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Understanding the Role of Personality and Emotional Factors in Learners' Metacognitive Performance in Mathematics

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Abstract

The research analyzes how metacognitive awareness and Five-Factor Model based personality traits and anxiety degrees affect students' mathematical problem-solving performance. The study used SEM with SmartPLS to gather data from secondary school students who answered self-assessment questionnaires consisting of MAI, BFI and STAI. Student performance in problem-solving improves notably when they possess advanced metacognitive abilities because they effectively use planning and evaluation alongside monitoring of their cognitive approaches. People who are open to new experiences along with those who are conscientious show stronger metacognitive abilities which supports their problem-solving effectiveness. Research discoveries revealed that enhancing anxiety raises obstacles to metacognitive processing that results in reduced academic performance among students in mathematics. The research showed personality traits and anxiety independently affect metacognition but failed to identify any direct influence between these constructs. Educational strategies should focus on building metacognitive capabilities and anxiety control systems because studies indicate they will boost mathematical performance outcomes. This investigation demonstrates how personalized educational strategies that regard individual personality characteristics might deliver positive outcomes.

Introduction

Basic mathematical knowledge and strong competence in suitable metacognitive strategies serve as necessary elements for student achievement in mathematical problem-solving tasks. Hill et al. (2005) noted that metacognition as a framework of self-awareness together with cognitive process regulation includes strategy development followed by implementation and evaluation in resolving problems. Proper management of this process serves as the foundation for student improvement regarding problem-solving skills and mathematical proficiency. According to Puente-Díaz et al. (2022) mathematical accomplishment depends heavily on metacognitive abilities of students when studying this discipline.

Students experience significant academic performance changes in mathematics based on their levels of metacognition according to Muncer et al. (2022). Multiple research studies demonstrate that mathematical problem-solving performance improves when students develop strong metacognitive abilities particularly for solving mathematical problems.

The study conducted by Gartmann & Freiberg (1995) revealed that metacognitive skills determine the outcomes of mathematical problem-solving. Higher metacognitive awareness among students enabled them to develop better math problem-solving abilities by planning effectively and monitoring their progress through evaluation of solution results. According to Desoete et al. (2001) students who undergo metacognitive training demonstrate improved planning of strategic problem-solving steps combined with better strategic execution supervision and enhanced strategy evaluation capabilities. The research underlines how

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effective metacognition training techniques help build better mathematical skills in students. Jacobse & Harskamp (2012) dedicated their research to creating assessment methods for measuring mathematical metacognitive capabilities in students while showing reflective skill assessment helps students evaluate their strategy performance to determine necessary modifications. The research offers school instructors an assessment protocol which aids them in evaluating and developing their students' metacognitive competencies. Schoenfeld (2020) develops the understanding of metacognition in mathematics education by highlighting how teachers along with students need these abilities to create effective teaching methods. The effectiveness of teaching depends on how well teachers understand their students' metacognitive processes because it allows educators to develop better problem-solving strategies along with reflective learning strategies. The research reveals that meta-cognitive skill improvement enables students to master math concepts and solve problems creatively and effectively handle obstacles they encounter.

Mastering fundamental mathematical ideas alongside developed metacognitive abilities leads to successful mathematical problem-solving outcomes (Chiu & Yang, 2024; Hidayat et al., 2022). Research proves that students who develop self-regulatory skills demonstrate improved results in their mathematical problem-solving tasks. Puente-Díaz et al. (2022) proved that students who demonstrate strong metacognitive control along with awareness perform better at monitoring strategy planning and adaptation according to encountered difficulties. Strong metacognitive abilities provide students with better competence in error detection alongside situational-based approach modifications (Yusri, 2020).

The subject of metacognition has received research attention throughout investigations of multiple cognitive and non-cognitive traits starting with knowledge and continuing through efficacy and motivation concluding with self-regulation. The research by Jacobse & Harskamp (2012) demonstrates how planning and monitoring play vital roles in developing high school students' mathematical problem-solving skills. Research demonstrates that effective problem managers develop action plans before checking their advancement. Students who use metacognitive processes enable themselves to control their thinking processes and repair errors while changing their problem-solving techniques (Halmo et al., 2024; Maksum et al., 2022).

The research explores how metacognitive skills affect two vital non-cognitive elements namely personality traits (Batteson et al., 2014) and anxiety levels (Dragan et al., 2012). The Five-Factor Model (FFM) provides a system for describing personality traits through five distinct factors including openness to experience along with friendliness and awareness and emotional stability and extroversion (Wiggins, 1996). Researchers explain individual differences in metacognitive processes through this analysis of personality factors and metacognition according to Song et al. (2011).

Puente-Díaz et al. (2022) evaluated students through an analysis aimed at stating whether Five Factor Model (FFM) personality traits relate to metacognitive competencies. The levels of metacognition matched the numbers students received in awareness tests along with their scores for openness to new experiences. The personality trait of openness to experience led students to better reflect on problem-solving alongside strategy adaptation whereas prudence enabled students to effectively generate goals and make plans and track their progress (Song et al., 2025; Lupiáñez et al., 2024). The study identifies how personality characteristics strongly affect how people use metacognition during problem-solving activities.

The mental process of metacognition receives major influence from both cognitive processes and non-cognitive elements such as personality factors along with anxiety levels. Puente-Díaz et al. (2022) explained in their research that the Five-Factor Model (FFM) demonstrates

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through openness to experience, friendliness, awareness, emotional stability and extroversion how different personality traits influence students' metacognitive abilities. The problem-solving style of students who show high openness toward experiencing new things demonstrates both creative thinking ability and cognitive adaptability. Hill et al. (2021) show that students with well-developed awareness display better organizational abilities and shows advanced planning in their academic activities.

The performance of metacognitive abilities in students gets influenced significantly by their anxiety levels. High student anxiety disrupts their mental regulation of cognitive processes for planning and monitoring therefore impacting their success with math problems according to Beilock & Maloney (2015). High-anxiety students experienced both problems with sustained attention and heightened confusion in selecting their problem-solving approach.

Methods

The study relies on the cross-sectional method to gather data that shows present relationships between important researched variables. The researcher employed cluster random sampling to select an example group from predetermined classes from the full population consisting of junior high school students.

Research Instrument

The research instrument comprised self-assessment questionnaires that evaluated metacognitive abilities as well as personality traits and levels of anxiety in participants. The Metacognitive Awareness Inventory (MAI) constitutes the main research instrument of this study because it allows researchers to evaluate mathematical problem-solving metacognitive awareness through a Likert version scale designed by Hardiyanti & Shifa (2023). The Big Five Inventory (BFI) serves to determine participant personality traits using the Five Factors Model by measuring extroversion together with friendliness and awareness and emotional stability and openness to experience. The investigation featured thirdly the State-Trait Anxiety Inventory (STAI) as an instrument to assess participant anxiety characterized by stable traits and temporary and situation-related states. Spielberger (1983) developed the STAI instrument utilized here. Participants have access to two submission methods through online and face-to-face contact and receive guidance to follow proper implementation procedures. The research appendix contains all used instruments to provide detailed information about questionnaire items directed towards respondents.

Procedure

The researcher presented a review of research materials starting with relationships and functions before distributing the questionnaire according to the description in CHAPTER II. The researcher presents this content to verify students understand the examination topics sufficiently. The researcher followed by providing specific questions related to the material that students needed to answer. The first measurement stage enables assessment of students' fundamental grasp and solution skills in mathematics. The researcher distributes the questionnaire to selected students who finished their practice questions. The survey contains questions intended to evaluate student anxiety regions alongside personality features as well as metacognitive capabilities. The researchers perform each stage of this process with precision to achieve accurate and valid data results. Student participation occurred only after the complete completion of their assigned math problems in their comprehension test of the explained material.

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Instrument Validity

The researchers obtained validation from the Research Instrument Validator Board established at the State University of Makassar. The instrument validation process checks the instrument's substance as well as its construction and applicability against research aims. The validator establishes that the evaluation tool precisely measures the targeted variables. In addition, validation is also carried out in data analysis using *Structural Equation Modeling* (SEM) to verify that the instrument is statistically appropriate and valid. This validation process ensures that the research results are reliable and relevant to draw valid conclusions.

Table 1. Validation and Reliability

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted	Status
A	0.807	0.866	0.910	0.835	Valid
M	0.864	0.877	0.908	0.712	Valid
PT	0.798	0.825	0.862	0.560	Valid

Researchers use Cronbach's alpha value to determine how consistently the research instrument measures its intended concepts. The validity of an instrument as an internal consistency measure can be confirmed if its value exceeds 0.7. All variables (A, M, PT) within this table exceed 0.7 Cronbach's alpha values which demonstrates that the instrument shows reliable results.

Data Analysis

The research utilizes SmartPLS analysis with SEM to explore the complex interrelationships involving three variables: metacognitive awareness, personality characteristics from the McCrae & John (1992) FFM model and student anxiety tracked using STAI results alongside academic information. The collected data originated from a Likert-scale rated statements survey which researchers imported to SmartPLS for additional analysis. The research analysis starts with data readiness before moving to modeling latent constructs about metacognitive awareness and personality traits together with anxiety measurements alongside indicator determination for each construct. The check for both validity and measurement model goodness-of-fit occurs to verify the model's appropriateness with present data. The analysis starts with establishing relationships between latent variables according to research hypotheses then moving to path analysis to determine hypothesis significance and strength. When necessary the analysis includes both mediation and moderation procedures to understand the effects of these variables throughout the model. The analysis results present clear data in tables and graphical representations which helps understanding the mutual interactions between metacognitive awareness and personality traits and anxiety during mathematical problem-solving by students.

Results and Discussion

The data indicates that students demonstrate positive personality traits since their average score reaches 3,928. This finding shows that most students have learning-compatible traits of openness to experience and prudence. A considerable portion of students exhibit strong metacognitive abilities as their mean score reached 4,092. Different levels of anxiety affected students in the sample because their average anxiety score was 2.947 while the standard deviation came out to 0.719. This indicates that students exhibited both heightened and lowered levels of anxiety.

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Table 2. Descriptive Statistics

	Mean	Median	Observed min	Observed max	Standard deviation	Excess curtosis	Skewness	observations used
A	0.000	-0.080	-2.655	2.301	1.000	0.478	-0.232	78.000
M	0.000	0.170	-3.576	2.529	1.000	1.471	-0.606	78.000
PT	-0.000	-0.030	-2.030	2.851	1.000	0.380	0.607	78.000

The statistical consistency of students' personality characteristics (0.497) and metacognitive competencies (0.435) was higher than their reported anxiety levels (0.719) in the population. Most students demonstrate strong metacognitive abilities although a smaller student group requires additional intervention so they can better control their anxiety when it threatens learning processes. A sufficient number of 218 students participated in this study to create trustworthy results relevant to its investigation.

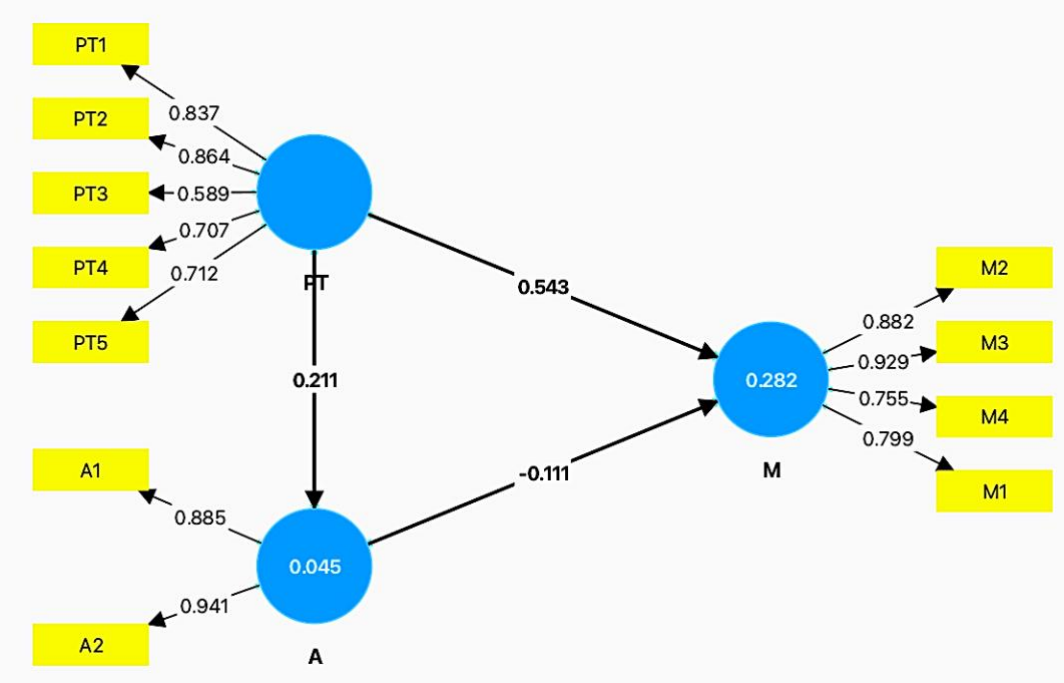

Figure 1. PLS Peratama Interaction Algorithm

The first iteration of this study presents Figure 4.1 that demonstrates the main construct relationships between indicators used to measure the constructs through Partial Least Squares (PLS) modeling. This study examined three main constructs including Personality (PT), Anxiety (A), Metacognition (M). There are five indicators measuring PT under Personality and two indicators measuring A under Anxiety. The measurement of M contains four indicators spanning from M1 through M4. A yellow box displays each indicator pointing to its construct through an arrow that represents its outer loading value. These outer loadings values indicate how strongly the indicator contributes to measuring their respective constructs, with higher values (above 0.7) indicating a significant contribution.

Table 1. First Iteration Coefficient Patch

	A	M	PT	Status
A1	0.885			Valid
A2	0.941			Valid
M1		0.799		Valid

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M2		0.882		Valid
M3		0.929		Valid
M4		0.755		Valid
PT1			0.837	Valid
PT2			0.864	Valid
PT3			0.589	Drop
PT4			0.707	Valid
PT5			0.712	Valid

The measure of Path Coefficient evaluates the connection intensity between measuring elements and their corresponding construct. The indicators considered significant for construct measurement show values greater than 0.7 according to this analysis. The construct measurement indicators A1, A2, M1, M2, etc. qualify as valid because they maintain a strong link with their corresponding construct when the value reaches 0.7. The model requires removal of the PT3 indicator because its contribution to measuring the PT construct is insignificant based on its 0.589 path coefficient value. The initial assessment of the model demonstrates that the majority of indicators function well in detecting constructs yet some could benefit from modification to strengthen the model validity.

The second iteration with SMRTPLS evaluated the first iteration model to improve and validate the developed model. The model enhancement process results in indicator modifications or eliminations of indicators with minimal contribution to the first iteration leading to enhancement of validity and reliability. In the second iteration the model will verify that all kept indicators provide important measurement value to their respective constructs while establishing stable construct relationships. Further analysis will start with the second iteration results as they produce sounder models with stable structures.

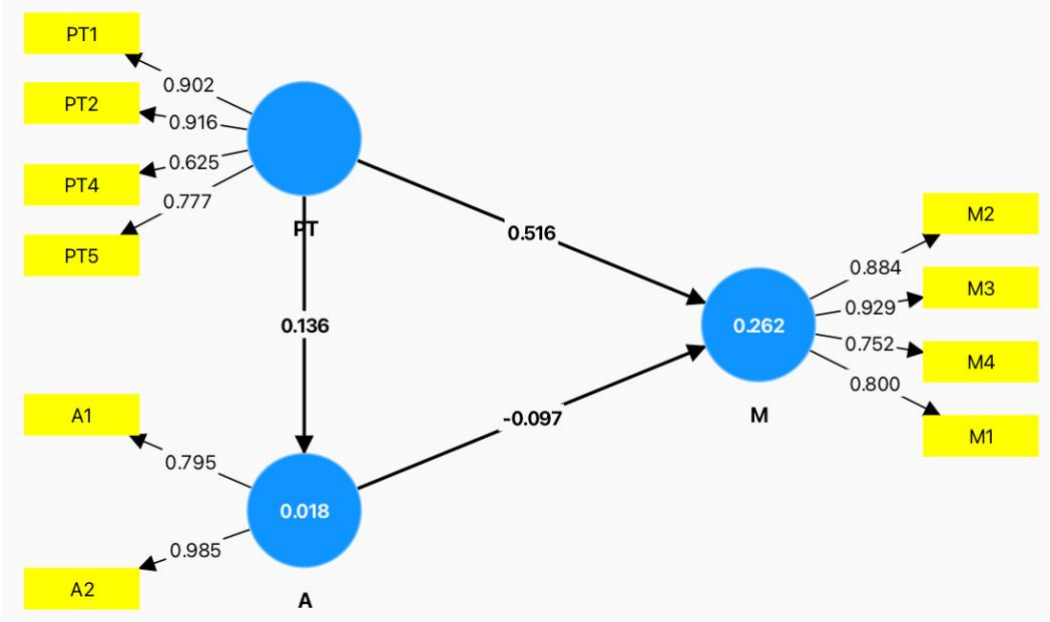

Figure 2. PLS Iteration Algorithm 2

The second iteration model based on PLS shows how the key constructs PT, A, and M along with their individual measuring indicators relate to each other following model refinement. The construct of PT measures four indicators then PT1, PT2, PT4 and PT5 while the construct of A depends on two indicators A1 and A2. There are four indicators used to measure the construct

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of M: M1 to M4. The yellow box indicators demonstrate significant measurement validity since they exceed 0.7 in outer loading values.

Measurement of construct strength exists through analysis of these linked variables. The path coefficient value of 0.516 between PT and M shows that students' metacognitive abilities experience positive and significant personality-related influences. The relationship between personality and anxiety at A of 0.136 showed a positive connection yet demonstrated weaker strength according to the results. The value of -0.097 between A and M revealed that anxiety-levels showed a weak negative impact on metacognitive abilities without producing a statistically significant outcome.

Table 2. Path Coefficient Iteration 2

	A	M	PT	Status
A1	0.795			Valid
A2	0.985			Valid
M1		0.800		Valid
M2		0.884		Valid
M3		0.929		Valid
M4		0.752		Valid
PT1			0.902	Valid
PT2			0.916	Valid
PT4			0.625	Valid
PT5			0.777	Valid

The table reveals how strong and directional the second-stage relationship exists between the latent measure and its indicator. The second iteration of testing demonstrates the impacts of model development since initial adjustments were applied after the first iteration run. All indicators that carried forward to the second iteration displayed minimum path coefficients exceeding 0.7 which established their validity as well as their meaningful contribution to their respective construct measurement. Construct A can be measured effectively by dynamic indicators A1 with 0.795 coefficient value and A2 with 0.985 because of their high measurement quality.

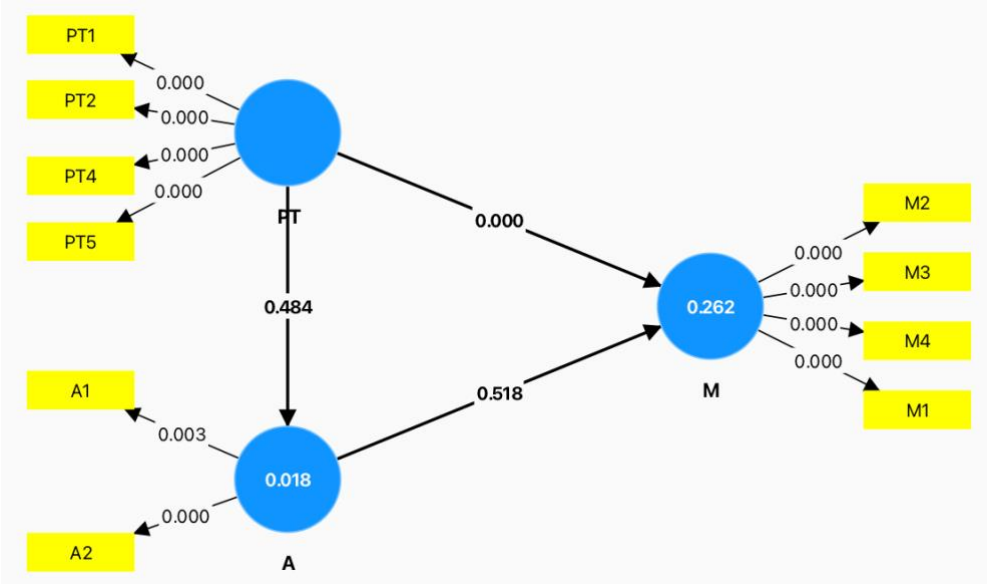

Figure 3. 3rd Iteration (Bootsraping)

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The third iteration Partial Least Squares (PLS) model depicts how the main constructs (Personality (PT), Anxiety (A) and Metacognition (M)) and their measurement indicators (PT1, PT2, PT4, PT5, A1, A2, M1 to M4) remain at a stable relationship. Four primary indicators namely PT1, PT2, PT4 and PT5 define the construction of PT in this figure. The measurement scale of Construct A contains both A1 and A2 while the four indicators M1 to M4 assess Construct M. The importance of these indicators in measuring the constructs is shown by their displayed outer loadings of 0.000. Each set of measurement indicators plays an essential role in constructing their associated constructs because their outer loading values are very high thereby validating the model's measurement procedures.

The constructed path coefficients in this framework show both the relationships strengths and directions between the individual constructs. This model demonstrates that personality shows no direct effect on metacognition because its relationship value stands at 0.000. The data between personality (PT) and anxiety levels (A) at 0.484 established a significant and moderate correlational pattern thus showing how personality affects student anxiety. The strength of relationship between anxiety and metacognition reveals a significant and positive influence as indicated by an A to M value of 0.518.

Table 3. Total Effect

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
A -> M	-0.097	-0.056	0.150	0.647	0.518
PT -> A	0.136	0.118	0.193	0.701	0.484
PT -> M	0.516	0.533	0.128	4.032	0.000

The model displays completed effects of variables upon different elements. Research findings show that PT (Personality) creates a significant positive impact on M (Metacognition) because it yields a T-value of 4.032 and a P-value of 0.000. The research indicates that metacognitive abilities of students experience a strong positive impact from their personality traits. Results show no significant relationship between personality (variable A) and metacognition (3.20) based on the T-statistics of 0.647 and P-value 0.518. The relationship between personality and metacognition stands out as significant according to the findings while other variables show negligible direct relationships thus requiring consideration in future analysis.

Table 4. Indirect Effect

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
PT -> A -> M	-0.013	-0.001	0.032	0.418	0.676

The data in the table demonstrates that PT influences M through A at a small negative level of -0.013 yet its T-statistics is 0.418 and P-value stands at 0.676. Anxiety does not play a meaningful role in connecting personality dimensions to metacognitive skills because the statistical analysis shows their mediation paths are insignificant. The minimal level of influence indicates that metacognition receives direct effects from personality rather than passing through anxiety for mediation purposes. The third cycle of analysis demonstrates that anxiety does not substantially affect the link between personality traits and metacognition. The evidence demonstrates that anxiety variables function as minimal or non-significant pathways to explain mediation effects during student math problem-solving.

Personality and Metacognition

Relevant research shows that personality variables especially open-mindedness and responsibility involve favorable correlations with metacognitive functions. Research by Tika

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(2021) demonstrated that students who demonstrate higher openness characteristics have better abilities to use innovative reflective metacognitive tactics for solving mathematics questions. These findings are consistent with the results of this study, where openness to experience is associated with improved metacognitive abilities, which in turn assists students in planning, monitoring, and evaluating their problem-solving strategies.

Caution as a personality trait displays a direct link with metacognitive ability within the educational framework of Indonesia. According to Gusnur (2021) students with higher caution levels in Surakarta demonstrated superior metacognitive approach through their strategic planning and evaluation activities than students who were less cautious. The study confirms that students who show caution use it to enhance their strategic and thorough math problem-solving techniques.

The research by Merma-Molina et al. (2022) worldwide establishes a direct link between openness to experience and critical reflective thinking capacity which makes up the essential elements of metacognition. Schmidt et al. examined German student groups and discovered that open-minded students demonstrated stronger skills for checking their learning strategy effectiveness thus leading to superior academic achievements. Research from Costa & McCrae (1992) which focuses on five-factor personality model validates these findings. Openness to experience enables people to become adaptable and creativity-oriented in their thinking enabling more effective development of complex cognitive approaches such as metacognition. Multiple further studies used this initial investigation to prove personality acts as a determining element for educational success such as metacognitive aptitude.

This research demonstrates strong consistency with existing literature but personality and metacognition show different relationships based on cultural and educational system contexts. Students in East Asian countries including South Korea and Japan demonstrate positive attitudes toward openness to experiences but this openness gets reshaped by strong social pressure and demanding academic standards in educational settings (Smith et al., 2024). A culture focusing on high competition might lead students to adopt established fruitful study methods rather than exploring unproven novelty-oriented approaches even though they remain open to experience.

Anxiety and Metacognition

Research demonstrates how anxiety creates destructive impacts on student metacognitive abilities because scientists have established anxiety as a force disrupting cognitive functioning. Research results from Yogyakarta presented by Ririn (2022) demonstrate academic anxiety is negatively related to student academic achievements when they perform math problems requiring advanced cognitive functions. Santoso et al. discovered that high-anxiety students showed poor performance in learning process planning and evaluation thus leading to their lowered academic achievements.

Beaudoin & Desrichard (2011) reported similar findings as this study showed that people with high anxiety levels displayed reduced accuracy in their memory performance assessments. Research conducted by Ikhsan (2021) demonstrates that test anxiety causes kids in Indonesia to use fewer effective metacognitive planning and evaluation methods thus resulting in diminished mathematical examination outcomes.

Research conducted by Silaj et al. (2021) verifies that anxiety strongly influences how a person monitors their cognitive processes. The research determined that people with elevated anxiety levels showed poor ability to evaluate their cognitive performance when attempting tasks demanding deep comprehension such as math problem-solving and reading complex materials.

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The study findings confirm the research results because anxiety was discovered to negatively impact students' capacity for objective math problem-solving ability assessment. The research of Culot et al. (2021) indicates that worry decreases a person's ability to track their mental processes when performing reading comprehension tests. Participants who faced high anxiety levels demonstrated below-average abilities concerning mental tracking of their reading comprehension and ended up assessing the text comprehension poorly. The study results matched these findings by showing that student metacognitive abilities experienced impairment specifically during monitoring processes and evaluation activities because of anxiety.

Numerous research outcomes display a negative metacognition-anxiety relationship but evidence exists of specific situations where anxiety leads students to adopt metacognitive strategies for stress management. According to Sulistyawati (2022) students from Surabaya who experience high anxiety levels develop increased practice of monitoring and evaluation strategies to manage academic stress. This data fails to establish a universal correlation because the study shows anxiety generally decreases metacognitive abilities. Anxiety relationships with metacognition face additional influencing factors where students' social environment together with their received support play a role. According to Balta (2018), metacognitive performance risks fewer negative effects when students receive social aid from their family members and peers. Within the educational system of Indonesia where family support usually determines student academic results social networks potentially protect against the harmful effects of student anxiety even though this research did not investigate this potential protective role.

The Interaction Between Personality and Anxiety

There were independent effects of personality and anxiety on metacognition but no significant two-factor relationship in the results. The research results demonstrate that personality fails to change the way anxiety affects metacognition in this study despite previous studies finding that personality could protect against anxiety-related problems.

Hoffman & Spatariu (2008) discovered that self-efficacy functions as a moderating factor for anxiety effects on metacognitive control since self-efficacy displays similarities with prudence in personality characteristics. An evaluation of this study reveals that self-efficacy surpasses personality when it comes to regulating the connection between anxiety levels and metacognition during mathematical problem-solving tasks.

Research conducted by Veenman et al. (2000) demonstrates that personality characteristics can regulate the way anxiety affects metacognitive assessments. The research findings indicate that personality traits and anxiety show independent patterns which do not create joint effects on metacognition processes. The study results may reflect the complex nature of these variables since external factors beyond research scope including social support and academic history possibly contribute more to relationship moderation. According to Scheibe et al. (2023) students who feel exam anxious demonstrate deficient abilities to use metacognitive control methods for comprehension tracking and learning method adaptation. The research findings stand supported along with the necessity to ascertain the overall impact of additional variables such as intrinsic motivation and extroversion that were not measured in this study.

Özcan & Eren Gümüş (2019) found in their investigation that metacognitive regulation depends on self-efficacy beliefs in people with high anxiety levels. Studies confirm that additional effects from elements surpassing personal characteristics must be accounted for to understand the complex relationships between anxiety and metacognition. The study endorses current research about personality and anxiety effects on metacognition but finds that these

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factors do not combine as anticipated. Additional research should investigate which other variables including self-efficacy and social support influence this relationship when students learn mathematics.

Explanation of Inconsistent Results

The study's results match previously documented data but some findings from this investigation show dissimilarities compared to studies particularly conducted in Indonesia. According to Kurlia (2023) students who experience high anxiety use metacognitive strategies to manage their situation. The study results differed from this research because anxiety showed a negative relationship with metacognition.

Various reasons help to explain this distinction. The study outcomes diverged because of potential influences from cultural environments as well as education systems. According to Kurlia (2023) the students in his study experienced an educational setting that potentially boosted their adoption of active coping approaches for anxiety management. Students who come from societies that provide strong social and family backing may use metacognitive strategies to handle their anxiety more motivated. In contrast, in this study, students may be in a less supportive environment, so anxiety is more likely to interfere with their metacognitive processes.

Research analysis methods adopted in these studies show differences between them. Through qualitative methods Kurlia (2023) conducts research that enables detailed study of how students interact with their anxious feelings. Qualitative research collects specific individual characteristics and unique manifestations which quantitative approaches like the SEM analysis method in this work fails to detect. Through personal interviews researchers uncover singular techniques that students make use of for coping as well as receive personal support that traditional statistics cannot show.

The research results could be affected because the samples used for this study present varying characteristics. The study population at Kurlia (2023) possibly interacted with young people who possessed better access to educational opportunities and social networks leading to improved anxiety management through effective metacognitive strategies. Students who participated in this study might belong to groups where anxiety negatively influenced their metacognitive abilities compared to participants in Kurlia (2023).

The connections between anxiety and personality together with metacognition function distinctively depending on factors such as cultural settings and research tactics and social integrity systems within the population. The contradictory research results do not demonstrate theoretical discrepancies since these findings stem from the multifaceted nature of the investigated subject. Morsanyi et al. (2019) documented decreased metacognitive regulation among people with high anxiety until they received sufficient support and resources which lead to their development of efficient coping strategies.

These inconsistent research findings demonstrate that education-related factors like education policies teaching standards and psychological aid need examination when studying metacognitive processes. Additional study must analyze what happens when education factors merge with personality characteristics while combining with anxiety to affect metacognition. Educational programs following Bellon et al. (2021) help decrease arithmetic anxiety levels by teaching metacognitive strategies thus validating targeted educational approaches as tools for anxiety reduction and better metacognitive outcomes. The study contributes additional knowledge to our comprehension of personality and anxiety effects on metacognition within Indonesian mathematics education despite certain different results from prior studies. The

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inconsistent research findings underline the necessity of conducting additional scientific studies that explore diverse environmental elements and methodological elements together with intervention strategies for student-specific support. University researchers should employ flexible educational strategies because approaches that succeed with one student population fail to address others effectively.

Conclusion

Metacognitive awareness and FFM personality traits in combination with anxiety levels established themselves as fundamental elements affecting mathematical problem-solving performance in students. The research verifies that students who possess strong metacognitive abilities demonstrate superior mathematical problem-solving results because they effectively manage their strategic planning and evaluation and monitoring steps. Relevant personality aspects like openness to experience together with conscientiousness demonstrate positive relationships with metacognitive abilities which enhances students' ability to think strategically and reflectively. Study results demonstrate anxiety generates negative effects on metacognitive processes because high anxiety inhibits students' cognitive activity regulation leading to worse mathematical outcomes. The research demonstrates that despite the significant variables relationships personality and anxiety work independently to affect metacognition because no significant moderation effect emerged between them. This evidence indicates that both traits and anxiety affect metacognition independently but through separate mechanisms of influence. The research results emphasize that educational environments should develop metacognitive abilities while controlling anxiety because they enhance mathematical achievements for students. Strategies that develop metacognitive understanding together with strategies to lower student anxiety provide great potential benefit. Educational strategies built on individual differences show promise to maximize learning results since personality traits influence metacognitive abilities.

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