



TOWARDS ADDRESSING ALTERNATIVE CONCEPTIONS IN MATHEMATICS

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ABSTRACT

Alternative conceptions are one of the most common errors that students commit especially in dealing with problems in Mathematics. This study identified the alternative conceptions of Grade 9 students of Lucsuhin National High School for school year 2022-2023 from the identified lessons in Algebra. Specifically, it investigated the students' level of performance and alternative perceptions in solving quadratic equation, quadratic inequalities, and graphs of quadratic functions. The significant relationship between the alternative conceptions and students' level of performance in algebra was determined. Intervention material was proposed to address the misconceptions.

The study utilized the descriptive method of research. A researcher – made questionnaire was the main data - gathering instrument complemented by a documentary analysis of the students' scores on their tests. Respondents were 241 Grade 9 students who were randomly selected. Statistical tools were used to treat gathered data. As revealed, students have low level of performance in the identified topics. The common misconceptions committed includes using different methods and identifying relationships of the roots and intercept of quadratic equations. For quadratic inequalities and graphs of quadratic functions, misconceptions came from interpreting the solution regions, and understanding behavior of the graph, shape, opening, values, and location of vertex. Statistically, it was found out that there is a significant relationship between the perceived alternative conceptions of students to their level of performance to the

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identified topics in Grade 9 Algebra. The use of the intervention material made can be considered as an alternative method of addressing misconceptions in the identified topics. The scope of the study can be expanded dealing with other areas of Mathematics wherein teaching guides and learning materials can be crafted.

Keywords: Alternative conceptions, quadratic equations, quadratic inequalities, quadratic functions, intervention activities



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Introduction

Mathematics, as one of the core subjects in any educational institution has remained included for any level of learning. The role that this subject played in the different areas of living has been developed as time passed by. A great impact in the different aspects of life has been scaffold through Mathematics such as research, economics, engineering, and business. The concepts that have been passed from generation to generation from known mathematicians and scientists that brought a great part in the industries today are still present and used.

Based on the Mathematics Framework for Philippine Basic Education, the Philippine Mathematics education has been compelled with Mathematical empowerment through the connection of content, cognitive demands, and cognitive values of the learning area. Critical and analytical thinking skills are the target abilities that should be gained by the Filipino learners as the main goal of uplifting the level of education in this subject. Problem solving, communication skills, reasoning and making mathematical connections are some of the specific goals to promote and gain desirable outcomes in learning Mathematics.

Based on the PISA 2018 National Report of the Philippines, Filipino students achieved an average score of 353 points in Mathematical literacy that was significantly lower than the OECD average point of 489. The result reflected in this report shows that 1 out of 5 Filipino student or 19.7% only attained at least the minimum proficiency level. The performance of learners in dealing with mathematical concepts and variables involved in solving are very low. As reflected in this report, even on the advancements and developments in education, there are still improvements to be done based on the difficulties experienced in both teaching and learning aspect.

Up until this time, discoveries through research and other related works in Mathematics is continuously emerging. But as the teaching and learning of concepts occur in the subject,

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learners tend to construct their thoughts and ideas based on their life experiences and natural matters that tends to differ from the scientific and mathematical views which can be defined or associated as a misconception or alternative conceptions. There are several factors that were identified that play a part on how learners develop misconceptions among concepts related to Mathematics that may lead to lowering the numeracy level among them. As teachers' prior knowledge is essential for providing new learning to students, learners tend to create individual method of learning. Several reasons that affect understanding due to misconception includes lack of previous knowledge about certain concept, inability of learner to link with what they know to the new concepts, misinterpreting the match between the new and previous knowledge and adhering to different perception in terms of learning the subject matter. It could also be added that there are teaching approaches and strategies that emphasizes on vague procedural concepts that results in creating misconceptions in learning (Shalash, 2019).

As misconceptions on learning and solving problems arise in mathematics, teachers provide intervention measures that may lessen the development of these errors. Activities such as drills, games, and extra problems to solve are given to students having difficulties of learning such concepts. Furthermore, remediation or remedial classes are also done to provide additional time for learners to understand and master concepts that find difficult. Classroom – based and home – based intervention materials are provided to suffice and respond to the needs of learners in dealing with difficult concepts.

Misconceptions of learners in learning are some of the most important areas to be considered and given attention to help in the mastery and development of ideas. As the world gears towards skills in technology and mathematics, numeracy skills and the likes are pivotal in the real field. The identification of the errors committed by learners in learning in their early years of education will make a difference in their performance. The conduct of this study on addressing

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the alternative conceptions in Mathematics in specific areas of the subject will be of great help in providing intervention measures and respond to the needs of the learners.

Methodology

This study utilized the use of the descriptive type of research to identify the alternative conceptions of students in Grade 9 Mathematics focusing in three (3) topics in Algebra. The respondents of the study were 241 randomly selected Grade 9 students of Lucsuhin National High School for S.Y. 2022 – 2023 that takes the identified topics in Algebra. The researcher utilized the Raosoft sample size calculator with five percent margin of error in determining the sample size.

The researcher wrote a letter addressed to the Principal of Lucsuhin National High School seeking permission in administering and distributing the survey questionnaire to randomly selected Grade 9 students from the said school. In the conduct of the survey, the students were oriented on the process of answering the questionnaire. The materials were gathered on the same day of its administration. Documentary analysis was also be done with the students' score they obtained from the tests they had about quadratic equations, quadratic inequalities, and graphs of quadratic functions. The data gathered were taken with utmost confidentiality.

The data obtained from the respondents was tallied, tabulated, analyzed and interpreted using the different descriptive statistical tools. Frequency and percentage were used to determine the number and percentage distribution of responses of the research participants. This was also used to describe the level of performance of the students in solving items involving quadratic equations, quadratic inequalities, and graphs of quadratic functions. Pearson product moment correlation (Pearson r) was applied to determine if there is a significant relationship on the

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perceived alternative conceptions of students in the given topics in Algebra to their level of performance. Ranking was also used to determine the positional rank of each sub – topics or variables. Lastly, weighted mean was utilized to assess the perceived alternative conceptions of students in Grade 9 Mathematics.

Results and Discussion

1. Level of performance of the students. Students' level of performance can vary across different stages, such as beginning, approaching proficiency, developing, proficient, and advanced levels. These levels represent different degrees of mastery and indicate the progression of students' abilities in mathematics.

1. 1 Quadratic equations. The level of performance of students in quadratic equations refers to their proficiency, understanding, and skills in solving problems related to quadratic equations. It indicates how well students are able to comprehend the concepts, apply relevant techniques, and solve quadratic equations accurately.

Table 1

Students' Level of Performance in Quadratic Equations			
Level of Performance	Frequency	Percentage	Rank
Beginning (74.99% and below)	187	78	1
Developing (75.00% - 79.99%)	6	2	4
Approaching Proficiency (80.00% - 84.99%)	10	4	3
Proficient (85.00% - 89.99%)	3	1	5
Advanced (90.00% and above)	35	15	2
Total	241	100	
Mean Percentage Score		59.00	
Standard Deviation		22.94	
Verbal Interpretation		Beginning	

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Table 1 presents an analysis of the performance levels of students in quadratic equations. According to the table, 187 students, comprising 78 percent of the total population, were at the beginning level of performance in quadratic equations. This suggests a significant proportion of students who had limited knowledge and skills in this area. The data also highlights those 35 students, accounting for 15 percent of the total population, were classified as being in the advanced level of performance. This smaller group demonstrated a high level of proficiency and understanding in quadratic equations, indicating their mastery of the subject matter.

Taking into considerations the mean score of 59.00, it can be gleaned from the table that students were only in the beginning level of performance in quadratic equations. The relatively low mean score indicates that the students' overall performance aligned with this level, indicating a need for further instruction, practice, or support to improve their understanding and proficiency in solving quadratic equations.

This result affirms with the study of Cordova & Tan (2018) which noted that the mathematics performance of Grade 9 was under the category of beginning. It implied that there should be a much more effort in terms of giving importance and considerations on the issues and concerns that leads to this problem. Areas such as determining the level of student's mathematical proficiency, attitude, and performance is an important area to be considered.

1.2 Quadratic inequalities. The level of performance of students in quadratic inequalities refers to their proficiency, understanding, and skills in solving and working with inequalities involving quadratic equations. It reflects how well students can manipulate and analyze quadratic inequalities to determine the set of values that satisfy the given conditions.

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Table 2

Students' Level of Performance in Quadratic Inequalities			
Level of Performance	Frequency	Percentage	Rank
Beginning (74.99% and below)	186	77	1
Developing (75.00% - 79.99%)	10	4	3
Approaching Proficiency (80.00% - 84.99%)	30	12	2
Proficient (85.00% - 89.99%)	8	3	4
Advanced (90.00% and above)	7	3	5
Total	241	100	
Mean Percentage Score		57.00	
Standard Deviation		20.09	
Verbal Interpretation		Beginning	

Table 2 provides data on the level of performance of students in quadratic inequalities. It becomes apparent that 186 students, equivalent to 77 percent of the total population, were classified as being at the beginning level of performance. This indicates that the majority of students are at an introductory stage in understanding and solving quadratic inequalities. On the other hand, the advanced level included seven students, also representing three percent of the total population. These students showcase an exceptional level of proficiency and mastery in quadratic inequalities.

Furthermore, considering the mean score of 57.00, it becomes evident from the table that students' performance in quadratic inequalities is predominantly at the beginning level. This suggests that, on average, students' understanding of quadratic inequalities is limited, reflecting the need for further improvement and development.

The result of this study is in accord with study of Aspillaga & Esperson (2018) which showed that the proficiency level of Grade 9 students in Mathematics did not meet expectations which implied that the students did not master the competencies required for them. It was also added that there is a little retention in terms of the information received resulting to gaps on the competencies to be learned. It is important to create a

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better learning process and methods to increase the level of their performance in this field.

1.3 Graphs of quadratic functions. The level of performance in graphs of quadratic functions reflects how well students understand and apply concepts related to this topic. Graphs of quadratic functions represent parabolic curves and play a crucial role in understanding the behavior and characteristics of quadratic equations.

Table 3
Students' Level of Performance in Graphs of Quadratic Functions

Level of Performance	Frequency	Percentage	Rank
Beginning (74.99% and below)	208	86	1
Developing (75.00% - 79.99%)	7	3	3
Approaching Proficiency (80.00% - 84.99%)	3	1	5
Proficient (85.00% - 89.99%)	5	2	4
Advanced (90.00% and above)	18	7	2
Total	241	100	
Mean Percentage Score		54.11	
Standard Deviation		21.13	
Verbal Interpretation		Beginning	

Table 3 displays the levels of performance among students in graphs of quadratic functions. According to the data presented, 208 students, accounting for 86 percent of the total population, were categorized as being at the beginning level of performance. This indicates that many students have a basic understanding of graphing quadratic functions. Additionally, 18 students, making up seven percent of the total population, achieved an advanced level of performance. These students demonstrate a high level of proficiency and mastery in graphing quadratic functions.

Considering the mean score of 54.11, it becomes evident from the table that students' overall performance in graphs of quadratic functions is primarily at the beginning level. This suggests that, on average, students have a limited understanding of graphing quadratic functions, highlighting the need for further improvement and development.

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This result is in congruence with the study of Refugio, et. al (2019) that revealed there are some learning competencies which learners find hard understanding that leads them to achieve a low performance rating. The mean percentage score that these learners usually obtain are below the passing level of 75.

2. Perceived alternative conceptions of students. Identifying and addressing these perceived alternative conceptions is crucial for effective mathematics instruction. Teachers can use formative assessments, questioning techniques, and classroom discussions to uncover and challenge these misconceptions.

2.1 Quadratic equations. Perceived alternative conceptions of students in quadratic equations refer to the misconceptions or alternative understandings that students may have about this mathematical topic. These alternative conceptions can arise from students' prior knowledge, experiences, or interpretations of quadratic equations, leading them to develop misconceptions that differ from the accepted mathematical principles.

Table 4 presents the perceived alternative conceptions of students in quadratic equations. Based on the respondents' responses, indicator no. 2 which pertains to the students' ability to identify a quadratic equation from a set of equations, received the highest weighted mean of 3.43, which corresponds to the verbal interpretation of "agree." This indicates that, on average, students possess a reasonable understanding and ability to identify quadratic equations correctly when presented with a set of equations.

On the other hand, indicator no. 10, which pertains to students' knowledge of the relationship between the roots of a quadratic equation and the x-intercepts of its graph, ranked last among the indicators. This item obtained the lowest weighted mean of 1.92, which corresponds to the verbal interpretation of "disagree." This finding indicates that, on average, students in the study have difficulty understanding the connection between the

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roots of a quadratic equation and the x-intercepts of its graph. This alternative conception suggests that students may not recognize that the solutions to a quadratic equation correspond to the points where the graph of the equation intersects the x-axis.

To sum up, the respondents' perceived alternative conceptions in quadratic equations got a composite mean of 2.59, verbally interpreted as agree. Their misconceptions are particularly visible on the higher level of understanding such as the nature of quadratic equations, the methods for solving them, or the relationships between their algebraic solutions and graphical representations.

This result is in accord with the study of Baidoo (2019) which found out that there are several reasons why learners commit mistakes in solving algebra related problems. This includes mathematical language, and procedural and application errors on concepts.

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Table 4
Students' Perceived Alternative Conceptions in Quadratic Equations

<i>In solving quadratic equations, I am able to ...</i>	Weighted Mean	Verbal Interpretation	Rank
1. understand what a quadratic equation is.	3.34	Agree	2
2. can identify a quadratic equation from a set of equations.	3.43	Agree	1
3. understand that every quadratic equation has exactly two real roots.	3.06	Agree	4
4. identify the proper and most suitable way (e.g. extracting the square root, factoring, quadratic formula, completing the square) to solve a given quadratic equation.	3.21	Agree	3
5. factor quadratic equations.	2.22	Disagree	6
6. understand the quadratic formula and how to use it to find the solutions of a quadratic equation.	2.32	Disagree	5
7. solve quadratic equations and find its solution through the use of completing the square and its underlying process.	2.12	Disagree	8
8. understand the concept of the discriminant of a quadratic equation and how it can be used to determine the number and type of solutions.	2.07	Disagree	9
9. describe and understand the relationship between the coefficients of a given quadratic equation and its roots.	2.17	Disagree	7
10. know the relationship between the roots of a quadratic equation and the x-intercepts of its graph.	1.92	Disagree	10
Composite Mean	2.59	Agree	

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2.2 Quadratic inequalities. In the context of quadratic inequalities, students may develop alternative conceptions about various aspects, such as the methods for solving quadratic inequalities, interpreting the solution regions, or understanding the behavior of quadratic inequality graphs. These misconceptions can lead to errors in solving quadratic inequalities and hinder a deeper understanding of the concept.

Table 5 contains the students' perceived alternative conceptions in quadratic inequalities. Based on the respondents' responses, indicator no. 3 which pertains to students know how to use the "less than", "greater than", "less than or equal to" and "greater than or equal to" symbols in quadratic inequalities, received the highest weighted mean of 3.37, which corresponds to the verbal interpretation of "agree." The finding indicates that, on average, students in the study demonstrate a good understanding of how to correctly use these inequality symbols in the context of quadratic inequalities.

Table 5

Students' Perceived Alternative Conceptions in Quadratic Inequalities			
<i>In solving quadratic inequalities, I am able to...</i>	Weighted Mean	Verbal Interpretation	Rank
1. understand what a quadratic inequality is.	3.29	Agree	2
2. know that quadratic inequality can be written in four (4) different forms.	3.15	Agree	3
3. know how to use the "less than", "greater than", "less than or equal to" and "greater than or equal to" symbols in quadratic inequalities.	3.37	Agree	1
4. find the roots of a quadratic inequality by getting it in its corresponding equality.	2.14	Disagree	5
5. identify correctly the solution set of a quadratic inequality.	2.12	Disagree	6
6. plot points in a number line to identify the test points to be used in identifying the solution set of a given quadratic inequality.	2.05	Disagree	8
7. know how to use test points to determine the solution set of a quadratic inequality.	2.00	Disagree	9
8. represent the solution set of a quadratic inequality using interval notation.	1.39	Strongly Disagree	10
9. understand that changing the sign of the inequality symbol always changes the direction of the parabola.	2.19	Disagree	4
10. familiarize myself with the common mistakes that can occur when solving quadratic inequalities.	2.11	Disagree	7
*** Composite Mean	2.38	Disagree	**

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On the other hand, indicator no. 8, which pertains to students' ability to represent the solution set of a quadratic inequality using interval notation, ranked last among the indicators. This item obtained the lowest weighted mean of 1.39, which corresponds to the verbal interpretation of "strongly disagree." This indicates a lack of understanding and proficiency in using this specific mathematical notation to express the solution range or interval for a quadratic inequality.

To sum up, the respondents' perceived alternative conceptions in quadratic inequalities got a composite mean of 2.38, verbally interpreted as disagree. The disagreement suggests that the respondents do not possess an accurate understanding of quadratic inequalities, including the methods for solving them, interpreting the solution regions, and understanding the behavior of quadratic inequality graphs.

This result is in accord with the study of Djam'an, et. al (2018) which identified that some of the alternative conceptions that learners commit includes lack of comprehension to a given quadratic inequality especially in translating it. Aside from this, based on the study, there were also misunderstandings in terms of making mathematical models.

2.3 Graphs of quadratic functions. When studying graphs of quadratic functions, students can form different understandings or misconceptions regarding elements like the graph's shape, vertex position, direction of opening, and behavior of the axis of symmetry. These misconceptions have the potential to result in mistakes when interpreting and analyzing quadratic function graphs, ultimately impeding a thorough comprehension of the concept.

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Table 6

Students' Perceived Alternative Conceptions in Graphs of Quadratic Functions

<i>In graphing quadratic functions, I am able to...</i>	Weighted Mean	Verbal Interpretation	Rank
1. understand that the graph of a quadratic function is a parabola.	3.29	Agree	1
2. know how to determine the intercepts of a quadratic function.	2.08	Disagree	6
3. know how to plot points to graph the given quadratic functions.	3.12	Agree	2
4. understand the basic features of a quadratic function graph (vertex, axis of symmetry, intercepts).	3.06	Agree	4
5. identify the vertex and axis of symmetry of a quadratic function graph given in standard form.	2.06	Disagree	7
6. I can identify the vertex and axis of symmetry of a quadratic function graph given in vertex form.	3.07	Agree	3
7. use the leading coefficient of a quadratic function to determine whether it opens upward or downward.	2.99	Agree	5
8. understand how to determine the minimum and maximum values of a quadratic function and their significance.	1.42	Strongly Disagree	10
9. understand the role of the discriminant in determining the opening of the graph of a quadratic function.	2.05	Agree	8
10. understand that changing the values of a, h, and k in a given quadratic function in vertex form can affect its graph.	1.43	Strongly Disagree	9
Composite Mean	2.46	Disagree	

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Table 6 presents the students' perceived alternative conceptions in graphs of quadratic functions. According to the table, indicator no. 1, which pertains to students' understanding that the graph of a quadratic function is a parabola, received the highest weighted mean of 3.29. This corresponds to the verbal interpretation of "agree". This indicates that the students in the study demonstrate a solid understanding that the graph of a quadratic function takes the form of a parabola and has conceptual understanding of the fundamental shape of quadratic function graphs.

On the other hand, indicator no. 8, which pertains to students' ability to determine the minimum and maximum values of a quadratic function and their significance, ranked last among the indicators. This item obtained the lowest weighted mean of 1.42, which corresponds to the verbal interpretation of "strongly disagree." The strong disagreement among the respondents in this indicator highlights a significant gap in students' knowledge and skills related to identifying and interpreting the minimum and maximum points of a quadratic function. It suggests that students may face challenges in determining the vertex, understanding the relationship between the vertex and the minimum or maximum value, and applying this knowledge in real-world situations.

Overall, the composite mean of 2.46, indicates that the students disagreed on the given understanding about graphs of quadratic functions. This suggests that students generally possess alternative conceptions or misconceptions in terms of the lessons about graphs of quadratic functions, including the shape of the graph, the location of the vertex, the direction of the opening, minimum and maximum values, and the behavior of the graph's axis of symmetry. This shows that the students have relatively low understanding and has minimal knowledge acquisition on this area of Algebra.

The study of Hoon, et. al (2018) supports the result of this study as it also found out that the level of performance in terms of quadratic functions of students are very low. This was reflected on their difficulties in understanding and applying the concepts on

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finding the maximum and minimum values of the graph and constructing and applying the graph of quadratic functions. It was concluded that more effort on the part of educators and students must be made to promote understanding from the above - mentioned areas of quadratic functions.

3. Relationship between the students' perceived alternative conceptions and their level of performance. Addressing students' perceived alternative conceptions is essential for improving their level of performance. By providing targeted instruction, engaging in explicit discussions, and addressing misconceptions directly, educators can help students overcome their alternative conceptions and develop a more accurate understanding of the subject matter.

Table 7
Relationship between the Students' Perceived Alternative Conceptions and their Level of Performance

Students' Perceived Alternative Conceptions	Level of Performance	t-stat	R-value	p-value	Decision on H ₀	Interpretation
Quadratic Equations		6.74	0.40	0.00	Reject H ₀	Significant
Quadratic Inequalities		9.08	0.51	0.00	Reject H ₀	Significant
Graphs of Quadratic Functions		9.69	0.53	0.00	Reject H ₀	Significant

Table 7 provides evidence that the p-value of 0.00, which is lower than the significance level of 0.05, indicates the need to reject the null hypothesis. This suggests a significant relationship between students' perceived alternative conceptions and their level of performance in quadratic equations, quadratic inequalities, and graphs of quadratic functions.

The moderate positive correlation, as indicated by the R-values ranging from 0.40 to 0.53, suggests that as students' perceived alternative conceptions increase, there is a tendency for their level of performance in quadratic concepts to also increase. This implies

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that students who have a better understanding and fewer alternative conceptions tend to perform at a higher level in quadratic topics.

These findings emphasize the importance of addressing and correcting alternative conceptions to improve students' performance in quadratic equations, quadratic inequalities, and graphs of quadratic functions. Educators can focus on identifying and addressing specific alternative conceptions through targeted instruction, providing opportunities for clarification, and engaging students in activities that promote conceptual understanding.

Prior to the findings, the study of Cardino & Cruz (2020) supports the present study as it also seen a significant relationship between the performance of the learners in Mathematics but on the strategies and learning styles. It is important to identify the relationship of the different factors in learning such as the misconceptions as it may primarily affect the learner's performance.

4. Proposed Intervention Material. Results of the present study showed that there were alternative conceptions that students commit in learning and solving quadratic equations, quadratic inequalities, and graphs of quadratic functions. Moreover, it was also revealed that students have a very low performance in terms of the mentioned topic in algebra brought by their misconceptions. Although teachers teach these concepts using various methods and strategies, students still commit errors when solving problems especially in the said topics in Algebra.

From the identified alternative conceptions based on the gathered data from the survey and the level of performance of the students, an intervention material was propped to address this problem. The intervention material was crafted based on the Most Essential Learning Competencies (MELCs) of Grade 9 focusing on quadratic equations, quadratic inequalities, and graphs of quadratic functions.

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Conclusions

In the light of findings, the following conclusions are drawn:

1. The Grade 9 students are only on beginning level on their level of performance in solving quadratic equations, quadratic inequalities, and graphs of quadratic functions.
2. There are different alternative conceptions that Grade 9 students perceive in terms of solving the identified Algebra related topics. The prominent alternative conception of students in the three topics involve includes identifying the relationship between roots of quadratic equation, ability to represent the solution set of a quadratic inequality using interval notation and determining the minimum and maximum values of quadratic functions.
3. There is a significant relationship between the perceived alternative conceptions of students in the lessons on solving quadratic equations, quadratic inequalities, and graphs of quadratic functions to their level of performance.
4. The proposed intervention material may help address the alternative conceptions of students in solving quadratic equations, quadratic inequalities, and graphs of quadratic functions through guided activities and exercises.

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