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Profile and Relationship of Minimum Competency Assessment-Type Mathematical Literacy, Creative Thinking, and Mathematics Anxiety in Solving Algebra

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Abstract

This study aims to describe the profile and relationships among Minimum Competency Assessment (AKM)-type mathematical literacy, creative thinking, and mathematics anxiety of junior high school students in solving algebra problems in Yogyakarta City. The study employed a survey method with a quantitative approach, involving 397 eighth grade students selected through proportional stratified random sampling. The study instruments included a mathematics anxiety questionnaire, creative thinking test, AKM-type mathematical literacy test, and a questionnaire on factors causing mathematics anxiety. The instrument's validity was examined using content validity (through expert judgment) and construct validity with Confirmatory Factor Analysis (CFA), whereas its reliability was assessed using Cronbach's alpha coefficient. The results showed that all instruments were valid and reliable. Data were analyzed using interval estimation and path analysis. The results showed that: (1) The mathematics anxiety of junior high school students in Yogyakarta City was in the moderate criteria; (2) The creative thinking ability of junior high school students in Yogyakarta City was in the very low criteria; (3) The mathematical literacy ability of junior high school students in solving AKM-type problems was in the criteria of requiring special intervention; (4) The factors that cause the highest level of mathematical anxiety in junior high school students in Yogyakarta City are environmental factors and intellectual factors; (5) There is a negative relationship and a direct influence between mathematical anxiety and creative thinking; (6) Creative thinking is positively associated with and directly influences mathematical literacy; and (7) Mathematical anxiety is negatively associated with and directly influences mathematical literacy, as well as an indirect effect mediated by creative thinking.

Keywords: *Mathematical Literacy; Creative Thinking; Mathematics Anxiety; AKM*

Introduction

AKM is an assessment of minimum abilities conducted on students, in the form of the most basic abilities that must be mastered by students at a certain level (Pusmenjar, 2020). AKM content consists of several materials in mathematics, one of which is algebra. Aditya et al. (2018) noted that algebra is a branch of mathematics frequently applied in everyday life. Hence, students need to enhance the capacity to understand problems, formulate them into mathematical models, and determine their solutions. Nevertheless, findings from the study conducted by Agasi et al. (2017) show that junior high school students still have difficulty in solving algebraic problems.

The AKM serves as an instrument to assess students' reading and mathematical literacy (Handayani et al., 2021). Students need mathematical literacy skills because they can be used to make informed decisions and help interpret the usefulness of mathematics in life (Hayati & Kamid, 2019). However, there are problems related to this. In 2020, the National Examination (UN) was abolished, resulting in the lack of a standard for mapping education quality in the Special Region of Yogyakarta (DIY). To this end, the DIY Education Office, along with districts/cities, initiated the Regional Education Standards Assessment (ASPD). Although the average UN mathematics score in Yogyakarta City and several districts was previously higher than the provincial average, the ASPD results actually showed a decline. Yogyakarta City, known as a student city, also faces education quality issues, as evidenced by the average ASPD mathematics score of only 40.91 (low category). This suggests the need for further research in Yogyakarta. Consistent with the results of the UN and the ASPD, findings from Susanta et al. (2022) found that students generally only mastered basic literacy skills. Research by Safitri & Retnawati (2020) also showed that students still struggle to apply formulas, with their mathematical literacy skills falling into the low to moderate range.

Furthermore, creative thinking, as part of life skills, is also important to improve. Research by Slyamkhan et al. (2022) shows a strong positive relationship between creative thinking and mathematical literacy, although another study by Sepriyanti et al. (2022) found this relationship to be low. Several studies also reveal that students' creative thinking abilities are still low (Nugroho et al., 2020) although some show quite good results (Albab & Wangguway, 2020). Although various studies have measured creative thinking skills and mathematical literacy, including UN and ASPD results, a representative picture of junior high school students in Yogyakarta City is not yet fully clear. This raises questions about how junior high school students' creative thinking and mathematical literacy fare in solving AKM-type problems in the city.

One psychological factor that could potentially hinder this is math anxiety. Findings from previous studies have been mixed, with several highlighting the presence of high anxiety levels (Ulfah et al., 2021), low anxiety levels (Widjajanti et al., 2020), and some finding a negative relationship with mathematical achievement and literacy (Ng et al., 2022). However, there are also findings that the greatest influence occurs at moderate levels of anxiety Hiller et al. (2022), and not all low achieving students feel anxious (Buckley et al., 2016). The inconsistency of the connection between mathematics anxiety, creative thinking, and mathematical literacy as conveyed by Orbach et al. (2019) shows the importance of teachers' understanding of student anxiety. The factors causing mathematics anxiety need to be identified as according to Suren & Ali Kandemir (2020), so empirical data is needed regarding the level and relationship of these three variables in junior high school students in Yogyakarta City. The findings may provide a basis for teachers to develop learning designs tailored to students' needs, consistent with the principles of differentiated learning in the Independent Curriculum.

There has not been any research that simultaneously describes and connects AKM-type mathematical literacy, creative thinking, and junior high school students' mathematical anxiety in solving algebra problems in Yogyakarta City. Previous studies have only focused on separate variables, such as mathematical anxiety (Widjajanti et al., 2020) in Kulon Progo Regency, creative thinking skills (Nugroho et al., 2020) in Gunung Kidul Regency, and mathematical literacy (Safitri & Retnawati, 2020) in Sleman Regency. However, as far as the researcher is aware, no prior study has focused on describing the profile and connects these three variables in junior high school students in Yogyakarta City, especially regarding mathematical literacy of the AKM-type which was just implemented in the 2021 academic year (Pusmenjar, 2020). In addition, no research has been found that reveals the factors causing junior high school students' mathematical anxiety in Yogyakarta City based on literature searches in electronic databases. Therefore, this study focuses on the profile and relationship of mathematical literacy of the AKM, creative thinking, and junior high school students' mathematical anxiety in solving algebra problems.

Method

A survey method within a quantitative framework was employed in this study to analyze the mathematics anxiety, creative thinking, and mathematical literacy of junior high school students in solving AKM-type algebra problems in Yogyakarta City, Special Region of Yogyakarta. The survey was chosen because it could describe the attitudes, beliefs, and behaviors of the population. The study population was eighth grade junior high school students in Yogyakarta City. In light of the relatively large population, a proportional stratified random sampling approach was applied to secure a representative sample. Consequently, 397 students were selected for this study, including 133 students in the high-level group, 97 in the middle-level group, and 167 in the low-level group.

In this study, the instruments employed were a mathematics anxiety questionnaire, creative thinking questions, AKM-type mathematical literacy questions, and a questionnaire on factors contributing to mathematics anxiety. The study instruments included a creative thinking test, an AKM-type mathematical literacy test, a questionnaire on factors contributing to mathematics anxiety, and a mathematics anxiety questionnaire. The creative thinking test measures fluency, flexibility, and elaboration, while the mathematical literacy test includes the ability to interpret, formulate, and use at the cognitive levels of knowing, applying, and reasoning in personal, sociocultural, and scientific contexts. The math anxiety questionnaire covers cognitive, affective, and somatic aspects, while the anxiety causing factors questionnaire covers environmental, intellectual, and personality aspects.

Content validity was determined based on the instrument's alignment with the designed indicators, and then revised based on expert input. Once declared valid, the instrument was piloted on students. CFA was employed to assess the construct validity of the mathematics anxiety questionnaire as well as the math anxiety causing factors questionnaire. Based on the CFA results, all items in the questionnaire had factor loadings > 0.30, thus concluding that all items were valid for use in the study.

This study employed both inferential and descriptive statistics methods for data analysis. Descriptive statistics were used to describe the data through tables, averages, and standard deviations to determine the level of mathematics anxiety, creative thinking, and mathematical literacy of students in solving AKM-type algebra. The score range and scale of mathematics anxiety criteria are based on Table 1 below.

Table 1. Mathematics Anxiety Criteria

Interval	Student Score	Criteria
$X > \mu_i + 1.5\sigma_i$	$X > 80$	Very High
$\mu_i + 0.5\sigma_i < X \leq \mu_i + 1.5\sigma_i$	$66{,}67 < X \leq 80$	High
$\mu_i - 0.5\sigma_i < X \leq \mu_i + 0.5\sigma_i$	$53{,}33 < X \leq 66{,}67$	Moderate
$\mu_i - 1.5\sigma_i < X \leq \mu_i - 0.5\sigma_i$	$40 < X \leq 53{,}33$	Low
$X \leq \mu_i - 1.5\sigma_i$	$X \leq 40$	Very Low

Description:

σ_i = Ideal standard deviation
μ_i = Ideal mean
X = Total score obtained

The criteria of creative thinking ability are presented in Table 2 below.

Table 2. Creative Thinking Criteria

Student Score	Criteria
$X > 80$	Very High
$65 < X \leq 80$	High
$55 < X \leq 65$	Moderate
$45 < X \leq 55$	Low
$X \leq 45$	Very Low

Description:
Maximum score = 100
Minimum score = 0
X = Total score obtained

The criteria of AKM-type mathematical literacy ability are presented in Table 3 below.

Table 3. AKM-Type Mathematical Literacy Criteria

Student Score	Criteria
$X > 70$	Advanced
$60 < X \leq 70$	Proficient
$46{,}67 < X \leq 60$	Basic
$X \leq 46{,}67$	Requires Special Intervention

Description:
Maximum score = 100
Minimum score = 0
X = Total score obtained

Meanwhile, inferential statistics were used to examine the relationships among AKM-type mathematical literacy, creative thinking, and mathematics anxiety of students in solving algebra problems. The analyses employed to test the hypotheses in this study were interval estimation and path analysis.

Findings and Discussion

Mathematics Anxiety Profile of Students

This study seeks to provide a description of the profiles and to analyze the relationships among AKM-type mathematical literacy, creative thinking, and mathematics anxiety in junior high school students solving algebra problems in Yogyakarta City. Data analysis revealed that mathematics anxiety scores in high level schools fell within the low to moderate range, in middle level schools fell within the moderate range, and in low level schools fell within the moderate to high range. Overall, in this study, the level of mathematics anxiety of students was in the moderate criteria with an average of $58.58 \leq \mu \leq 61.37$. This is consistent with research by Azizah et al. (2019) and Widjajanti et al. (2020) which show that junior high school students experience moderate mathematics anxiety. Students with good mathematics abilities still experience mathematics anxiety.

Overall, in this study, the cognitive aspect demonstrated the highest level of mathematics anxiety compared to other aspects, which corresponds to the results obtained by Anugrah et al. (2019) that cognitive anxiety of mathematics anxiety is in the high category, which is caused by students often forgetting material when working on problems. The affective aspect in this study is at almost the same level as cognitive, while the somatic aspect is at the lowest level, supporting the results of the study Hayati & Kamid (2019) which states that students somatic anxiety tends to be low. Students generally feel anxious, nervous, and afraid when facing math tests.

Creative Thinking Profile of Students

The data analysis in this study indicates that students' creative thinking skills at all school levels are in the very low criteria, with an average of $31.07 \leq \mu \leq 34.08$. This is consistent with Nugroho et al. (2020) who also found that most students are categorized as less creative. This is due to conceptual misunderstandings and a lack of practice working on problems that refer to students' creative thinking skills. This study shows that at all school levels, fluency scored highest, followed by elaboration, while flexibility scored lowest. Thus, students tended to provide multiple answers but struggled to use more than one correct solution strategy.

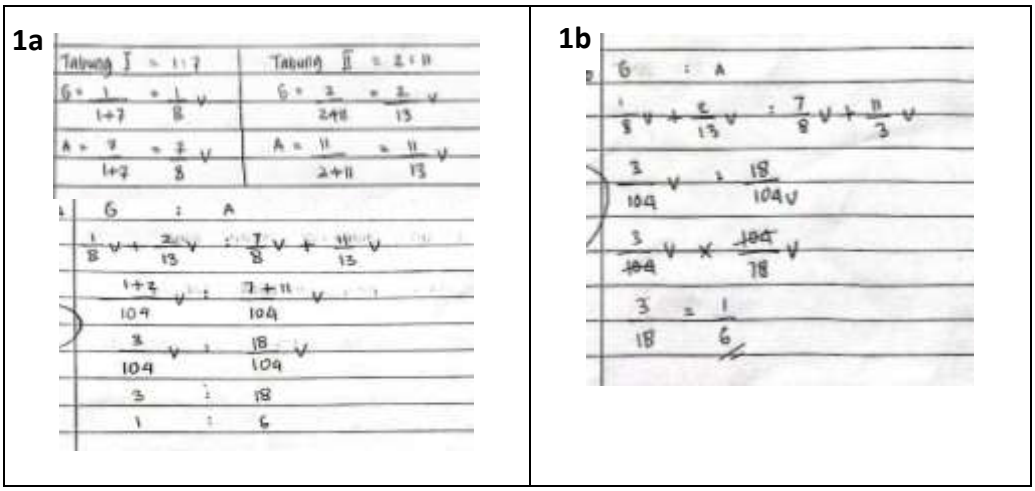

Figure 1. Example of Student Answers (Score 3) for Question 1a and (Score 2) for Question 1b

Figure 1 displays students' answers to questions 1a and 1b, which require an understanding of the concept of ratio. The creative thinking aspect of question 1a is elaboration, while that of question 1b is flexibility. In question 1a, the student received a score of 3 because, despite an incorrect calculation due to a mistake in a fraction operation, the answer still included complete details. Meanwhile, in question 1b, the student received a score of 2; He tried a different strategy by changing fraction division to multiplication, but still made similar calculation errors. This is consistent with Puspitasari et al. (2018) who stated that students with low ability still have difficulty understanding problems, are less thorough in calculations, provide incorrect ideas, and lack structure in the elaboration aspect. This is consistent with Maharani et al. (2020) who found that students' main weakness lies in the flexibility aspect.

Figure 2 displays student answers to question 2, which requires an understanding of algebraic arithmetic operations using the creative thinking aspect of fluency. The student earned a score of 5 for presenting more than one relevant solution accompanied by correct calculations. Consistent with Astuti et al. (2020), fluency is included in the high criteria on creative thinking tests. Arista & Mahmudi (2020) also found that, based on the average creative thinking ability results, fluency was the aspect with the highest percentage, followed by elaboration and flexibility.

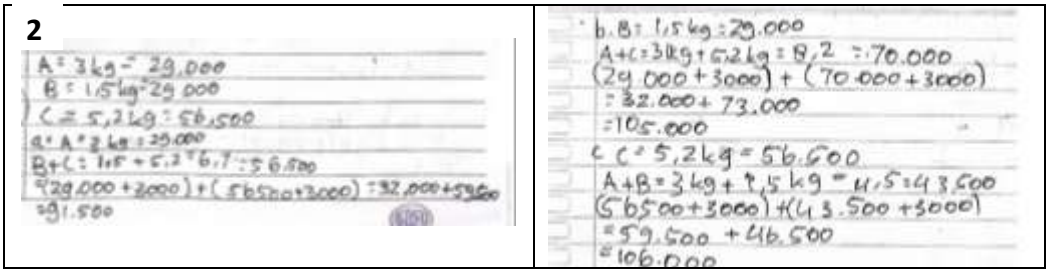

Figure 2. Example of Student Answers (Score 5) for Question 2

Mathematical Literacy of AKM-Type Profile of Students

The average AKM-type mathematical literacy skills showed a high level in the basic-proficient criteria, a moderate level in the requiring special intervention-basic criteria, and a low level in the requiring special intervention criteria. Overall, junior high school students' mathematical literacy skills were categorized as requiring special intervention, with an average of $41.36 \leq \mu \leq 45.78$. Students only mastered partial concepts with limited computational skills. This corresponds to the findings of Solihin et al. (2023) and Nisa & Arliani (2023) which also indicate that junior high school students' mathematical literacy skills are in the low to very low category due to difficulties in analyzing facts and relating them to relevant mathematical concepts.

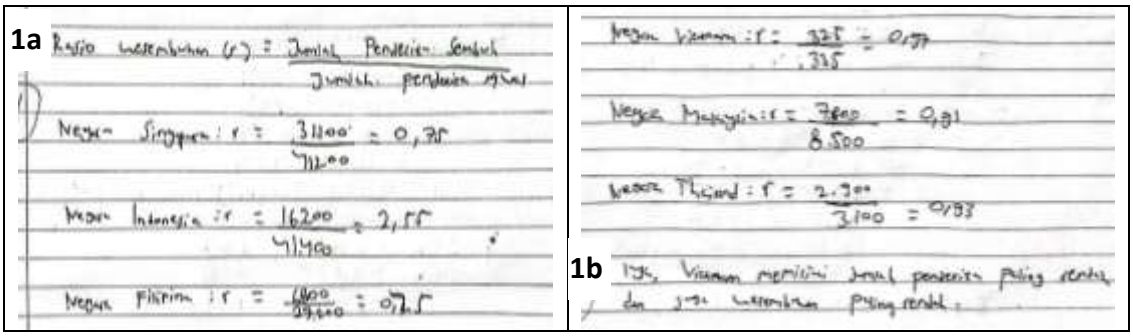

Figure 3. Example of Student Answers (Score 4) for Question 1a and (Score 1) for Question 1b

The results showed that the average formulate-knowing, employ-applying, and interpret-reasoning aspects in high level schools were better than in other levels, while low level schools had the lowest results. In general, the employ-applying aspect was the highest, followed by formulate-knowing, while the interpret-reasoning aspect was the lowest. This indicates that most students were unable to interpret mathematical solutions correctly.

Figure 3 displays students' answers to questions 1a and 1b, which require an understanding of ratios in a socio cultural context. The mathematical literacy aspect of question 1a is employ-applying, with a score of 4 because the student was able to use the concept and procedures of ratios despite still having minor errors in the calculations. Meanwhile, question 1b belongs to the interpret-reasoning aspect, with a score of 1 because the student misinterpreted the meaning of the mathematical solution, namely concluding that Vietnam has the lowest recovery rate based only on the lowest number of cases.

This is consistent with Kurniawati & Mahmudi (2019) who showed that the employ aspect had the highest average score compared to other aspects of mathematical literacy. Conversely, the interpret aspect was classified as very low (Sari & Wijaya, 2017), indicating that students had difficulty interpreting context, arguing, and evaluating solutions. This is reinforced by Kurniawati & Mahmudi (2019) who found that many students were unable to construct arguments from the mathematical results obtained.

An example can be seen in the answer to question 4a (Figure 4), which is a formula-knowing aspect. The student received a score of 2 because he made an error when creating a mathematical model using inequality symbols. The answer should have been written as $20x + 60 \leq 2000$, where x is the number of boxes transported by the car per trip.

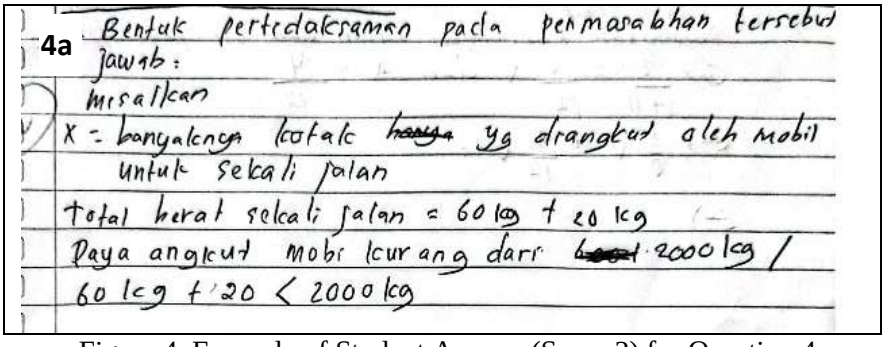

Figure 4. Example of Student Answer (Score 2) for Question 4a

This is consistent with Nisa & Arliani (2023) who stated that many students still experience difficulties in the formulation stage. Students often misconnect facts and concepts, and struggle to interpret the obtained solutions appropriately within the problem's context. Research by Megawati & Sutarto (2021) on AKM mathematical literacy found that students' ability to apply concepts was high, but conceptual mastery was still low and reasoning ability was very low. In AKM, the context represents the

real life situation used in the problem. This study used personal, sociocultural, and scientific contexts in the mathematical literacy questions. The results showed the highest achievement in the sociocultural context, followed by scientific, while the personal context was the lowest.

Factors Causing Students' Math Anxiety

Findings from this study show that the highest scoring factors for math anxiety stem from environmental and intellectual factors. Meanwhile, personality factors were not among the highest scoring factors. Thus, environmental factors are the dominant factor causing math anxiety. Previous research confirms that environmental factors are the primary cause of math anxiety, both through teacher and parental attitudes. Therefore, environmental factors contribute the most to math anxiety, followed by personality factors (Acharya, 2017).

The results of this study also indicate that the statements with the highest scores related to environmental aspects were: parents rarely teach math at home and parents often get angry when math scores are low. This aligns with the findings of Szczygieł & Pieronkiewicz (2022) that parental attitudes can be a major source of students' anxiety and self doubt in math. In this study, the primary factor causing math anxiety stems from the family environment, such as parents rarely motivating their children when they receive low grades, forcing children to excel in math, or learning difficulties from siblings. These results correspond to the findings of O'Leary et al. (2017), which indicate that high levels of math anxiety are caused by a lack of family support.

Regarding the school environment, anxiety arises from a lack of peer support and teachers who are unpopular, indifferent, or even embarrassing. This is supported by Beyaztaş & Bostancı (2023) who stated that the main cause of math anxiety in students is teacher attitudes in the classroom. Intellectually, students are anxious due to a lack of understanding of basic theories, difficulty remembering material, and confusion in applying concepts in everyday life. These results correspond to the findings of Anugrah et al. (2019) that math anxiety arises from a combination of factors from family, friends, teachers, and a weak understanding of concepts.

The Relationship between Students' Mathematical Literacy, Creative Thinking, and Math Anxiety

Based on Tables 4 and 5, the correlation test indicates a moderate negative relationship between math anxiety and creative thinking (r = -0.295). The path analysis yielded a Beta coefficient of -0.320, meaning math anxiety contributes -32% to creative thinking; each one unit increase in anxiety decreases creative thinking ability by 0.320 units. This result corresponds to prior research, as reported by Fetterly (2020) which showed that higher math anxiety leads to lower creative thinking ability, characterized by limited understanding, ideas, and answer detail.

Table 4. Correlation Coefficient Test Results

		Math Anxiety (X)	Creative Thinking (M)	Mathematical Literacy (Y)
Math Anxiety (X)	Pearson Correlation	1	-,295**	-,442**
	Sig. (2-tailed)		<,001	<,001
	N	397	397	397
Creative Thinking (M)	Pearson Correlation	-,295**	1	,702**
	Sig. (2-tailed)	<,001		<,001
	N	397	397	397
Mathematical Literacy (Y)	Pearson Correlation	-,442**	,702**	1
	Sig. (2-tailed)	<,001	<,001	
	N	397	397	397

Furthermore, as shown in Tables 4 and 5, the correlation coefficient test revealed a strong positive relationship (r = 0.702) between creative thinking and mathematical literacy skills, which means there is a

positive relationship between creative thinking and mathematical literacy skills, including the criteria for strong correlation. The path analysis equation for the creative thinking variable and mathematical literacy skills acquired a Beta coefficient value of 0.916. This value indicates the contribution of creative thinking to mathematical literacy skills of 91.6%. A positive result on the Beta coefficient can be interpreted that if creative thinking increases by one unit, then mathematical literacy skills will increase by 0.916 units. In line with the research findings of Qadri et al. (2019) showed that the higher the creative thinking ability, the better the mathematical literacy of students. A similar finding was found by Asmara et al. (2017) that students with low creative thinking tend to have low mathematical literacy, Meanwhile, students who exhibit higher creative thinking skills are more likely to achieve better mathematical literacy.

Table 5. Summary of Direct Effect Results

Effect of Variables	Calculation Results Beta Coefficient
X on M	-0,320
X on Y	-0,407
M on Y	0,916

Based on Tables 4 and 5, the correlation test results indicate a moderate negative relationship between mathematics anxiety and mathematical literacy of -0.442. Path analysis yielded a Beta coefficient of -0.407, meaning mathematics anxiety contributes -40.7% to mathematical literacy. Thus, a one unit increase in anxiety decreases mathematical literacy by 0.407 units. This is supported by Irfan (2017) who showed that students with high anxiety often make errors in symbols, model interpretation, and writing consistency, which hinder problem solving. Hiller et al. (2022) reported a moderate negative correlation between mathematics anxiety and mathematical literacy, such that improvements in literacy are accompanied by reductions in anxiety. This is consistent with Gabriel et al. (2020) also showed that math anxiety negatively impacts mathematical literacy.

Furthermore, based on the calculation of the indirect effect (the effect of math anxiety on mathematical literacy through creative thinking), the multiplication of the Beta coefficient for the math anxiety variable and the Beta coefficient for the creative thinking variable yielded -0.293. The Sobel test yielded a z-value of -5.8095. As the z-value lies beyond the critical threshold of ±1.96, it can be concluded that creative thinking can mediate the relationship between math anxiety and mathematical literacy. This suggests that as math anxiety increases, students' creative thinking abilities tend to decline, which in turn impacts their mathematical literacy abilities.

Conclusion

Based on the study results, the mathematics anxiety of eighth grade junior high school students in Yogyakarta City is in the moderate criteria, with the highest cognitive aspect and the lowest somatic aspect. Creative thinking ability is classified as very low, with the highest fluency and the lowest flexibility. Meanwhile, mathematical literacy ability in AKM-type algebra problems is in the criteria requiring special intervention, with the highest employ-applying and the lowest interpret-reasoning. Factors causing anxiety include environmental aspects (lack of parental support, indifferent teacher attitudes, non conducive learning atmosphere, and minimal peer support) and intellectual aspects (lack of understanding basic theories, difficulty remembering material, and confusion in application). The results of the analysis show that creative thinking is positively associated with and directly influences mathematical literacy; mathematics anxiety is negatively associated with and directly influences mathematical literacy, and there is also an indirect effect of mathematics anxiety on mathematical literacy mediated by creative thinking.

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