coefficient was utilized to determine the degree of relationship between the level of students' interest in learning quadratic functions after utilizing GeoGebra software and the extent of GeoGebra's usefulness.

2.7 Ethical Considerations

Research ethics were primarily observed and maintained throughout the study. Ethical approval was obtained from the Foundation University Research Office's ethical committee. Informed consent was obtained through the disclosure statement from all individual respondents in the study before its implementation. The rights to self-determination, confidentiality and anonymity, benefits, and risks of the study were also highlighted.

3.0 Results and Discussion

3.1 Students' Interest in Learning the Graphs of Quadratic Functions before and after using GeoGebra

Tables 1, 2, and 3 present the levels of students' interest in learning the graphs of quadratic functions before and after using GeoGebra Software.

Table 1. Level of students' interest in learning the graphs of quadratic functions before and after using GeoGebra

Indicators	Before			After		
	$w\bar{x}$	VD	LoI	$w\bar{x}$	VD	LoI
1. I look forward to learning about quadratic functions with my classmates	3.67	A	H	4.48	SA	VH
2. I look forward to using graphing software to practice drawing the points of quadratic functions.	3.59	A	H	4.50	SA	VH
3. I prefer graphing software over manual graphing to learn more about how to graph a quadratic function.	3.58	A	H	4.56	SA	VH
4. I am eager to practice drawing the points of quadratic functions	3.57	A	H	4.47	SA	VH
5. I am looking forward to learning quadratic functions	3.55	A	H	4.53	SA	VH
6. I study for my math class and pay close attention whenever my teacher discusses the graph of quadratic functions.	3.54	A	H	4.48	SA	VH
7. I get more excited and curious about graphing quadratic functions	3.44	A	H	4.78	SA	VH
8. I find joy in learning quadratic functions	3.43	A	H	4.60	SA	VH
9. I am motivated to complete my math work about graphs of quadratic functions	3.34	MA	M	4.55	SA	VH
10. I am confident in my ability to excel in tests, assignments, and projects related to learning the graph of quadratic functions.	3.31	MA	M	4.51	SA	VH
Composite	**3.50**	**A**	**H**	**4.55**	**SA**	**VH**

Legend: 4.21 – 5.00 Strongly Agree (SA) Very High (VH), 3.41 – 4.20 Agree (A) High (H), 2.61 – 3.40 Moderately Agree (MA) Moderate (M), 1.81 – 2.60 Disagree (D) Low (L), 1.00 – 2.60 Strongly Disagree (SD) Very Low (VL)

Table 1 shows the students' interest in learning the graphs of quadratic functions before and after using GeoGebra. It is shown that before using GeoGebra, students have a "high" level of interest in (a) learning about quadratic functions with their classmates ($w\bar{x}$ = 3.67), (b) using graphing software to practice drawing points of quadratic functions ($w\bar{x}$ = 3.59), and (c) graphing software over manual graphing to learn more about how to plot a quadratic function ($w\bar{x}$ = 3.58). These findings suggest that students have a high regard for collaborative learning, show readiness for the use of graphing software, and recognize the efficiency and utility of digital tools in mastering the graphs of quadratic functions. The table further shows that before the utilization of GeoGebra, the students had "moderate" interest in (a) completing their math work about the graph of quadratic functions ($w\bar{x}$ = 3.34) and (b) having themselves excelled in tests, assignments, and projects related to learning the graph of quadratic functions ($w\bar{x}$ = 3.31). This moderate level of interest entails a shift in classroom instruction to ignite their interest in learning graphs of quadratic functions.

On the other hand, after the utilization of GeoGebra software, the data exposed that students have a "very high" interest in (a) learning about quadratic functions with their classmates ($w\bar{x}$ = 4.84), (b) using graphing software to practice drawing points of quadratic functions ($w\bar{x}$ = 4.50), and (c) graphing software over manual graphing to learn more about how to plot a quadratic function ($w\bar{x}$ = 4.56). These results indicate that the students managed to raise a more positive collaborative work with their classmates, value the interactive features of GeoGebra for a deeper understanding of graphical representations, and emphasize GeoGebra's role in optimizing learning efficiency and effectiveness. Furthermore, the data show that after the utilization of GeoGebra, the students exhibit a "very high" interest in (a) completing their math work about the graph of quadratic functions ($w\bar{x}$ = 4.55) and (b) having themselves excelled in tests, assignments, and projects related to learning the graph of quadratic functions ($w\bar{x}$ = 4.51). These findings connote that the students enjoy the utilization of GeoGebra and acknowledge its usability to a very high level in learning graphs of quadratic functions. Generally, the level of students' interest in learning graphs of quadratic functions was "high" before GeoGebra was utilized ($w\bar{x}$ = 3.50) and "very high" after GeoGebra was introduced ($w\bar{x}$ = 4.55). A difference in their level of interest exists considering the samples.

The above findings align with the study by Rojo et al. (2023), which explored how a pedagogical innovation called the 'King and Queen of Mathematics Initiative' (KQMI) impacts students' interest in learning mathematics and improves their achievement. It was also found that students developed a newfound interest in mathematics through the real-world context of the mathematical modeling unit. Similarly, the study by Jalandoni and Futalan (2024) found that after the intervention using game-based instructions (Integer Math Maze and Intego Card Game), students improved their understanding of addition and subtraction of integers. This improvement suggests that game-based instruction can effectively scaffold students' difficulties in learning the addition and subtraction of integers, leading to enhanced learning outcomes and increased interest in the subject.

Table 2. Level of students' interest in finding the equations of quadratic functions before and after using GeoGebra

Indicators	Before			After		
	$w\bar{x}$	**VD**	**LoI**	**$w\bar{x}$**	**VD**	**LoI**
1. I look forward to learning about how to find the equation of quadratic functions with my classmates	3.59	A	H	4.60	SA	VH
2. I study for my math class and pay close attention whenever my teacher uses graphing software to discuss how to find the equation of quadratic functions.	3.57	A	H	4.53	SA	VH
3. I prefer graphing software over manual graphing to learn more about finding the equations of quadratic functions.	3.57	A	H	4.55	SA	VH
4. I look forward to practicing finding the equation of quadratic functions.	3.56	A	H	4.55	SA	VH
5. I find joy in learning how to find the equation of quadratic functions	3.52	A	H	4.59	SA	VH
6. I am looking forward to solving equations of quadratic functions	3.51	A	H	4.56	SA	VH
7. I am eager to practice identifying the zeroes and vertex points of the quadratic functions	3.50	A	H	4.53	SA	VH
8. I get more excited and curious about finding the zeroes of the quadratic functions	3.36	MA	M	4.52	SA	VH
9. I am confident in my ability to excel in tests, assignments, and projects related to finding quadratic function equations.	3.36	MA	M	4.46	SA	VH
10. I am motivated to complete my math work because I understand how to find the equation of a quadratic function	3.31	MA	M	4.55	SA	VH
Composite	**3.49**	**A**	**H**	**4.54**	**SA**	**VH**

Table 2 presents the data on students' interest in finding the equations of quadratic functions before and after using GeoGebra software. Before using GeoGebra, the students showed a "high" level of interest in several areas, such as (a) learning with classmates ($w\bar{x}$ = 3.59), (b) paying attention during lessons involving graphing software ($w\bar{x}$ = 3.57), and (c) preferring graphing software over manual graphing ($w\bar{x}$ = 3.57). These findings suggest that students appreciate collaborative learning and acknowledge the benefits of digital tools in understanding quadratic equations. However, students only had a "moderate" level of interest in aspects like (a) finding the zeroes of quadratic functions ($w\bar{x}$ = 3.36), (b) excelling in tests and assignments related to quadratic equations ($w\bar{x}$ = 3.36), and (c) completing their math work ($w\bar{x}$ = 3.31). This moderate interest indicates areas where additional instructional support could be beneficial to engage students further. After using GeoGebra, the data show a "very high" level of interest in all indicators. Students displayed a "very high" interest in (a) learning collaboratively ($w\bar{x}$ = 4.60), (b) paying close attention during lessons ($w\bar{x}$ = 4.53), (c) preferring graphing software ($w\bar{x}$ = 4.55), and (d) practicing finding equations ($w\bar{x}$ = 4.55). The increased scores imply that GeoGebra enhanced students' engagement and understanding, making learning more interactive and enjoyable.

Overall, the level of students' interest in finding the equation of quadratic functions was "high" before GeoGebra was used ($w\bar{x}$ = 3.49) and "very high" after GeoGebra was explored ($w\bar{x}$ = 4.54). This finding indicates a noticeable difference in their interest levels based on samples. One key finding is that students appreciated the collaborative learning approach and recognized the benefits of digital tools in enhancing their understanding of quadratic equations. Hoyles (2018), likewise, believes that using technology-based tools, such as videos and PowerPoint presentations, can make learning complex and abstract mathematical concepts more achievable for learners. Furthermore, incorporating digital tools like graphing software can create a more interactive and enjoyable learning process, strengthening students' engagement and understanding when working with quadratic functions (Hoyles, 2018). However, the result also suggests that additional instructional support could be beneficial to further engage students in learning mathematics. The transformation of mathematics classrooms through the use of the internet and digital technologies has occurred in distinct phases, and there is a need to provide appropriate guidance and support to help students effectively utilize these tools (Engelbrecht et al., 2020; Naidoo & Hajaree, 2021).

Table 3 illustrates students' interest in learning the applications of quadratic functions before and after using GeoGebra software. Initially, students exhibited a "high" level of interest in (a) using graphing software to practice solving problems ($w\bar{x}$ = 3.58), (b) preferring graphing software for learning ($w\bar{x}$ = 3.51), and (c) learning applications with classmates ($w\bar{x}$ = 3.50). These responses indicate a positive attitude toward using technology and collaborative learning in understanding quadratic function applications. The study of Scherer et al. (2019), corroborates these findings, claiming that students who find educational tools easy to use are more likely to have a positive attitude toward learning.

Table 3. Level of students' interest in learning the real word problems on quadratic functions before using GeoGebra

Indicators		Before			After		
		$w\bar{x}$	VD	LoI	$w\bar{x}$	VD	LoI
1.	I look forward to graphing software to practice solving more problems related to quadratic functions.	3.58	A	H	4.53	SA	VH
2.	I prefer graphing software to learn more about solving problems involving quadratic functions.	3.51	A	H	4.57	SA	VH
3.	I look forward to learning the application of quadratic functions with my classmates	3.50	A	H	4.58	SA	VH
4.	I study for my math class and pay close attention to what my teacher says. I want to do well on tests, assignments, and projects related to the application of quadratic functions.	3.49	A	H	4.55	SA	VH
5.	I look forward to learning quadratic functions by applying them to real-life situations.	3.45	A	H	4.58	SA	VH
6.	I find joy in solving problems of quadratic function.	3.44	A	H	4.63	SA	VH
7.	I am motivated to complete my math work related to the application of quadratic functions because I understand it better using graphing software.	3.41	A	H	4.56	SA	VH
8.	I get more excited and curious about applying the concepts of quadratic functions in problem-solving.	3.35	MA	M	4.53	SA	VH
9.	I am confident in my ability to excel in tests, assignments, and projects related to the application of quadratic functions.	3.33	MA	M	4.55	SA	VH
10.	I regularly apply the principles of quadratic functions learned through graphing software to solve real-world problems independently.	3.30	MA	M	4.51	SA	VH
Composite		**3.43**	**A**	**H**	**4.56**	**SA**	**VH**

As reflected in the table, students have a "moderate" level of excitement about applying quadratic functions in problem-solving ($w\bar{x}$ = 3.35) and being confident in their ability to excel in related tests and assignments ($w\bar{x}$ =

3.33). This moderate interest suggests areas for further engagement and instructional support. Zimmerman (2002) suggested that students with moderate interest may lack self-regulation skills, which can be developed through targeted instructional support. Instructional support to develop self-regulation can help moderately interested students become more proactive and engaged learners. After implementing GeoGebra, the data reveal a "very high" level of interest in all indicators. Students expressed a “very high” interest in (a) using graphing software to practice solving problems ($w\bar{x} = 4.53$), (b) preferring graphing software for learning ($w\bar{x} = 4.57$), and (c) learning with classmates ($w\bar{x} = 4.58$). Collectively, the level of students’ interest in learning the applications of quadratic functions is “high” before GeoGebra was employed ($w\bar{x} = 3.43$) and “very high” after GeoGebra was presented ($w\bar{x} = 4.56$). A difference in their level of interest exists considering the samples.

The overall findings support the study by Karma et al. (2019), which discusses the positive impact of software on students' interest and motivation in learning applied mathematics subjects. Using multimedia technology and online resources can provide students with various learning modalities, catering to diverse learning styles and preferences, further enhancing their interest and motivation in the subject. According to Conceição (2021), using dynamic and interactive software tools, such as Mathematica, can greatly enhance students' understanding and engagement with mathematical concepts like quadratic functions, positively impacting their interest and motivation in learning these concepts.

3.2 Difference in the Level of Students’ Interest in Learning Quadratic Functions before and after Utilizing GeoGebra

Table 4 reveals the data signifying the difference in students’ interest in learning the three topics in quadratic functions before and after utilizing GeoGebra software.

Table 4. Analysis table on the difference in the level of students’ interest in learning quadratic functions before and after utilizing GeoGebra

Topics	Median		Comp.	p-	Decision	Remark
	Before	After	W	value		
Graph of Quadratic Functions	3.50	4.60	188.50	<.001	Reject H_{o1}	Significant
Finding the Equation of Quadratic Functions	3.50	4.60	183.50	<.001	Reject H_{o1}	Significant
Application of Quadratic Functions	3.45	4.60	277.50	<.001	Reject H_{o1}	Significant
Overall	**3.50**	**4.60**	**28284**	**<.001**	**Reject H_{o1}**	**Significant**

Wilcoxon Test (W) at 0.05 Level of Significance

Using the Wilcoxon Test to identify the difference, the data show that all p-values of the three topics are less than the significance level (0.05). This finding allows the rejection of the null hypothesis. This means that there is a significant difference in the level of students’ interest in (a) learning the graph of quadratic functions, (b) finding the equation of quadratic functions, and (c) learning the application of quadratic functions before and after the utilization of GeoGebra software. Considering the values of the medians before and after the utilization of the intervention, one can conclude that using GeoGebra impacts students, enabling them to boost their interest. The above findings support the conclusions drawn by Sheikh Qasem (2020), Birgin and Topuz (2021), and Zulu et al. (2022), who collectively demonstrated how GeoGebra software effectively enhances mathematics education. Generally, these studies emphasize the significance of integrating technology such as GeoGebra into mathematics teaching to enrich students' learning experiences and improve their comprehension of mathematical concepts. Handayani et al. (2022) also noted that the software enhances problem-solving skills and sustains student interest by offering creative and interactive models. Rabi et al. (2021) stressed GeoGebra’s positive influence on students' attitudes and ability to depict mathematical ideas visually. Moreover, Bekene Bedada and Machaba (2022) demonstrated GeoGebra's advantages across various mathematical domains, affirming its role in enhancing overall mathematical literacy and engagement. Collectively, these studies affirm GeoGebra as a transformative educational tool that enhances the interactivity, engagement, and effectiveness of mathematics instruction.

3.3 The Extent to Which Students Perceive the Usefulness of GeoGebra in Learning Quadratic Functions

Tables 5, 6, and 7 show the extent to which students perceive GeoGebra as a useful tool for understanding quadratic functions, visual presentation, student-teacher interaction, and assessment results. The data in Table 5 further shows that students perceive GeoGebra as “very highly” useful for understanding quadratic functions, with a composite weighted mean of 4.71. Specifically, students claim that GeoGebra is “very useful” in plotting points of quadratic functions ($w\bar{x}$ = 4.78), drawing graphs ($w\bar{x}$ = 4.78), and identifying key features such as the opening of the graph intercepts, center, and line of symmetry ($w\bar{x}$ = 4.69). Moreover, the students divulge that GeoGebra is "very useful" in discussing concepts with peers ($w\bar{x}$ = 4.71) and demonstrating an understanding of solving quadratic functions ($w\bar{x}$ = 4.66). These ratings accentuate GeoGebra's effectiveness in aiding comprehension and communication related to quadratic functions. The consistently high composite score suggests widespread recognition of GeoGebra's usefulness in this context.

Table 5. The extent to which students perceive the usefulness of GeoGebra in learning quadratic functions in terms of conceptual understanding

Indicators	$w\bar{x}$	VD	EoU
1. Plot the points of quadratic functions.	4.78	A	VH
2. Draw the graphs of quadratic functions.	4.71	A	VH
3. Identify the opening of the graph, the intercepts, the center, and the line of symmetry.	4.69	A	VH
4. Discuss the concepts of quadratic functions with my fellow students.	4.71	A	VH
5. Demonstrate my understanding of solving quadratic functions.	4.66	A	VH
Composite	**4.71**	**A**	**VH**

These findings are consistent with Birgin and Yazıcı's (2021) research, which demonstrated that GeoGebra's interactive and visual tools significantly improve students' understanding and retention of mathematical concepts, especially in complex areas such as Algebra and Calculus. Santia and Sutawidjadja (2019) also emphasized how GeoGebra's dynamic approach helps tackle common mathematical challenges by presenting well-structured and manageable problems. Furthermore, GeoGebra has been found to increase students' self-assurance and academic performance in mathematics. Studies by Kado and Dukpa (2020) and Mosese and Ogbonnaya (2021) revealed that GeoGebra remarkably improves conceptual understanding, especially in differential calculus. Uwurukundo et al. (2020) also reported that GeoGebra generally enhances students' knowledge and engagement, although its effectiveness may vary based on the specific implementation methods.

The data in Table 6 displays that the students perceive GeoGebra as "very highly" useful for visual presentation of learning quadratic functions, achieving a composite weighted mean of 4.68. Explicitly, the data indicate that students perceive GeoGebra as "very highly" useful in the sense that it enables them to show their skills in learning quadratic functions ($w\bar{x}$ = 4.71). The visual aids provided by GeoGebra also make abstract mathematical concepts more tangible and comprehensible for students. The software significantly enhances students' understanding by providing real-life visual experiences. Students further reported that GeoGebra helps create an (a) engaging learning atmosphere ($w\bar{x}$ = 4.62), (b) easy understanding of quadratic functions ($w\bar{x}$ = 4.68), (c) improved students' analytical skills ($w\bar{x}$ = 4.66) and (d) attentive learner ($w\bar{x}$ = 4.74).

Table 6. The extent to which students perceive the usefulness of Geogebra in learning quadratic functions in terms of visual presentation

Indicators	$w\bar{x}$	VD	EoU
1. Show skills in learning about quadratic functions when my teacher uses GeoGebra software to show me how they look on a graph.	4.71	A	VH
2. Create an atmosphere of interest in learning quadratic functions through GeoGebra presentation.	4.62	A	VH
3. Understand quadratic functions quickly and easily. This is because they give me a real-life visual experience through graphics and virtual screen	4.68	A	VH
4. By using GeoGebra for visual presentations and demonstrations, I can analyze things better, and my level of understanding is now excellent.	4.66	A	VH
5. Develop my attention in learning quadratic functions using GeoGebra creative templates, tools, tables, and algebra.	4.74	A	VH
Composite	**4.68**	**A**	**VH**

These findings imply that GeoGebra is a highly effective tool for enhancing understanding, engagement, and analytical skills through visual presentations. Its use in the classroom can improve learning outcomes, particularly for visual learners, and support teachers in delivering more effective and engaging instruction. These findings are consistent with research that supports the effectiveness of visual learning tools in enhancing understanding and engagement in mathematics. According to Azizah et al. (2021) and Vágová and Kmetová (2019), learning mathematics involves the application of visualization skills. GeoGebra plays a crucial role in developing these skills by allowing students to accurately perceive geometric structures in 2D and 3D formats. Furthermore, Tamam and Dasari (2021) found in their study that students who used GeoGebra achieved higher assessment scores, improving their ability to visualize mathematical concepts. Integrating tools like GeoGebra into educational environments has become indispensable due to rapid technological advancements and the economy.

The data displayed in Table 7 demonstrate how GeoGebra enhances student-teacher interaction regarding quadratic functions. The results with a composite score of 4.71 suggest "Always" useful and "Very High" effectiveness. Active participation, lesson understanding, open communication, exploring ideas, and clarifying confusion all received high scores, from 4.61 to 4.76, reflecting the role of GeoGebra in fostering collaborative and interactive learning environments. This implies that GeoGebra enhances student-teacher interactions, leading to a more collaborative and interactive learning environment. According to Dahal et al. (2019), GeoGebra promotes active knowledge construction through collaboration and engagement, transferring the instructional emphasis from the teacher to the learners.

Table 7. The extent to which students perceive the usefulness of GeoGebra in learning quadratic functions in terms of student-teacher interaction

Indicators	$w\bar{x}$	VD	EoU
1. Actively took part in joint learning tasks with my peers.	4.74	A	VH
2. Understand the lessons on quadratic functions. When I had questions, my teacher clarified things using GeoGebra Software.	4.74	A	VH
3. Talked to my teacher and asked questions openly.	4.61	A	VH
4. Explore ideas and skills in graphing and solving quadratic functions when my teacher gave me input on my answer, which was suitable and useful.	4.67	A	VH
5. Understand when my teacher explained very well using GeoGebra Software when some students showed confusion.	4.76	A	VH
Composite	**4.71**	**A**	**VH**

The versatility of the software in addressing design issues, geometry, algebra, and other mathematical fields expands its utility in numerous areas (Saputra & Fahrizal, 2019). Research consistently demonstrates that integrating GeoGebra into the classroom yields favorable results. Wijaya et al. (2020) observed improvements in problem-solving capabilities and visual cognition, while Birgin and Topuz (2021) reported enhancements in performance, retention, and attitudes of seventh-grade students in geometry when utilizing GeoGebra within a computer-supported collaborative learning (CSCL) setting. This shows that GeoGebra enhances scholastic achievement and cultivates favorable attitudes toward mathematics. GeoGebra's ability to connect mathematical concepts with practical applications augments student engagement and comprehension (Lopes et al., 2019).

Table 8 assesses GeoGebra's impact on evaluation and assessment in learning quadratic functions. The composite score of 4.72 depicts GeoGebra as "Always" useful and "Very Highly" effective. This implies that students felt at ease solving problems, taking exams, participating in activities, and improving grades, with scores ranging from 4.68 to 4.76.

Table 8. The extent to which students perceive the usefulness of GeoGebra in learning quadratic functions in terms of results of assessment

Indicators	$w\bar{x}$	VD	EoU
1. Solve problems in quadratic functions and make me feel at ease.	4.76	A	VH
2. I took the exam easily and felt comfortable doing a task because my teacher used GeoGebra to make the graphs on the test easy to see.	4.68	A	VH
3. Participate in performance-based activity in solving quadratic functions.	4.71	A	VH
4. Participate actively in the tasks my teacher gave us.	4.70	A	VH
5. Do better in school by improving my grades and academic performance in mathematics.	4.74	A	VH
Composite	**4.72**	**A**	**VH**

These results underscore the tool's ability to enhance students' confidence and performance in quadratic function assessments. Research consistently supports the efficacy of GeoGebra in enhancing students' mathematical representation capabilities, regardless of their prerequisite skill levels (Acharya, 2020; Alabdulaziz et al., 2021). Students instructed using GeoGebra consistently perform better post-tests than those taught with conventional methods (Uwurukundo et al., 2022). This finding is reinforced by Harahap et al. (2021), Kholid et al. (2022), and Nurzannah et al. (2021), who demonstrated significant improvements in students' abilities when using GeoGebra. Pari-Condori et al. (2020) also found that GeoGebra enhances students' engagement and comprehension by enabling a dynamic understanding of geometry. Similarly, Ridha and Pramiarsih (2020) showed substantial enhancements in geometry transformation proficiency among college students using GeoGebra.

GeoGebra is highly regarded in mathematics education for its time-saving, representational, and participatory benefits (Awaji, 2021). It is particularly effective in calculus, geometry, and algebra. For instance, a study by Tong et al. (2021) revealed that eleventh-graders taught continuous functions via GeoGebra exhibited higher motivation and achieved superior results than those taught using traditional methods. Eid and Abdulla (2021) also observed that GeoGebra helped learners better comprehend triangular similarities. GeoGebra's impact on higher-order thinking and problem-solving abilities is well-documented, with studies showing that it also reduces learning anxiety and cognitive burden (Juandi et al., 2021; Yohannes & Chen, 2021). Arnawa and Fitriani (2022) emphasized that GeoGebra helps students visualize and understand intricate calculus principles, enhancing their logical thinking and overall comprehension.

3.4 Relationship between the Level of Student's Interest in Learning Quadratic Functions after Utilizing GeoGebra and the Perceived Usefulness of GeoGebra

Table 9 shows the relationship between students' interest in learning quadratic functions after using GeoGebra and the perceived usefulness of the tool across various dimensions.

Table 9. Relationship between the level of student's interest in learning quadratic functions after utilizing GeoGebra and the perceived usefulness of GeoGebra

Level of Interest in…	r_s	p-value	Decision	Remark
Learning Quadratic Functions vs. Perceived Usefulness in Terms of Understanding the Concepts	0.191	0.003	Reject H_{o2}	Significant
Learning Quadratic Functions vs. Perceived Usefulness in Terms of Visual Presentation	0.115	0.078	Fail to reject H_{o2}	Not significant
Learning Quadratic Functions vs. Perceived Usefulness in Terms of Student-Teacher Interaction	0.153	0.018	Reject H_{o2}	Significant
Learning Quadratic Functions vs. Perceived Usefulness in Terms of Evaluation/Assessment	0.149	0.022	Reject H_{o2}	Significant
Learning Quadratic Functions vs. Overall Perceived Usefulness	0.174	0.007	Reject H_{o2}	Significant

Spearman Rank-Order Correlation at 0.05 Level of Significance

As shown, there is a significant positive relationship between students' interest and the perceived usefulness of GeoGebra in understanding concepts (r_s =0.191, p = 0.003). Similarly, a significant positive correlation exists for student-teacher interaction (r_s = 0.153, p = 0.018) and evaluation/assessment (r_s = 0.149, p = 0.022). These results suggest that increased interest in learning quadratic functions is associated with higher perceived usefulness of GeoGebra in these areas. The study finds a significant positive relationship between students' interest in learning quadratic functions and their overall perception of GeoGebra’s usefulness (r_s = 0.174, p = 0.007). These results imply that GeoGebra effectively enhances students' interest in learning quadratic functions, particularly conceptual understanding, student-teacher interaction, and evaluation/assessment. Educators can leverage GeoGebra to boost student engagement and comprehension in these key areas, leading to better learning outcomes.

Extensive research supports these findings, showing that GeoGebra facilitates the acquisition of mathematical principles, especially in geometry and algebra (Acharya, 2020; Alabdulaziz et al., 2021). Studies have consistently demonstrated that GeoGebra's interactive functionalities lead to higher levels of mathematical interest and improved performance (Uwurukundo et al., 2022; Harahap et al., 2021; Kholid et al., 2022; Nurzannah et al., 2021). GeoGebra's dynamic user interface and ability to integrate arithmetic, algebra, and geometry make it a powerful tool in mathematics education (Dahal et al., 2019; Hayati & Ulya, 2022). The software's efficacy in helping students comprehend complex concepts through graphical and line representations is well-documented (Zulnaidi et al., 2020). However, there is no significant relationship between students' interest and their perception of the usefulness of GeoGebra in terms of visual presentation (r_s = 0.115, p = 0.078). This might be due to the necessity of adequate teacher preparation to optimize the software's capabilities. Successful integration of GeoGebra into classroom instruction depends heavily on teachers' proficiency with the tool, underscoring the need for professional development (Sheikh Qasem, 2020).

4.0 Conclusion

Utilizing the GeoGebra software greatly amplifies the students' enthusiasm for comprehending quadratic functions. There is a significant difference before and after using GeoGebra in the students' involvement, assurance, and drive in comprehending quadratic functions, such as plotting, determining equations, and utilizing these functions in practical scenarios. Using real-time visualization and interactive graphical representations of quadratic functions seems to enhance students' comprehension of intricate topics and cultivate a heightened enthusiasm for the subject matter. The interactive and visual tools offered by GeoGebra enhance engagement and reduce intimidation, thus promoting a cooperative and pleasurable learning atmosphere among the students. The students' motivation in studying quadratic functions is strongly associated with their perceived benefit in three areas: comprehending the concepts, student-teacher interaction, and evaluation or assessment. Those more interested in quadratic functions after using GeoGebra are more inclined to value these areas. GeoGebra is, indeed, an invaluable instructional instrument that significantly improves students' motivation, confidence, and capacity to solve real-world problems while engaging in the study of quadratic functions. However, there is no significant relationship in visual presentation, as all students find GeoGebra's visual presentation components highly valuable.

5.0 Contributions of Authors

The author attests to his involvement in all aspects of this research. The author reviewed and approved the final version of this paper.

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7.0 Conflict of Interests

This study has no conflict of interest of any sort.

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