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THE RESOLUTION OF QUADRATIC INEQUALITY PROBLEMS IN MATHEMATICS: DISCREPANCIES BETWEEN THOUGHT AND ACTION

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ABSTRACT

This research explores the intricate relationship between students' cognitive processes and problem-solving approaches, explicitly focusing on misconceptions in solving quadratic inequalities. This study was conducted among 179 undergraduates in a mathematics education program in Malang, East Java, Indonesia; this mixed-method concurrent explanatory sequential design research employed the DISC questionnaire and quadratic inequality assignments. The DISC questionnaire categorized respondents into Dominance, Influence, Steadiness, and Conscientiousness. Data were generated from these pre-service teacher responses to the questionnaire, task assignment, and follow-up interviews to solicit information. Purposive sampling facilitated in-depth interviews, providing nuanced insights into the interplay between personality types and mathematical misconceptions. The quantitative data analysis results show a significant association between personality type and the type of error experienced by students when completing an open-ended task about quadratic inequalities $X^2(12) = 26.836$, $p = 0.008$, $V = 0.224$. Meanwhile, qualitative data analysis findings reveal patterns associating personality types with specific misconceptions. Dominant traits are linked to theoretical misconceptions, while Influence and Conscientiousness traits correspond to conceptual misconceptions. Additionally, Steady traits are associated with classification misconceptions. This study contributes novel perspectives to mathematics education by exploring the influence of personality on mathematical cognition. The aim is to inform tailored teaching strategies for optimized learning outcomes, addressing persistent barriers posed by misconceptions in quadratic inequalities.

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1. INTRODUCTION

The significance of quadratic inequalities with a solitary variable in pre-service teacher education is crucial in augmenting students' comprehension of algebraic principles and their aptitude for problem-solving. The use of these inequalities serves as a connection between algebraic manipulation and graphical representation, providing pre-service teachers with the opportunity to clarify the relationship between algebraic solutions and geometric regions on the coordinate plane. The significance of integrating several mathematical representations to enhance comprehension is highlighted by the visual-algebraic relationship (Wilkie, 2022).

A comprehensive approach to the pedagogy of quadratic inequalities is essential for preparing pre-service teachers to skillfully guide their students in developing a holistic understanding of the intricate relationship between algebraic and graphical aspects within the realm of mathematics (Ndlovu & Ndlovu, 2020). Beyond the theoretical realm, proficiency in instructing quadratic inequalities proves to be imperative for effectively addressing real-life situations, thereby fostering students' ability to practically apply mathematical principles. The incorporation of mathematical modeling in education emerges as a particularly valuable strategy, enabling pre-service teachers to accentuate the practical relevance of mathematical principles in diverse contexts (Van den Heuvel-Panhuizen & Drijvers, 2014). By equipping pre-service teachers with a multifaceted pedagogical toolkit that spans theoretical foundations and practical applications, educators can cultivate a more robust and well-rounded mathematical education for their students.

In this research, multifaceted pedagogy refers to a comprehensive and varied approach to teaching quadratic inequalities that encompasses theoretical and practical aspects. It emphasizes the importance of equipping pre-service teachers with diverse instructional tools and strategies, ranging from theoretical foundations to real-world applications. This multifaceted approach aims to provide educators with a comprehensive toolkit to guide students in developing a holistic understanding of the intricate relationship between algebraic and graphical aspects within quadratic inequalities. By incorporating mathematical modeling into education, pre-service teachers can highlight the practical relevance of mathematical principles in diverse contexts, fostering students' ability to apply these principles effectively in real-life situations. A multifaceted pedagogical approach ensures a well-rounded and robust mathematical education, enabling educators to address theoretical concepts and practical applications in their teaching methods (Tisdell, 2018; Tsamir & Reshef, 2006).

However, pre-service teachers often grapple with misconceptions related to single-variable quadratic inequalities. While one assumes that this issue would not persist among pre-service teachers who are undergraduate students, the reality suggests otherwise. Singh et al. (2017) discovered that the misconceptions experienced by college students mirrored those of school students. Moreover, Naseer (2015) and Godden et al. (2013) have emphasized a prevalent misconception among pre-service teachers, namely, the exclusive focus on determining the roots of quadratic equations, neglecting the critical consideration of inequality signs. This misconception impedes their ability to guide students in understanding and solving quadratic inequalities effectively.

Another prevalent misunderstanding concerns the orientation of the parabolic graph associated with a quadratic inequality. Some pre-service instructors incorrectly assume that the orientation of a parabola is solely determined by the leading coefficient of the quadratic term, neglecting the impact of the coefficient of the linear term (Bachmaier, 2010; Quintanilla, 2022; Su et al., 2020). Addressing these misconceptions is crucial for proficiently instructing quadratic inequalities and facilitating students' full comprehension.

This comprehension not only enhances the precision of graphing and explaining quadratic inequalities but also plays a pivotal role in fostering a nuanced connection between algebraic manipulations and visual representations. Conversely, the challenge arises when students fail to establish this crucial link between algebraic and pictorial representations, leading to difficulties in solving quadratic inequalities and accurately determining the number of roots in quadratic functions (Huang & Kulm, 2012).

In this research, algebraic manipulations and visual representations denote the essential connection between symbolic mathematical operations and graphical depictions within quadratic inequalities. In quadratic functions, algebraic manipulations involve the mathematical processes and transformations applied to equations, such as factoring, completing the square, or manipulating coefficients (Herawaty et al., 2021; Hoan et al., 2022; Weiss, 2016). On the other hand, visual representations pertain to the graphical depiction of these equations, particularly the parabolic graphs associated with quadratic inequalities. Comprehending this interplay is crucial for instructors and students as it enables a nuanced understanding of how algebraic manipulations directly influence the shape, orientation, and position of the associated parabolic graph (Aquino et al., 2017; Srinivasan, 2013). Proficiency in recognizing and exploiting this connection enhances the precision of graphing and explaining quadratic inequalities. Furthermore, it is pivotal in fostering a more holistic understanding of the relationship between algebraic manipulations and their corresponding visual representations. It facilitates more effective problem-solving and interpretation of quadratic functions.

Many researchers have found that the roots of this misunderstanding among pre-service teachers have been meticulously explored. Pre-service mathematics teachers in Indonesia use three different solution strategies for solving absolute value equations and inequalities, indicating a need for improved symbol sense in higher education (Jupri et al., 2022). Pre-service teachers' conceptual structures in absolute and quadratic inequalities are often incorrect, negatively impacting their mathematics teaching and learning and potentially inappropriately applied in daily life (Ali & Wilmot, 2016). Doing so is vital for pre-service teachers to effectively guide their students in comprehending quadratic inequalities, facilitating their journey toward a comprehensive understanding of these principles.

The study conducted by Öztürk et al. (2020) has demonstrated that personality factors substantially impact problem-solving behaviors, hence influencing the effectiveness and precision of solutions. This finding aligns with Karimah et al. (2018) on cognitive biases based on personality traits affecting distinct errors in mathematical problem-solving. Understanding these influences is essential for educators, allowing them to tailor instructional strategies and interventions to rectify misconceptions. According to a study conducted by Karimah et al. (2018) it has been found that cognitive biases based on personality traits can result in the occurrence of distinct errors in mathematical problem-solving. The findings underscore the importance for educators to consider individual personality variations when developing instructional strategies and interventions aimed at rectifying misconceptions. Notably, personality types contribute to misconceptions in solving quadratic inequality problems.

The diverse cognitive tendencies associated with distinct personality qualities influence individuals' learning processes. Past studies revealed that there are impacts of personality types on problem-solving approaches (Mann et al., 2017; Rosidin et al., 2019), interpretation of mathematical circumstances (Godino et al., 2019), creativity (Grégoire, 2016), and decision-making (Rimfeld et al., 2016). One factor that causes misconceptions in solving quadratic inequality problems is personality types. The impact of personality type on misunderstandings in resolving quadratic inequality problems is discernible through the

diverse cognitive tendencies associated with distinct personality qualities that individuals possess during learning.

The interplay between personality traits and learning styles adds complexity to this phenomenon. Mehta et al. (2020) findings suggested an association between specific personality traits and the propensity to adopt distinct learning styles, influencing engagement and comprehension with educational resources. Incorporating these observations into educational strategies can lead to customized approaches that resonate with pupils, promoting deeper comprehension and a more nurturing learning atmosphere. Moreover, the interplay between personality traits and learning styles introduces an additional level of intricacy to this intricate phenomenon. According to the findings of Mehta et al. (2020), there is a potential association between specific personality traits and the propensity of individuals to adopt distinct learning styles, influencing their level of engagement and comprehension while interacting with educational resources. By incorporating these observations into educational strategies, it is possible to develop customized instructional approaches that better connect with pupils, promoting a more profound comprehension of the content and cultivating a more nurturing atmosphere for learning.

Individualized interventions promote socioemotional development in addition to academic success. In order to create a learning environment that fosters cooperation, critical thinking, and self-awareness, Gregory and Fergus (2017) underlines the importance of identifying distinctive variances in personality and cognitive processes. With this knowledge, educators can use strategies to address misconceptions, build on students' strengths, and get beyond obstacles to learning. The integration of individualized interventions not only enhances academic achievement but also plays a significant role in fostering the holistic socio-emotional growth of pupils. The study Gregory and Fergus (2017) highlights the need to recognize the unique variations in personality and cognitive processes in order to establish an educational environment that fosters collaboration, critical thinking, and self-awareness. Educators equipped with this knowledge possess the ability to employ tactics that effectively tackle misconceptions, foster the development of student's strengths, and facilitate their triumph over learning barriers.

The DISC personality model holds relevance in understanding misconceptions about quadratic inequalities due to its emphasis on observable behavior and cognitive inclinations. According to Ahmad and Siddique (2017), the DISC model classifies individuals into four primary personality types: Dominance, Influence, Steadiness, and Compliance. These different personality types influence individuals' approaches to and comprehension of mathematical concepts, potentially leading to misconceptions.

The DISC model's thorough classification of behavioral inclinations and communication modes makes it highly suitable for delineating misunderstandings in mathematics. It provides a comprehensive perspective of the many strategies people use when solving mathematical problems and any possible cognitive errors that they make. Satriani et al. (2020) provide empirical evidence supporting the DISC model's significance in understanding the impact of personality traits on problem-solving behaviors and cognitive inclinations, contributing to misconceptions in mathematical subjects.

Despite the DISC model's applicability in understanding personality traits, existing research on misconceptions associated with DISC primarily focuses on Trigonometry (Satriani et al., 2020), with a noticeable gap in examining misunderstandings connected to quadratic inequalities. Educators can tailor their instructional strategies to effectively address misconceptions and enhance students' comprehension of mathematical concepts by considering the unique characteristics associated with each individual's personality type. However, the existing body of research on misconceptions related to the DISC method

primarily focuses on Trigonometry (Satriani et al., 2020). Notably, more research needs to examine misunderstandings connected to quadratic inequalities.

Furthermore, the DISC assessment can be utilized in educational settings to gain insights into student behavior and customize instructional approaches. The popularity of this option across various areas can be attributed to its versatility and practicality. In contrast to other personality assessments that explore broader personality traits or dimensions, the DISC evaluation offers a more superficial comprehension of behavioral styles. While it does not comprehensively encompass the intricate nuances of an individual's personality, it provides vital insights into their observable behaviors and communication preferences. Hence, the present study aims to address the following research questions: (a) Is there any significant association between personality type and the error students make when engaging in tasks related to quadratic inequalities? (b) What are the misconceptions exhibited by pre-service teachers when attempting to solve problems involving one-variable quadratic inequalities, with a focus on the influence of DISC personality types?

2. METHOD

This study is mixed method concurrent explanatory sequential design. It was carried out among 179 undergraduate students in Mathematics Education program a private university located in Malang, East Java, Indonesia. Given the diverse educational backgrounds in senior high schools in Indonesia, each institution has its curriculum with varying emphasis on mathematics. In this study, out of the 179 undergraduate students included as research subjects, 56% were from Islamic boarding schools, 31% were from senior high schools, and 13% were from vocational high schools.

In this research, students from the classes of 2019-2023 were given a comprehensive introduction to the project, including explaining why the project was created, its goals and objectives, and the potential risks and benefits of participating. Subsequently, students were requested to grant informed consent if they desired to partake in the study. The study included all incoming students who gave informed permission and completed the DISC evaluation. The students needed to be more motivated to participate in the study. However, they were notified that they would not incur any costs for the DISC personality evaluation.

The data collection was carried out during July 2023. All of the inquiries were duly finalized and submitted anonymously. The students were allocated six weeks to provide their electronic responses. Two reminder emails were sent to them regarding the questionnaire during this time frame. For a more comprehensive analysis, demographic data, including age, gender, and previous type of high school, were collected from the student affairs unit.

There are two main instruments used for this study. The respondents were given DISC personality test (questionnaire) and open-ended task were based on the national curriculum content standards regarding quadratic inequality. DISC measures dimensions of students' personalities. It does not measure intelligence, aptitude, mental health, or values. DISC profiles describe human behavior in various situations. In this context, DISC measures how students respond to challenges, influence others, use their preferred pace, and respond to rules and procedures. DISC is a tool for dialogue, not diagnosis. At its broadest, DISC measures four aspects of personality: dominance (D), influence (I), steadiness (S), and conscientiousness (C) (Agler et al., 2020; DeYoung & Gray, 2009; Rimfeld et al., 2016).

The questionnaire utilized in this study comprised 18 items, each presenting four statements reflecting DISC personality types (Owen et al., 2020). Participants were instructed to choose one statement that best suited them and another that least suited them for each case. The completion time for the questionnaire was approximately 15 minutes.

Subsequently, the statements were mapped to DISC factors, and scores were calculated to determine participants' personality types, accompanied by a description of the selected type. The DISC model categorizes personalities into four basic types based on individuals' perceptions of their surroundings and their control over them. This standardized and validated questionnaire assessed the reliability and validity of the DISC assessment tool. All responses were submitted anonymously, and participants had six weeks to provide electronic replies, receiving two reminder emails during this period. Specifically, the characteristics of each personality type can be seen in Table 1.

Table 1. General characteristic of student based on DISC personality test

	Dominant	**Influence**	**Steady**	**Conscientious**
General Characteristic	Students with a high dominant trait tend to be direct, assertive, and independent and usually solve problems using a quick and active approach	Students with a high influence are entertaining, social, extroverted, and outgoing, considering meeting people as a need	Students with high steadiness do not like surprises, and usually, they are accommodating and consistent in their way of life	Students high in this domain are interested in accuracy, enjoying the details, and focusing on the facts
Specific behavior	The “D” type person seeks out challenges and competition, and dominant people are usually convinced that they can achieve their objectives by using logic and their arguments	The “I” type of person acts toward the relationships surrounding them and enjoys public recognition	The “S” type person believes that collaboration and mutual support are the keys to maintaining stability and harmony. They also can be considered people-pleasers since they enjoy serving others’ needs	The “C” type of person does not have an unmerciful need to socialize. They consider more critical as “clearly defined rules and structure rewards based on quality, accuracy, and individual contribution

Summarising the DISC concept, it presents two dimensions. First, how students perceive the environment (it can be favorable or unfavorable to them). Second, how students perceive themselves (students can have control or lack it). In addition to those dimensions, four behavioral tendencies characterize people: task-oriented, outgoing, reserved, and people-oriented. In general, most people show one or two of these tendencies more significantly throughout life, while the remaining two tendencies do not regularly integrate their behavior (Owen et al., 2020).

Furthermore, the second instrument is an open-ended problem about quadratic inequalities. Subjects in four certain personality types were given 30 minutes to complete it independently, without any assistance. Subjects were not allowed to ask questions or open books or notes. Subjects were asked to write their answers on a piece of paper. If there was an error, it was enough to mark it, not to erase it. During work, the subject was recorded

using audio and visual recorder. We then selected one subject with the highest score and good communication skills to represent each personality type. Totally there were four subjects to do the task below: Find the solution set of inequality: $x^2+2x+4>0$. This open-ended task was based on the national curriculum content standards regarding quadratic inequality. There was one problem given to participants that required procedural and conceptual understanding. The open-ended task was used to see obstacles in the form of ways of knowing in solving the problem of quadratic inequality.

According to the theoretical framework, an examination of students' errors in answering quadratic inequality problems can reveal the presence of epistemic barriers. Consequently, besides identifying errors, this study also investigated additional phenomena present in students' responses. The investigator employed a grounded theory methodology to categorize errors identified during the deductive process, with the purpose of examining the data and offering a response to the research inquiry (Cohen et al., 2017). Errors that shared the same pattern and type had been grouped. The gathered data, along with the outcomes of previous investigations, were utilized to define the conclusions regarding the assumptions about the components of methods of thinking and ways of understanding each type of inaccuracy. To enhance the reliability of the findings and establish a shared understanding of categorization, the researcher employed a random coding approach, involving the participation of one professor and two academics specializing in mathematics education.

Additionally, they were included in the examination of the descriptive assertions pertaining to different cognitive processes and methodologies employed in understanding students' errors among the selected subjects (n = 4). This action was undertaken in order to enhance the reliability of the results and align the error description with established theories and existing information. The task-oriented interviews were carried out subsequent to the classification and analysis of the descriptive claims on student errors. The interview transcript was utilized to enhance, clarify, or rectify the descriptive components of cognition and comprehension that contributed to the error. In order to attain a comprehensive understanding, a comparative analysis was conducted on the findings obtained from four individual student interviews for each aspect of cognition and knowledge.

An analysis was conducted to examine the influence association between personality type and the error students make when engaging in tasks related to quadratic inequalities. Chi-Square tests were employed, considering a significant result at a two-sided α-level of less than 0.05. To enhance the depth of the analysis; purposive sampling was utilized to select one participant from each personality category (Dominance, Influence, Steadiness, and Compliance) for interview sessions (Creswell, 2020). The selection of subjects considered the students' willingness to interview, their verbal communication skills, and their misconceptions when completing open-ended tasks related to inequalities. Students who need clarification in completing assignments or only minor errors are not considered to participate in this interview session. Specifically, Subject 1 (S1) exhibited the Dominance personality type, Subject 2 (S2) demonstrated the Influence personality type, Subject 3 (S3) displayed the Steadiness personality trait, and Subject 4 (S4) was associated with individuals possessing the Compliance personality type.

3. RESULT AND DISCUSSION

3.1. Results

Informed consent forms and DISC personality assessments were completed by 15 of 21 students from the class of 2019, 48 of 71 students from the class of 2020, 63 of 77 students

from the class of 2021, 39 of 40 students from the class of 2022, and 14 of 15 students from the class of 2024, for an overall response rate of 79.9%. The most common primary domain from the DISC assessment in the student cohort was conscientiousness (C) (n = 71) followed by steadiness (S) (n = 45), influence (I) (n = 33), and dominance (D) (n=30). Demographic data of consenting study participants can be found in Table 2.

Table 2. Demographic profile of students based on previous high school type

	Class of 2019	**Class of 2020**	**Class of 2021**	**Class of 2022**	**Class of 2023**
Islamic boarding schools	5	45	50	20	5
Senior high schools	10	20	17	15	8
Vocational high schools	6	6	10	5	2
TOTAL	**21**	**71**	**77**	**40**	**15**

The initial analysis of the errors made on the test generated four broad categories of errors: errors made in understanding the problem (E1), errors which occurred in devising a plan (E2), errors which appeared in carrying out the plan (E3), unverified solution (E4). Based on 179 undergraduate students' solutions to open ended task, the frequency and percentage of error types related to forms E1, E2, E3 and E4 are presented at Table 3.

Table 3. The frequency and percentage of error types based on personality type DISC

Error Type	**D**	**I**	**S**	**C**
E1	12 (40.00%)	15 (45.45%)	9 (20.00%)	20 (28.17%)
E2	2 (6.67%)	10 (30.30%)	10 (22.22%)	4 (5.63%)
E3	2 (6.67%)	1 (3.03%)	5 (11.11%)	6 (8.45%)
E4	1 (3.33%)	1 (3.03%)	1 (2.22%)	5 (7.04%)
No Error	13 (43.33%)	6 (18.18%)	20 (44.44%)	36 (50.70%)
TOTAL	**30 (100%)**	**33 (100%)**	**45 (100%)**	**71 (100%)**

Because the P-Value 0.008 < α (0.05) the results of the Chi-Square independence test indicate that there is a significant association between personality type and the type of error experienced by students when completing an open-ended task about quadratic inequalities $\chi^2(12) = 26.836$, $p = 0.008$, $V = 0.224$. More detailed SPSS output regarding the Chi Square test can be presented in Table 4.

Table 4. Chi square test results using SPSS

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	26.836[a]	12	0.008
Likelihood Ratio	28.014	12	0.006
Linear-by-Linear Association	5.290	1	0.021
N of Valid Cases	179		

a. 9 cells (45.0%) have expected count less than 5. The minimum expected count is 1.34.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	0.387	0.008
	Cramer's V	0.224	0.008
	Contingency Coefficient	0.361	0.008
N of Valid Cases		179	

Next, the results of qualitative data analysis of four selected subjects from each personality type who had errors at E1 to E4 are explained as follows. The following data analysis is based on the written results and interviews with all four subjects. Figure 1 is solution of the subject with Dominance Personality Type (S1). S1 has an error in choosing the strategy to be used in problem-solving. S1 is wrong in operating numbers in radical form. Resulting in an incorrect resolution procedure. In this research, S1 represent $\sqrt{20} = 4.5$

R : *How do you calculate so that you get the discriminant value as* $\sqrt{20}$ *?*
S1 : *I use the discriminant formula, where a = 1, b = 2 and c = 4. So, the value of* $b^2 - 4ac = 2^2 - 4.1.4$. *We see that* 2^2*equal with* $2 \times 2 = 4$. *So, we have 4 and 16, it equal with 20.*
R : *Tell me how you got results* $\sqrt{20}$ *equal with 4.5?*
S1 : *Wait, 20 can also be written as 4 × 5, right, and the symbol for the multiplication operation in mathematics can be written as a dot (.), so we have 4.5*

Figure 1 shows the theoretical misconceptions experienced by S1. S1 incorrectly applied the discriminant formula because he only focused on the operation results for each term in the formula without paying attention to the sign of the operation (it should be subtraction, not addition). S1 is confused in identifying the multiplication operations of integers and dot products (multiplication on matrices). In this case, S1 omits crucial steps or hurries through the steps of calculating quadratic inequalities, which results in mistakes. S1 needs to catch cues and information necessary for accurately resolving inequalities. This condition can be seen in the interview results between the researcher (R) and the subject with the dominant personality type (S1).

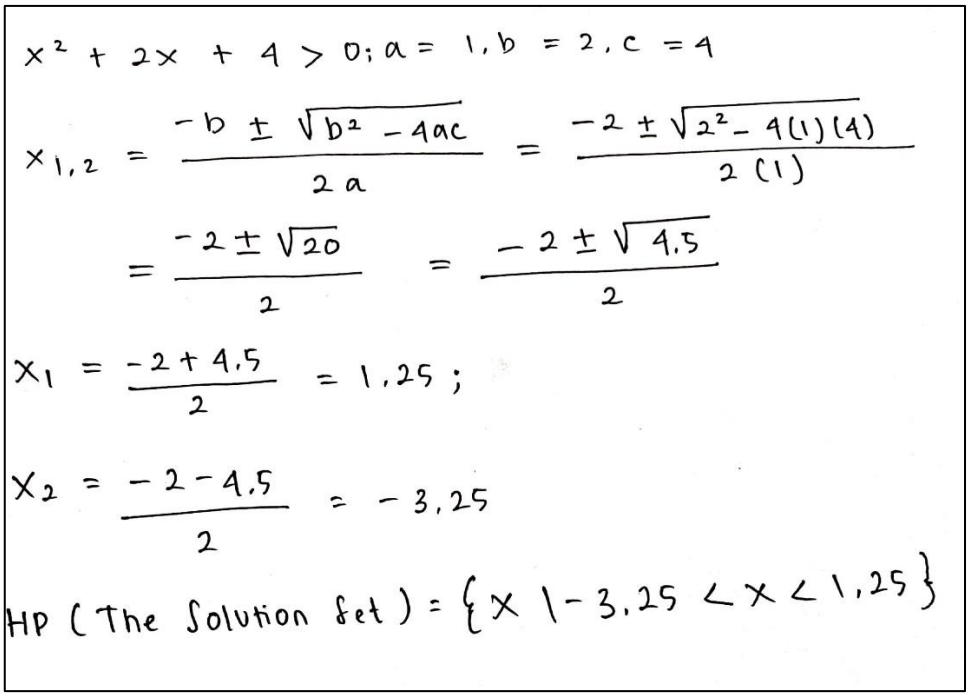

Figure 1. The answer of subject with dominance personality type (S1)

S2 concludes that the set of solutions does not exist in the set of real numbers, because it assumes that negative numbers in the square root form do not exist. The subject does not understand the concept of imaginary numbers. The answer of subject with Influence Personality Type can be seen in Figure 2.

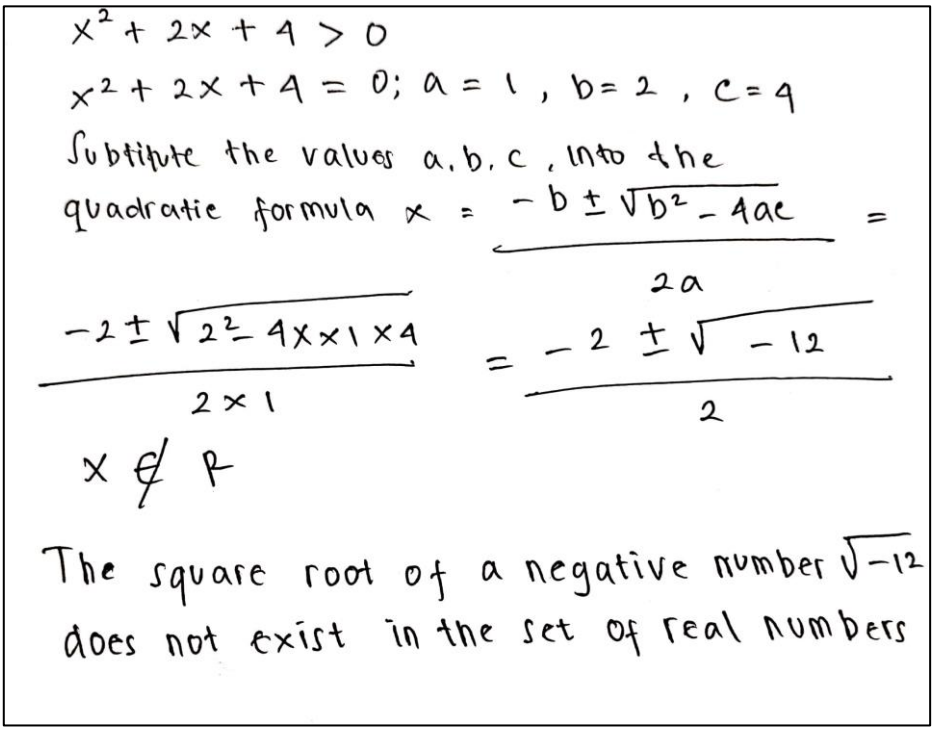

Figure 2. the answer of subject with influence personality type (S2)

In this case, S2 too much emphasis on group discussions and not enough time on solving quadratic inequalities alone. He could also find it difficult to follow the precise methods and formulas needed to solve inequalities. This can be seen in the results of the interview between the researcher (R) and the subject with Influence Personality Type (S2).

R : *So, what do you think is the solution to this problem?*
S2 : *since negative roots do not exist, the solution also does not exist (empty set).* ***I need to discuss this problem with my friend***
R : *Please, try to solve it by yourself*
S2 : ***I'm not sure***
R : *Try taking any real number, substituting it into the inequality, then what can you conclude?*
S2 : *for example, if I take 0, then I substitute it in the quadratic inequality* $x^2 + 2x + 4 > 0$ *I got results* $0^2 + 2.0 + 4 > 0$. *It's true*
R : *well, 0 is a member of the set of solutions to inequalities, right?*
S2 : ***I'm not sure,*** *is 0 a real number? If, yes, so,* ***I think the set of solutions of this inequality is all real numbers***

Furthermore, knowing the location and cause of errors in students in problem-solving will reduce errors made by the student. Thus, the students' mathematical problem-solving errors can be minimized. This error can also occur because students need help understanding the steps to solve a linear inequality. The student needs to understand the formula's meaning so that he cannot solve problems different from the one their lecturer taught or the completed problem, for example, in a textbook. This error can be minimized by enabling students to understand the meaning of existing formulas, asking students to do all sorts of questions related to linear inequality, and reinforcing the understanding of prerequisite materials such as numbers.

Next, S3 is a subject with a Steadiness personality type. The results of S3's work can be seen in Figure 3. S3 solves the problem by completing perfect squares. Solving a quadratic inequality using the method of completing the square involves transforming the inequality into a perfect square trinomial and then solving for the variable. This method is particularly effective when dealing with quadratic inequalities that can be rewritten in the form of $(x-h)^2 \geq 0$ or $(x-h)^2 \leq 0$ where h is a constant. The conditions under which completing the square can be applied to solve a quadratic inequality are as follows: The coefficient of the quadratic term must be positive; The quadratic term should be isolated on one side of the inequality; and the other side of the inequality (the side without the quadratic term) should ideally be zero if it is not zero. In this case, S3 must be more cautious and hesitant when solving quadratic inequalities. She becomes overwhelmed by the process's complexity and avoids taking risks, potentially leading to errors in their solutions. This condition can be seen from the interviews between researchers (R) and the subject with steadiness personality type (S3).

R : *Why do you use this method to solve the problem?*
S3 : ***This method is the easiest, and the most I understand, I don't think there's anything wrong with using it.***

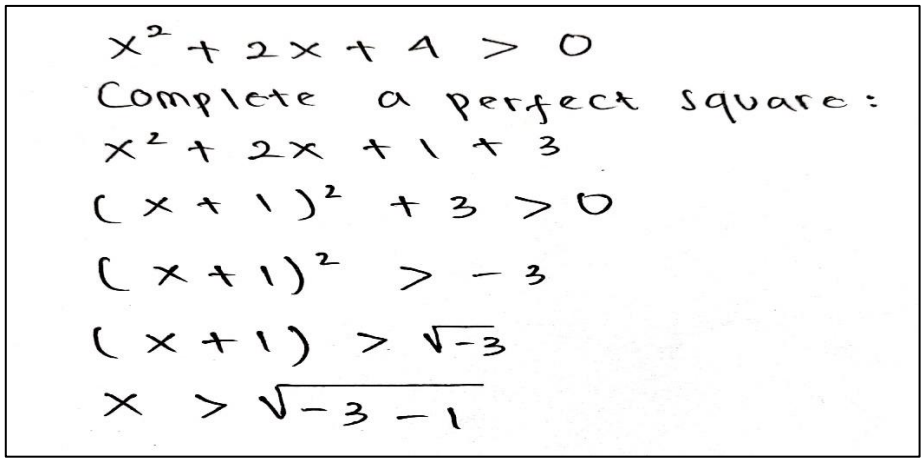

Figure 3. The answer of subject with steadiness personality type (S3)

The last, S4, is a subject with a conscientious personality type. The results of S4's work can be seen in Figure 4. Pre-service teachers could become preoccupied with overanalyzing the steps to resolve quadratic inequalities. She could place too much emphasis on particular stages and details (like describing the value of a, b, and c), losing sight of the bigger picture of how problems are solved. The same thing can also be seen in the results of the interview below,

R : *So, what do you think is the solution to this problem?*
S4 : *since negative roots do not exist, the solution also does not exist*
R : *Are you sure if there is no solution for this problem?*
S4 : *well, there should be a solution, but I don't know.*
Let me check first, maybe I was wrong in substituting the values for a, b and c.
R : *How about another way, is it possible for you?*
S4 : *Hmm, I think, I can try to solve it in other ways such as factoring or completing perfect squares*

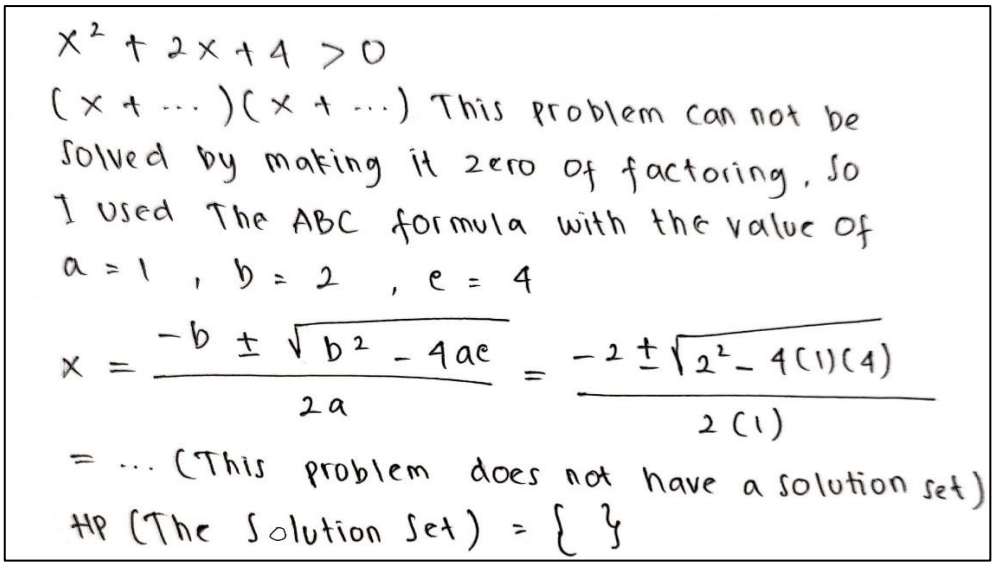

Figure 4. The answer of subject with conscientiousness personality type (S4)

The DISC personality assessment categorizes individuals into four main personality types: Dominance, Influence, Steadiness, and Conscientiousness. Each type has its characteristics and tendencies, which can influence how pre-service teachers approach and potentially misunderstand concepts like quadratic inequalities. In general, the profiles and misconceptions that occur among pre-service teacher students in this study can be seen in Table 5.

Table 5. Misconceptions on solving quadratic inequalities based on the personality type

Type of Personality	Profile	Type of Misconceptions	Mistake Made	Possible Reason	Thinking Process	Problem Solving Process
Dominance	S1 is assertive, results-oriented, and likes to take charge. He was more focused on finding a quick solution to problems	Theoretical	Error in determining the result of $b^2 - 4ac = 2^2 - 4.1.4 = 20$	S1 is confused about applying the formula, S1 focuses on the terms $b^2 = 2^2 = 4$ and $4ac = 4.1.4 = 16$, and doesn't pay attention to the type of operation, it should be subtracted instead of added	$b^2 - 4ac$	$b^2 + 4ac$
			Error in determining the result of $\sqrt{20} = 4.5$	S1 assumes 20 can be written in the form 4×5 S1 cannot differentiate between the concepts of multiplication and dot product, so he assumed that $4 \times 5 = 4.5$ (a decimal number)	$4 \times 5 = 4.5$	4.5 (A Decimal Number)
Influence	S2 is sociable, enthusiastic, and tends to focus on building relationships. He prefers collaborative learning environments	Conceptual	Error in determining the result of $\sqrt{-12}$	S2 does not understand the concept of imaginary numbers	There is no solution of $\sqrt{-12}$	There is no solution of $\sqrt{-12} \epsilon R$
Steadiness	S3 is patient, empatheticand value stability.	Classification	Error in determining the proper	S3 is incomplete	The right side is designed to	The right side of the inequality

Type of Personality	Profile	Type of Misconceptions	Mistake Made	Possible Reason	Thinking Process	Problem Solving Process
	She prefers structured and consistent approaches to learning		method to solve this problem	understanding the concept	possess a numerical value of zero	is already equal to zero. Therefore, incorrectly applying the process of S3 results in making the left side of the inequality equal to zero
Conscientiousness	S4 is detail-oriented, analytical, and value accuracy	Conceptual	Error in determining the result of $\sqrt{-12}$	S4 does not understand the concept of imaginary numbers	Every inequality should have a solution	There is no solution of $\sqrt{-12}$

3.2. Discussion

The reported completion rates of informed consent forms and DISC personality assessments provide valuable insights into students' participation and engagement levels across multiple graduating classes. The overall response rate of 79.9% indicates a relatively high willingness among students to partake in these assessments. The variance in response rates across different graduating classes is because of factors such as individual class dynamics, varying interest levels, or changes in the administration process over the years (Cutler et al., 2015; Light & Strayer, 2000). Analyzing and understanding these response rates can aid researchers in interpreting the reliability and generalizability of findings based on the collected data.

Furthermore, examining the distribution of primary personality domains within the student cohort, the prevalence of conscientiousness (C) as the most familiar domain suggests a shared tendency among students toward traits associated with carefulness, organization, and attention to detail. Steadiness (S), influence (I), and dominance (D) follow in descending order, providing a nuanced profile of the students' dominant personality characteristics. Exploring these DISC personality domains within the context of academic performance, interpersonal relationships, and future career aspirations could yield valuable insights into how individual and collective personality traits influence various aspects of student life (Conard, 2006; Noftle & Robins, 2007; Wortman et al., 2012), including errors and misconceptions experienced by students in solving quadratic inequality problems.

In mathematics education, distinguishing between errors and misconceptions is crucial, as they manifest differently but share an inherent connection. An error refers to inaccuracies (Luneta & Makonye, 2010), while a misconception result from a fundamental misunderstanding (Spooner, 2012). A common error in solving quadratic inequalities involves the misconception that one can factorize and separate each factor, akin to the zero-product property. However, this approach falls short as inequalities do not behave the same way as equations; for instance, if the product $AB < 0$, it is insufficient to solve both $A < 0$ and $B < 0$ independently—instead, their solutions depend on each other. Another prevalent

error arises in applying the quadratic formula, mainly when dealing with negative numbers or complex roots. Students often need to focus more on factoring out standard terms when simplifying quadratic expressions. Further contributing to the array of misconceptions, students need to understand the discriminant and its significance in determining the nature of the roots. These errors and misconceptions collectively underscore the intricate nature of quadratic problem-solving, highlighting the need for a comprehensive understanding to navigate these challenges effectively.

In the context of this research, misconceptions among students manifest as instances where they incorrectly link one notion to another or confuse new ideas with existing knowledge, resulting in the formation of inaccurate conceptions. These divergent student conceptions, often conflicting with those upheld by scientists, fall into three distinct categories: theoretical misconceptions, involving challenges in grasping fundamental theoretical concepts; classification misconceptions, reflecting difficulties in accurately categorizing and organizing information; and correlational misconceptions, where students misinterpret relationships or correlations between different variables or concepts (Amelia et al., 2020). Identifying and understanding these categories contributes to a more comprehensive insight into the nature of student misconceptions, facilitating targeted educational interventions for enhanced conceptual clarity.

Examining errors made on the test has led to identifying four overarching categories, shedding light on distinct stages where students encounter challenges in solving open-ended tasks about quadratic inequalities. The breakdown into errors made in understanding the problem (E1), devising a plan (E2), carrying out the plan (E3), and unverified solutions (E4) provides a structured framework to comprehend the nature and origin of students' mistakes (Veloo et al., 2015). This categorization not only aids educators in tailoring instructional strategies to address specific areas of difficulty but also contributes to a nuanced understanding of the cognitive processes involved in tackling complex mathematical problems.

The statistical analysis employing the Chi-Square independence test yields a noteworthy finding – a. The low *p-value* of 0.008, which is less than the chosen significance level ($\alpha = 0.05$), indicates that the observed association is unlikely to be due to chance. Furthermore, the Cramer's Value ($V = 0.224$) suggests a moderate degree of association, emphasizing the practical significance of the results. This statistical evidence not only reinforces the relevance of considering personality traits in the context of academic performance but also invites further exploration into the specific ways in which individual differences impact problem-solving approaches in mathematics (Wettstein et al., 2017; Zayas et al., 2002).

While the statistical significance is established, it is imperative to delve deeper into the implications of this association for educational practices. Understanding how distinct personality types influence the propensity for specific errors can guide the development of targeted interventions and support mechanisms. Tailoring teaching methodologies and providing personalized guidance based on individual personality profiles enhance students' problem-solving skills, potentially leading to improved academic outcomes. Integrating personality assessments into educational frameworks could offer a holistic approach to student development, acknowledging the interplay between cognitive processes and personality traits (Akubuilo, 2012; Qushem et al., 2022).

In relation to the characteristics of personality types, this research has shown that misconceptions regarding quadratic inequalities with one variable can vary among individuals with different personality types according to the DISC model: Dominance, Influence, Steadiness, and Compliance. Subject 1 (S1), with a dominant personality trait, tends to exhibit a rapid problem-solving approach, often overlooking subtle nuances in

interpreting inequalities. He prioritizes finding solutions efficiently but must pay more attention to the careful consideration needed when dealing with signs of inequality. This tendency aligns with studies by Tamba and Saragih (2020) and DeYoung and Gray (2009), which discuss how individuals with a dominant personality demonstrate impatience when engaging with intricate mathematical concepts, leading to misinterpretations of quadratic inequalities.

Students with a Dominance personality perceive the environment as a competitive arena where challenges are opportunities for them to assert control and showcase their leadership. They thrive in situations that allow them to make quick, decisive decisions, and they often find a favorable setting in dynamic, high-stakes environments. In their self-perception, Dominance personalities see themselves as having a significant degree of control and confidence in their ability to influence and shape the outcomes of events. This internal sense of control aligns with their proactive nature and assertiveness, driving them to take charge in various situations.

Conversely, Subject 2 (S2), with an influence personality trait, focuses on contextual understanding and intuitive approaches to problem-solving. This perspective could lead to misconceptions when prioritizing graphical interpretations over systematic algebraic solutions. Agler et al. (2020) have explored the role of personality traits in mathematical learning and highlighted how individuals with an influenced personality struggle with the abstract nature of algebraic manipulation, impacting their accuracy in solving quadratic inequalities.

Those with an Influence personality view the environment as a social stage where relationships and collaboration take center stage. They find favorable settings in environments that allow them to express ideas, connect with people, and contribute to a positive, vibrant atmosphere. In terms of self-perception, Influence personalities believe they have control over their social interactions and the ability to impact group dynamics. While their control is not dominant, it is rooted in their interpersonal skills, allowing them to navigate and influence social situations effectively.

Subject 3 (S3), with a steady personality, often exhibits a cautious and methodical problem-solving approach. In quadratic inequalities, this condition manifests as hesitation to perform necessary algebraic transformations, leading to misconceptions stemming from avoiding altering equations. Studies by Steger et al. (2008) and Locke and Braver (2008) offer insights into the cognitive tendencies of individuals with a steady personality, suggesting a preference for maintaining stability in mathematical processes. However, this inclination hinders her ability to solve quadratic inequalities accurately.

Steadiness personalities perceive the environment as a stable and structured space, finding comfort in situations that offer predictability and consistency. They favor environments with established routines and procedures, where sudden changes are minimized. A favorable setting for them provides a sense of security and reliability. Steadiness personalities see themselves as having control over their emotional responses and their ability to create stability. Their sense of control is linked to their patient and empathetic nature, allowing them to navigate challenges with a steady and composed demeanor.

Lastly, those with a Conscientiousness personality tend to favor systematic and precise problem-solving methods. However, this precision-oriented approach excessively focuses on the mathematical process rather than the broader interpretation of solutions. Studies by Mamba (2013) and Hillman et al. (2023) discuss how individuals with a compliance personality struggle to transition from procedural accuracy to conceptual understanding, potentially leading to misconceptions when solving quadratic inequalities. In conclusion, various personality types under the DISC model can influence the nature of misconceptions regarding quadratic inequalities with one variable, reflecting distinct

cognitive inclinations and problem-solving approaches. The studies referenced above provide valuable insights into these dynamics and can aid educators in addressing misconceptions by tailoring instructional strategies to accommodate diverse personalities within the classroom.

Conscientiousness personalities view the environment as an organized and detail-oriented space, thriving in situations that demand accuracy and precision. They prefer environments where rules are followed and a methodical approach is valued. Favorable settings for them are those that appreciate thoroughness and analytical thinking. In their self-perception, Conscientiousness personalities believe they have control over the quality of their work and their ability to maintain high standards. Their sense of control is grounded in their analytical mindset and commitment to delivering accurate results.

4. CONCLUSION

The study correlating DISC personality types with misconceptions in quadratic inequality problem-solving reveals a nuanced relationship between individual traits and cognitive approaches to complex mathematical concepts. The identified patterns emphasize the significance of recognizing and addressing specific challenges associated with each personality type within the realm of mathematical education. These insights underscore the need for tailored instructional strategies that consider diverse cognitive processes influenced by personality factors, highlighting the potential impact on problem-solving outcomes. In this research, the term "Discrepancies Between Thought and Action" refers to instances where pre-service teachers demonstrate misalignments between their cognitive understanding and the implementation of problem-solving strategies. This misalignment is observed in participants with different DISC personality types, such as Dominance (S1), Influence (S2), Steadiness (S3), and Conscientiousness (S4). Notably, Subject 1 (S1), with a Dominance personality type, demonstrates instances of theoretical misconceptions, while Subject 2 (S2) and Subject 4 (S4), characterized by Influence and Conscientiousness personality types, respectively, encounter conceptual misconceptions. Subject 3 (S3), identified with the Steadiness personality type, faces misconceptions related to the concept of Classification.

Similarly, participants with influence or conscientiousness personalities understand complex mathematical concepts conceptually but need help translating that understanding into accurate problem-solving actions. Understanding and addressing these conditions are pivotal for the development of targeted educational interventions. By acknowledging the misalignments between theoretical knowledge and practical implementation within the context of quadratic inequality problem-solving, educators can tailor their approaches to bridge these gaps. Additionally, addressing the acknowledged limitations and biases in the study is crucial for refining future research methodologies and enhancing the robustness of conclusions drawn from personality assessments in the realm of mathematics education.

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