The Influence of Working Memory Capacity and Mathematical Anxiety on the Creative Reasoning of Prospective Mathematics Teachers

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Abstract: This study examines the impact of working memory capacity and mathematics anxiety on the creative reasoning of prospective mathematics teachers, highlighting how these cognitive factors shape problem-solving processes. This research used a mixed-method sequence explanatory method with a sample size of 60 people for quantitative research, and four people were selected with high working memory capacity and different levels of anxiety. The quantitative phase employed multiple linear regression to assess the impact of working memory and anxiety on creative reasoning. The qualitative phase involved thematic analysis of problem-solving approaches among selected participants. To validate the consistency of the findings, the researcher uses the time triangulation method. It was found that working memory capacity and mathematics anxiety influenced the creative reasoning of prospective mathematics teachers in solving problems. Prospective mathematics teachers with high working memory capacity demonstrate flexibility and fluency in generating new ideas, can connect known mathematical concepts and provide logical arguments to support the truth of the ideas created. However, high and low levels of mathematics anxiety interfere with cognitive performance, causing a loss of focus in solving more complex problems and not providing arguments for the ideas created.

Keywords: Working memory capacity, creative reasoning, mathematics anxiety, problem solving

INTRODUCTION

A person will think and plan solutions based on mathematical concepts when facing a problem. Planning the solution leads to a process of creativity in reasoning. Planning the solution leads to a process of creativity in reasoning. Reasoning is part of mathematical thinking (T. Bergqvist & Lithner, 2005). Reasoning can be categorized as creative reasoning if the person creates their thoughts or recreates the strategies, not just remembering the procedures (Schwarz et al., 2010). Creative reasoning and logical argumentation are important parts of solving mathematical problems, leading students to build their solutions and thus benefit their learning (Olsson & Teledahl, 2017). According to several expert opinions, creative reasoning is defined in this research as a mental activity that produces original thoughts accompanied by logical arguments and supported by the accuracy of the mathematical concepts used.

Creative reasoning plays a vital role in solving non-routine problems because a complete solution scheme is unavailable, and the problem solver must construct at least part of the reasoning (Lithner, 2008). Problems, in this case, are defined as complex tasks for the individual who solves them (Schoenfeld, 1992). This difficulty is a deadlock in thinking about creating a solution. If someone has a way to complete a particular math task, then the task becomes an exercise and no longer a problem. So far, students have tended to use memorization strategies when faced with tasks that require a lower cognitive level (T. Bergqvist & Lithner, 2005). So, they are not used to new problems that require higher thinking because they lack sufficient knowledge to solve them. In contrast, tasks emphasizing creative reasoning problems can lead to higher levels of mathematical competence (Jonsson et al., 2014). Thus, to foster creative reasoning in a person, it is necessary to get used to completing non-routine problem-oriented tasks.

The importance of understanding mathematical concepts means that creative reasoning is considered practical reasoning in solving mathematical problems. Creative reasoning is more efficient than algorithmic reasoning for completing specific tasks (Lithner (2008). However, in reality, students are rarely directed towards learning mathematics, which is oriented towards creative reasoning; they are more often taught using algorithmic reasoning in solving problems. The cognitive domain is related to problem-solving, a set of skills essential for everyday life as well as other areas, including science and technology, and the attention to individual differences and the provocations during the challenging and alternative phase stimulates the emergence of new ideas that contribute to the improvement of individuals' mathematical creativity (Shodiq et al., 2023). Problem-solving is doing non-routine tasks where the solver does not know the previously learned scheme designed to solve it (Hasan et al., 2024). So, it impacts students' reasoning development. Analysis of this gap reveals that creative reasoning is often not directly integrated into current mathematics education curricula, highlighting discrepancies between research findings and daily learning practices in universities and schools. Educators of prospective mathematics teachers should consider encouraging these prospective mathematics teachers to enable students to engage in volition-enabling prompts through problem-solving, which is a central component of mathematics teaching (Hasan et al., 2024).

Although creative reasoning research has covered many aspects, some areas are under-discussed or require further exploration. Creative reasoning research covers a lot about how the creative reasoning process occurs, how creative reasoning and imitative reasoning work, and the framework of creative reasoning itself. Based on this, further studies are needed on how cognitive and affective factors influence creative reasoning and how the reasoning process occurs.

It is also important to examine the creative reasoning abilities of prospective mathematics teachers in the affective domain because factors in this domain also influence students' mathematics learning. The affective domain includes students' moods and feelings (*anxiety, self-confidence, and satisfaction in completing mathematics assignments*), the atmosphere where the learning process occurs, and individual aspects of the students themselves (Hembree, 2015). Anxiety causes students to have negative perceptions of mathematics, making them more likely to feel like they cannot succeed in mathematics. Students feel unable to solve problems and come up with ideas or solutions.

Research on creative reasoning is an important research trend in education because it can provide insight into practical ways to develop creative thinking skills among students as prospective mathematics teachers. At the same time, in the curriculum and teaching methodology, this study's results can help design learning plans to support and encourage creativity. Research on creative reasoning can also help explain how the creative process occurs in individuals and groups, including analysis of factors that influence creativity, such as environment, motivation, and collaboration in problem solving.

This research aims to see the impact of creative reasoning and mathematics anxiety on creative reasoning. It is important to study creative reasoning because it is needed to develop higher thinking skills. Creative reasoning is also related to how much information or knowledge a person has in working memory. Besides that, some affective factors can hinder a person's cognitive performance.

LITERATURE REVIEW

Creative Reasoning

Creative reasoning is a thinking process that fulfills the criteria of novelty, plausibility, mathematical foundation (Lithner, 2008). This means that creative reasoning is a thinking process to create new strategies accompanied by logical arguments based on the intrinsic mathematical properties of the components involved in reasoning. According to Schwarz et al., (2010) creative reasoning is an activity that involves creating ideas, strategies, and concepts to solve problems accompanied by arguments. It refers to using a different approach to completing a task (E. Bergqvist, 2007). It can also be interpreted as concluding with new ideas and logical arguments. These arguments support the truth of what has been concluded or a new idea that has been used.

Creative Reasoning Indicators	Indicators of Creative Reasoning in Problem Solving
Novelty	Develop new ideas or strategies for solving problems.
Plausibility	Build predictive and verifiable arguments about new ideas or strategies.
Mathematical foundation	1. Use problem-solving strategies based on the relevant intrinsic properties of mathematics 2. Provide logical arguments for the intrinsic properties of

	mathematics used in solving problems

Table 1: Indicators of Creative Reasoning in Problem Solving

Based on Table 1. Lithner (2008) developed a framework for understanding creative reasoning in problem-solving, especially in the context of mathematics. The three main indicators identified are novelty, plausibility, and mathematical foundation. These indicators of creative reasoning interact with each other and contribute to effective mathematical problem-solving. In this case, novelty is defined as the novelty of an idea, either by choosing a strategy or using a strategy in solving problems. The novelty here can be shown by ideas, concepts or procedures in solving problems. Plausibility is defined as the accuracy of the arguments used to support the selection of strategies and/or implementation of strategies in solving problems. In this way, individuals explain selecting strategies and/or using strategies in solving mathematical problems. Mathematical foundation is the accuracy of selecting mathematical concepts to solve problems. Individuals select and use appropriate mathematical concepts to use in solving problems.

Problem-solving in mathematics education became a keyword in creative reasoning research in the 1980s. Research has centered on problem-solving aspects, such as the activities and competencies required for constructive problem-solving (Schoenfeld, 1992). Mathematics problem solving not only encourages students to apply their understanding but also have the potential to form a deep understanding to improve their mathematical competency (Putri et al., 2023). The accompaniment of reasonable arguments and a mathematical basis characterizes creative reasoning in problem-solving (Lithner, 2008). Its quality is typified by the novelty of ideas and reasonable reasons. Creative reasoning especially has a prominent role in non-routine problem-solving (Lithner, 2006). Non-routine math problems cannot be solved by simply applying routine steps or mathematical formulas previously studied. They do not have a unique algorithm, so they require strategic thinking (Khusna et al., 2024). In non-routine problems, solutions are not always evident or immediately apparent. Solving these problems may involve exploring various approaches, in-depth use of logic and mathematical reasoning, and creative reasoning analysis. According to Wang & Chiew (2010) problem-solving is a cognitive process of the brain that involves finding solutions to a given problem or a way to achieve a specific goal. The cognitive process is the stage in reasoning whose goal is to achieve knowledge. It consists of mental activities of remembering and manipulating information to solve problems, including mathematical problems, accompanied by logical arguments. Effective information processing is required to achieve success in problem-solving. This process is closely related to working memory capacity (WMC).

Working Memory Capacity (WMC)

Research on working memory capacity (WMC) has been conducted since the 19th century. Working memory is a theoretical construct that has come to be used in cognitive psychology to refer to the system or mechanism underlying the maintenance of task-relevant information during a cognitive task (Baddeley & Hitch, 1994). It is a contemporary term for the cognitive resources used to carry out mental operations and remember the results of those operations for a short period (Stillman, 1996). It is a cognitive system that temporarily stores and manipulates information in our minds. It involves three main components: verbal storage related to words and facts, visual-spatial storage related to images and objects in space, and executive control to regulate attention and mental processes.

Working memory has a very limited duration and capacity (Cowan et al., 2004). Working memory limitations as a potential barrier to effective information processing in problem-solving. Not all information that a person receives is permanently stored in working memory. During the problem solving process, a person must gather information that helps in understanding the problem at hand, engage in problem comprehension, evaluate the relevance of the information to the specific problem at hand, and process the information to develop an appropriate solution strategy. Successful problem solving depends on the effective execution of these cognitive processes, which are consistently related to working memory capacity. Working memory capacity is essential for a variety of cognitive processes, including mathematical problem solving (Wiley & Jarosz, 2012). This highlights the importance of working memory capacity in facilitating a variety of cognitive functions including creative reasoning in problem solving, thereby increasing the understanding of the cognitive mechanisms involved in performing creative reasoning tasks.

Working memory has components responsible for storing and processing information; according to Baddeley and Hitch (1994), the components in question are the central executive, the phonological loop, and the visuospatial sketchpad. The central executive components determine topics that require more attention, topics that should be ignored, and what should be done if there is a disturbance (Holyoak, 2005). The phonological loop is repeating auditory information so that the information does not fade from working memory before it is finished being (Baddeley & Hitch, 1994). The visuospatial sketchpad component maintains visual and spatial information in a limited time, for example, remembering moving objects' shape, size and direction, allowing someone to manipulate the background or scene in mental activities (Baddeley & Hitch, 1994). Next, Baddeley discovered an additional component whose task was related to interaction with long-term memory, namely the episodic buffer. Baddeley and Hitch (1994) added an episodic buffer component to the multicomponent model of working memory.

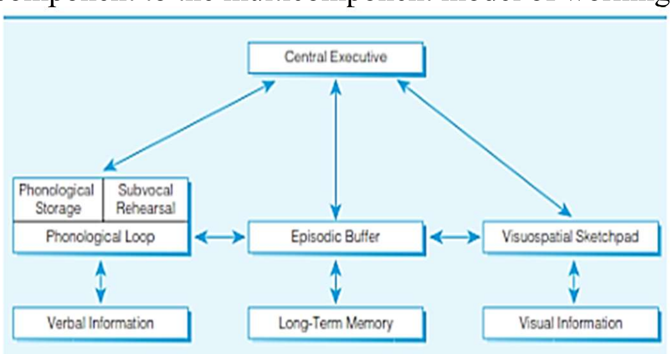

Figure 1: Multicomponent model of working memory

Research on working memory capacity sheds light on how working memory operates, what can be stored in it, and the extent of its limitations, helping us understand human limitations in simultaneous information processing or multitasking. By recognizing the limits of working memory capacity, this research provides a basis for developing strategies to improve cognitive abilities, allowing us to optimize performance in memory-based tasks using various techniques. Knowledge of working memory capacity is also important in educational contexts, where teachers and educators find it helpful in designing learning methods that suit the human ability to store and process information effectively in short-term memory.

Working memory capacity significantly impacts various cognitive processes, including mathematical problem-solving (Wiley & Jarosz, 2012). It can be measured using working memory span tasks, where people are requested to focus on two tasks simultaneously. As tasks compete for working memory resources, people with a smaller working memory capacity will show a performance deficit on a single task, if not two, while people with a higher working memory capacity will show a smaller deficit in performance. Engle (2004) States that working memory capacity is critical in supporting cognitive abilities in understanding, reasoning, and solving problems. He also found that working memory capacity differs for every individual. Using two different groups of students. Chamandar et al. (2019) found that the group with low mathematical achievements performed significantly worse on inhibition and working memory than the group with high mathematical achievements. Differences in working memory capacity impact cognitive performance when an individual reuses the information needed to solve problems. Working memory capacity positively influences creative reasoning in mathematics by enabling individuals to manage and manipulate multiple pieces of information simultaneously (Hasan & Juniati, 2025). This capacity allows prospective mathematics teachers to think flexibly and fluently, generate diverse solutions, and develop logical arguments grounded in correct mathematical concepts. High working memory enables the use of novel ideas and supports the cognitive processes necessary for effective problem-solving and creative reasoning. According to Lerik (2016), working memory capacity affects both how many items can remain working at one point in time and the type of strategy used when someone is working on a task.

Mathematics Anxiety

Lai et al. (2015) define mathematics anxiety as a feeling of tension and anxiety that interferes with a person's ability to process numbers and solve math problems in a variety of everyday and academic situations. Mathematics anxiety can reflect anxiety that occurs in test situations as well as anxiety related to everyday life, related to math. Mathematics anxiety makes it difficult for a person to concentrate when facing math-related problems. As a result, math problems that are usually easy for him can become difficult because of excessive math anxiety. Lai et al. (2015) also said that someone who experiences math anxiety often shows lower performance in math lessons. They may feel too stressed to function well, which negatively affects their ability to solve math problems.

Mathematics anxiety can hurt mathematical problem-solving. Not only does it cause cognitive deficits, but it also evokes a physiological reaction (Strohmaier et al., 2020). Anxiety can interfere with students' thinking and concentration when they are trying to solve math problems. Anxious students may have difficulty processing information correctly, understanding math concepts, or remembering previously learned strategies. Math anxiety causes decreased academic performance on math tasks, preventing students from achieving good results in the learning process (García-Santillán et al., 2016). These anxious students may make more mistakes, complete assignments more slowly, or have difficulty seeing important patterns and relations in problems. They may feel they are not intelligent or intellectually competent when learning mathematical concepts and skills. The effects of math anxiety are visible in the processes of calculations, operations, and procedures. Anxiety-related disorders may affect an individual's ability to understand and work with numbers (Ashcraft & Kirk, 2001). Mathematics anxiety has a significant negative impact on mathematics achievement, where the higher the level of anxiety, the lower the mathematics achievement achieved (Juniati & Budayasa, 2020a). This study shows that prospective mathematics teachers who experience high anxiety tend to have low mathematics abilities. These impacts are interrelated and can form a negative cycle where anxiety causes low achievement, low achievement further increases anxiety, and so on. Therefore, it is important to address this anxiety in order to improve mathematics achievement and reduce its negative impacts and provide emotional support so that students feel comfortable in learning and solving mathematics problems.

There has been much research related to mathematics anxiety. Wu et al. (2012), Georges et al. (2016), and Juniati and Budayasa (2020) all show a negative influence of math anxiety on math skills and math performance. Meanwhile, İbrahimoğlu (2018) showed a significant positive relationship between mathematics anxiety and learning helplessness. In addition, self-efficacy and mathematics anxiety have been found to play a role in prospective mathematics teachers' problem-solving abilities (Georges et al., 2016). Mathematics anxiety can obscure a person's cognitive ability to solve problems. This happens because of feelings of fear, doubt, and tension when solving problems. In addition, the relationship between working memory, mathematics anxiety, and mathematics learning achievement has also been extensively studied. However, research specifically examining the effect of different levels of working memory capacity and mathematics anxiety is rare.

Furthermore, a study on the creative reasoning of prospective mathematics teachers as a basis for teaching mathematics is needed. Creative reasoning is essential for prospective mathematics teachers' understanding of mathematics material and fosters students' reasoning. When entering teacher education institutions, prospective mathematics teachers hold several beliefs about mathematics, teaching and learning, the goals of teaching, and their ability to teach mathematics (Ball et al., 2005). Someone who has low math anxiety is more successful in solving geometry problems compared to someone with higher math anxiety, and someone with excessive levels of mathematics anxiety can hinder their performance in solving geometric problems (Wahyuni et al., 2024). These are aspects that prospective mathematics teachers must apply in mathematics teaching. This research is focused on examining in depth how a person's creative reasoning process in solving mathematical problems will vary with differences in the levels of working memory capacity and mathematics anxiety.

Theoretical Framework

Researchers use a theoretical framework for their research, which is interrelated between creative reasoning, working memory capacity, mathematics anxiety, and problem-solving.

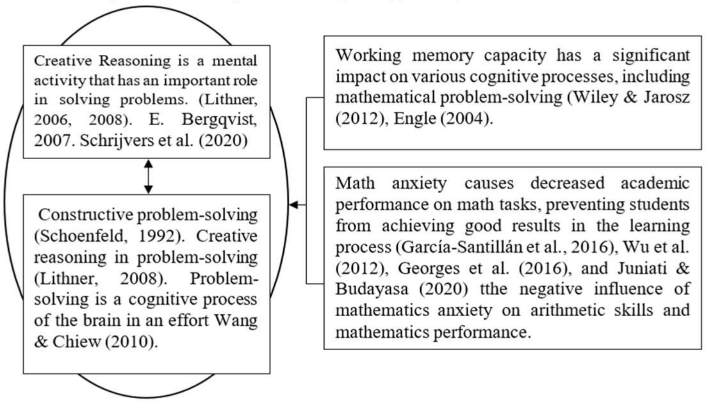

Figure 2: Theoretical Framework

Based on Figure 2. Theoretical Framework is a relationship between theories that form the basis of research and strengthen research findings. Experts have researched and studied creative reasoning as a mental activity related to the cognitive domain. This mental activity plays a role in solving mathematical problems. The problem-solving process is also inseparable from the role of working memory capacity, which shows the amount of information needed when solving a problem. On the other hand, some predictors can inhibit cognitive performance, namely the affective domain, which is related to mathematics anxiety. This theoretical basis strengthens researchers' ability to develop studies related to the creative reasoning of prospective mathematics teachers in solving problems.

METHOD

This research uses a mixed-method sequential explanatory design. Quantitative methods were used to determine the effect of working memory capacity and mathematics anxiety on creative reasoning. Qualitative methods were used to examine the creative reasoning process of prospective mathematics teachers with high working memory capacity and different levels of mathematics anxiety problem-solving.

Sample and Data Collection

In this research, a sample was selected by cluster random sampling. The sample consisted of two clusters, one comprising second-year students and the other comprising third-year students. From each cluster, one class was randomly selected. Sixty prospective mathematics teachers were selected as subjects for this research. The sample was given the OSPAN Task as a working memory capacity and mathematics anxiety test instrument. Then, it was grouped based on working memory capacity and level of math anxiety. Working memory capacity test scores and math anxiety test scores are independent variables. In this study, several data collection instruments were used. The Operation Span Task (OSPAN Task) measured working memory capacity. It assessed a subject's ability to focus on two tasks at once. The OSPAN Task was adapted from Turner and Engle (1989) and can be seen in Juniati and Budayasa (2020). The sample was given a mathematical operation task and asked to remember numbers simultaneously. Next, the sample was given a mathematics anxiety test questionnaire to categorize the sample. The mathematics anxiety test instrument was developed and adapted from Juniati and Budayasa (2020). The mathematics anxiety test instrument consists of 15 questions about the sample's condition and feelings towards mathematics.

Participants= 60		Working Memory Capacity	
		High	Low
Mathematics Anxiety	High	14	12
	Low	14	20

Table 2: Subject Selection Process

From Table 2. It is explained that the samples were grouped based on OSPAN test scores and mathematics anxiety. The OSPAN test results were obtained by 28 prospective mathematics teachers with high working memory capacity; the remaining 32 were included in the category with low working memory capacity. Researchers only took samples of prospective mathematics teachers with high working memory capacity for further analysis of their creative reasoning because creative reasoning requires high-level thinking. Of the 28 prospective mathematics teachers with high working memory capacity, they were then given an anxiety questionnaire, and it was found that 14 prospective teachers had high mathematics anxiety and 14 prospective teachers had low mathematics anxiety.

Data on creative reasoning in problem-solving were collected using a problem-solving test instrument. This instrument contains mathematics questions on plane geometry. Problem-solving tasks are developed based on indicators of creative reasoning, namely novelty, plausibility and mathematical foundation. Before being used, the problem-solving task instrument was validated by two validators who were experts in the material and problem-solving tasks. The following are the problem-solving tasks used in this research.

Make a non-rectangle land plan covering an area of 168m^2 with a plan of the house that will be built on the land. The house plan requirements must have three bedrooms with a minimum size of 3x3 meters, one living room with a minimum area of 20m^2, one family room with a maximum area of 25m^2, one kitchen with a minimum area of 12m^2, two bathrooms with a minimum size of minimum 2x2 meters, one car garage with a minimum area of 20m^2 and garden with a minimum area of 44m^2. Make a plan of the house. Explain your answer!

The mathematical problem-solving test developed with creative reasoning indicators is used to measure the creative reasoning performance of prospective mathematics teachers as the dependent variable. The qualitative research method involved 4 out of 60 participants as subjects. Consisting of three subjects with high working memory capacity with high mathematics anxiety and three subjects with high working memory capacity with low mathematics anxiety. Researchers used data from answers to problem-solving tasks made by the subjects, then conducted more in-depth interviews to confirm the consistency of the answers and obtain in-depth information.

Data Analysis

This study assessed working memory capacity using the OSPAN test instrument. In this test, participants were asked to remember numbers displayed for four seconds, during which participants were also asked to perform certain calculations. Upon completing the task, participants are allotted ten seconds to accurately recall and write down all the numbers they were instructed to remember. The working memory capacity score is derived by summing the number of digits recalled in the correct order, with a criterion that the percentage of correct responses for the operations must be at least 80%. The working memory capacity score ranges from 0 to 100. This study employs the quartile separation technique outlined by Conway et al. (1942). About the OSPAN test. While the instrument utilized is similar to existing tools, it features minor variations in the operations and numbers to be retained. The validity of the working memory assessment instrument is evaluated through content validity, which involves expert review to ascertain whether the instrument effectively measures its intended construct.

Additionally, the problem-solving test assesses creative reasoning by presenting participants with three non-routine questions. An assessment rubric evaluates the creativity level demonstrated in each response. The scoring for this test ranges from 0 to 80, with the final score calculated by dividing the total score obtained by the maximum possible score and multiplying by 100. Subsequently, the working memory capacity score serves as the dependent variable. In contrast, the creative reasoning score in problem-solving is treated as the independent variable, and both are analyzed using multiple linear regression analysis.

The data obtained were validated using the triangulation method by re-administering the problem-solving test at a different time to assess the consistency of the answers given by the subjects. The validated data were then analyzed. Qualitative data were analyzed in three stages: data presentation, reduction, and conclusion drawing. First, data from the participants' work and interviews were presented and grouped to consider their suitability. Then, these data were sorted and reduced, where data containing information relevant to the indicators of creative reasoning were used. Finally, conclusions were drawn based on the validity of the data obtained, which was in line with indicators of creative reasoning and the formulated research problems and objectives.

RESULTS

The research findings outline the results of both quantitative and qualitative analysis. Quantitative data was analyzed through multiple linear regression tests to investigate how working memory capacity and mathematics anxiety affect the creative reasoning abilities of prospective mathematics teachers.

Multiple R	R-Square	Adjusted R-Squared	Standard Error	Observations
0.4586	0.2103	0.1826	25.9806	60

Table 3: Summary of Multiple Linear Regression Test Results

Based on Table 3

Multiple R is 0.4586. Thus, this regression test shows a relationship between the independent variables (working memory capacity and mathematics anxiety) and the dependent variable (creative reasoning). An R^2 value of 0.21 suggests that while working memory capacity and mathematics anxiety contribute to creative reasoning, other unmeasured factors may also play a role. Future studies should explore additional cognitive and environmental influences. This shows that the influence of working memory capacity and mathematics anxiety on the creative reasoning performance of prospective mathematics teachers in solving mathematics problems is low. Meanwhile, the R-squared value of 0.1826 shows that about 18.26% of the variability in the dependent variable can be attributed to the independent variable, in the sense that around 18% of the variance in creative reasoning of prospective mathematics teachers in problem-solving is influenced by working memory capacity and mathematics anxiety.

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	10243.89	5121.944	7.588174	0.001197
Residual	57	38474.45	674.9903		
Total	59	48718.33			

Table 4: ANOVA Results on Creative Reasoning, Working Memory Capacity, and Mathematics Anxiety

Based on Table 4

Researchers used analysis of variance (ANOVA) as a statistical technique to determine whether the overall regression model is significant in explaining data variations. Table 4 shows that the multiple linear regression had 57 degrees of freedom (df) associated with residuals. This is the number of observations minus the number of predictors and one (n - k - 1), where n is the total observations and k is the number of predictors. Total degrees of freedom are equivalent to the total observations minus one (*n-1*). The regression sum of squares (SS) was 10243.89, the residual SS was 38474.45, and the total SS was 48718.33. The mean square (MS) was the result of dividing SS by the degrees of freedom (*df*) of each component. This analysis obtained an F-value of 7.5881 and a significance value of 0.0012. This value indicates the level of significance of the results of the ANOVA analysis, which shows strong statistical evidence to reject the null hypothesis (*which states that there is no relationship between the dependent and independent variables*). So, it can be concluded that there is a significant relationship between the independent and dependent variables based on the results of the ANOVA analysis Because the significance value was smaller than the alpha level (0.05). This means that working memory capacity and mathematics anxiety significantly influenced the creative reasoning of prospective mathematics teachers in solving mathematical problems. The regression model can explain a certain proportion of variance even though the previous Adjusted R-squared reflects only around 18% of the variance the predictor explains. However, a significant influence is still identified through the F test.

	Coefficients	*Std. Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-3.48674	26.16609	-0.13325	.894462	-55.8834	48.90994
WMC (X_1)	0.6309	0.168241	3.74997	0.000416	0.294003	0.967798
Anxiety (X_2)	0.336843	0.339391	0.992493	0.325152	-0.34278	1.016461

Table 5: Coefficients of Creative Reasoning, Working Memory Capacity, and Mathematics Anxiety

Based on Table 5

Intercept Value: -3.4867. This is the predicted value of the dependent variable when all independent variables (X_1 and X_2) are equal to zero. X_1=0.6309. This means that every one-unit increase in X_1 is expected to increase the value of the dependent variable by 0.6309, assuming X_1 remains constant. X_2 value: 0.3368. This means that each one-unit increase in X_2 is expected to increase the value of the dependent variable by 0.3368, assuming X_2 remains constant. Standard Error: This is a measure of uncertainty in the coefficient estimates. Intercept Value: 26.1661. This figure shows that there is high uncertainty in the intercept estimate. X_1 value: 0.1682, a smaller standard error indicates that the estimated coefficient X_1 is more stable; the value of X_2: 0.3393, and a larger standard error of X_1 indicates greater uncertainty in the estimated coefficient X_2.

This is the t statistic used to test the significance of coefficients, which is calculated by dividing the coefficient by the standard error Intercept value: -0.1333. This value is close to zero, indicating that the intercept is not statistically significant. X_1=3.7499, which shows that the coefficient X_1 is statistically significant. X_2=0.9925. This value is also close to zero, indicating that X_2 is not statistically significant. P-value: This is the probability that the coefficient under test equals zero. Intercepts: 0.8945. This indicates that the intercept is not significant at the 0.05 level. X_1=0.0004 shows that X1 is very significant ($p < 0.05$). X_2=0.3252, which shows that X_2 is not statistically significant. These are the 95% confidence intervals for the coefficients. Intercept, the confidence interval (-55.8834, 48.9099) shows that cannot reject the hypothesis that the actual intercept can vary widely, including a large negative probability. The confidence interval X_1=(0.2799, 0.9289) shows that we are very confident that X_1 has a significant positive influence on the dependent variable, and the confidence interval X_2 = (-0.294, 0.3428) indicates that we cannot conclude that X_2 has a significant effect. In the regression model, Y=-3.48674+.6309X_1+.336843X_2. If X_1=0 and X_2=0, Y=-3.48674; if X had a positive value of 1, Y=-3.70379+ 6309+336843. The greater the value of X, the greater the value of Y. In other words, the higher a person's working memory capacity, the higher his or her level of reasoning.

Creative reasoning of prospective teachers with high working memory capacity and high mathematics anxiety

Subjects with high working memory capacity and high math anxiety were able to solve a problem well. The subject (Aina=Pseudonym) made an answer by carrying out calculations using the concept of the area of a flat shape to obtain an angled trapezoid as the shape of the flat shape requested in the question. Aina also gave varied answers accompanied by logical arguments to support the answers she made. After carrying out calculations using the area of a trapezoid, the area obtained is $168m^2$, This means that the flat shape meets the requirements of the question, which asks to make a ground plan in the form of a flat shape, not a rectangle, with an area of $168m^2$.

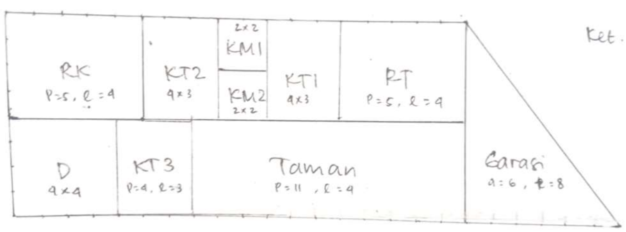

Figure 3: A Sketch by A High-Working-Memory-Capacity, High-Mathematics-Anxiety Subject

Figure 3

Aina is a category of subjects with high working memory capacity, and she has high math anxiety. Aina completed the assignment by sketching. She was confident he could complete the task because it was supported by knowledge of the area of flat shapes. Using the area formula, Aina succeeded in creating a non-rectangular shape as a trapezoid with an area of $168m^2$. The trapezoid has a height of 8 meters and a base length of 24 meters, a peak length of 18 meters, and a slanted side length of 10 meters. The area of the trapezoid is obtained.

$L = (AB + DC)/2.t = (24 + 18)/2 = 168m^2$.

Interview	Question and answers	Indicator	Coding
Researcher	Where can you make this flat trapezoid shape?		

Aina's	I used the **formula for the area of a trapezoid** so that an area of 168 m2 was obtained, thus **fulfilling the requirements**	formula for the area of a trapezoid	Mathematic Foundation (Fm)
		fulfilling the requirements	Plausibility (P)
Researcher	What was your initial idea to get the flat trapezoid shape?		
Aina's	I **made a sketch using side length calculation analysis** and **obtained a size that corresponds to an area of 168 m2**	made a sketch	Novelty (N)
		using side length calculation analysis,	Novelty (N)
		a size that corresponds to an area of 168 m2	Plausibility (P)
Researcher	Can it be made with other flat shapes?		
Aina's	Of **course, you can**, as long as we are careful in what we do	course you can	Novelty (N)

Table 6. Excerpts From Interviews With Subjects With High WMC And High Math Anxiety

Table 6

Based on Aina's work and interview (Table 6), the garage is triangular, with a base length of *6* meters and a height of 8 meters, so the area is $24m^2$, Which exceeds the minimum limit of the provisions. The park is rectangular, with a length of 11 meters and a width of 4 meters, so the area is $44m^2$, Which means it meets the minimum requirements. Next, the living room is rectangular, with a length of 5 meters and a width of 4 meters, so the area is $20m^2$. This area meets the minimum requirements. The family room is rectangular, with a length of 5 meters and a width of 4 meters.

Furthermore, the kitchen is square, with a side of 4 meters, so the area is $16m^2$, Which meets the provisions. Then, three bedrooms are rectangular with a length of 4 meters and a width of 3 meters. Each bedroom area meets the requirements. Moreover, there are two bathrooms in a square shape with a side of 2 meters, which means the area of the bathroom meets the requirements. Next, the researcher confirmed in depth with Aina regarding the answers that had been made. The following is an excerpt from the interview with Aina.

Interview	Question and answers	Indicator	Coding
Researcher	In your opinion, is your answer correct?		
Aina's	That is right, Sir. I sketched an angled "trapezoid of **the appropriate size."**	Trapezoid with the appropriate size	Mathematical Foundation (Fm)
Researcher	Try to explain this picture, especially the bathroom; where does the entrance come from?		

Aina's	Oh no, Sir, I **did not think that far**; what I thought was as long as the area was the same as the problem.	I did not think that far	Anxiety (Ax)
Researcher	Also, where are the doors to the family room and kitchen? Can you explain		
Aina's	It meets the requirements in terms of size, but I **misplaced the position** of each room, so there are rooms that **cannot be passed through**, and the floor plan is **not structured correctly**, Sir.	It cannot be passed through	Plausibility (P)
		not structured	Anxiety (Ax)
Researcher	Why?		
Aina's	My thoughts were not there; **this problem presented a challenge**. Initially, I was asked to make a flat shape, not a rectangle, but the area had to be 1682.. This is what makes me **think higher and be less sure.**	this problem presented a challenge	Anxiety (Ax)
		Think higher and be less sure.	Anxiety (Ax)

Table 7: Excerpts From Interviews With Subjects With High Working Memory Capacity And High Math Anxiety

Based on Table 7

Aina has sketched a non-rectangular flat shape with an area of $168m^2$ in the shape of a right-angled trapezoid. Then, using mathematical concepts in the form of areas of squares and rectangles, he created the space required in the problem according to his initial knowledge of mathematical concepts. All rooms created have met the requirements. After confirmation, Aina felt that the position of the room was not suitable. The first is the bathroom; the bathrooms are positioned in a row, so he forgot to make an entrance to the bathroom. Aina confirmed that the work on the questions did not focus on the details of the room; she only paid attention to the requirements for the number and area of the room requested. Likewise, the size of the family room and kitchen is appropriate. Aina's does not provide road access to these rooms.

Creative Reasoning of Prospective Teachers With High Working Memory Capacity and Low Mathematics Anxiety

Subjects with high working memory capacity and low math anxiety were able to solve a problem. The subjects gave varied answers accompanied by logical arguments to support the answers. One such subject is (pseudonym). Indah made a house plan based on the information in the problem-solving task. Indah sketched a plot of land measuring $168m^2$ in the shape of not a rectangle but an angled trapezoid.

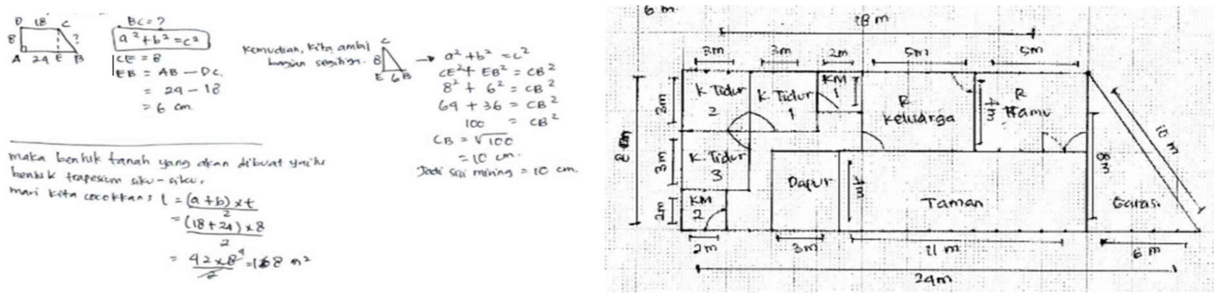

Figure 4: A Sketch by A High-Working-Memory-Capacity, High-Mathematics-Anxiety Subject
Figure 4
Indah completes assignments by making sketches. At first, he was not sure he could complete the task because he had to make a flat shape, not a rectangle, with an area of $168m^2$. After he tried many times to sketch a flat shape with an area of $168m^2$ he finally got a flat shape in the form of an angled trapezoid. The height of the trapezoid was eight meters, the base was 24 meters long, the top was 18 meters long, and the hypotenuse was 10 meters long. Indah divided the trapezoid ABCD into two parts: a rectangle AECD, with AD 8 and AE = 18 meters and correct CEB, with $EB = AB = 24 - 18 = 6$ and AC = 8. Using the Pythagorean theorem formula, the hypotenuse BC was 10. Indah calculated the area of the shape using the formula for the area of an angled trapezoid. $AB = 24, DC = 18$, and $AD = 8$; Using the formula for the area of an angled trapezoid, we obtain the area of the $trapezoidL = (AB + DC)/2.t = (24 + 18)/2.8 = 168$

Interview	Question and answers	Indicator	Coding
Researcher	How will you complete this task?		
Indah's	At first, "**I was not sure I could finish"** because the area had been determined and was not a rectangle.	I was not sure I could finish	Anxiety (Ax)
Researcher	You are making a plan in the shape of an angled trapezoid; why is that?		
Indah's	After trying to "**sketch"** with **"uncertainty"**, I finally found **a non-rectangular flannel bold 1 bold 6 bold 8, bold italic m bold 2,** namely a "**right-angled trapezoid."**	Sketch, right-angled trapezoid	Novelty (N)
		uncertainty	Anxiety (Ax)
		a non-rectangular flat shape with an area of 168	Plausibility (P)
Researcher	Apart from an angled trapezoid, are any other shapes that can be made but still meet the task requirements?		
Indah's	There could be, "**but it would take a long time to think about it."**	but it would take a long time to think about it	Anxiety (Ax)

Table 7. Excerpts From Interviews With Subjects With High Working Memory Capacity And Low Math Anxiety

Table 7

Based on the results of Indah's work and direct confirmation through interviews with the subject. Even though you feel anxious, you are unsure you can complete the task. Indah tried several times by sketching a flat shape with an area of $168m^2$. This sketch obtains a flat figure in the form of a trapezoid with an area of $168m^2$. Indah's next step was to make part of the room according to the provisions in the question. Indah made three bedrooms in the same area, namely. $9m^2$; The room size of these rooms met the requirements in the question; then, Indah made two bathrooms the same size as requested ($4m^2$), one living room with an area of $15m^2$, family room with an area of $15m^2$, kitchen with an area of $9m^2$, garden with an area of $44m^2$ and garage with an area of $24m^2$.

Next, the researcher confirmed in depth with Indah regarding the answers that had been made. The following is an excerpt from the interview with Indah.

Interview	Question and answers	Indicator	Coding
Researcher	In your opinion, is your answer correct?		
Indah's	That is right, Sir. I sketched an angled "trapezoid of **the appropriate size."**	Trapezoid with the appropriate size	Mathematical Foundation (Fm)
Researcher	Pay attention to the position of the three bedrooms you drew!		
Indah's	Yes, Sir, it is **the right size**, but I am **confused**" about where to position it.	the right size	Mathematical Foundation (Fm)
		Confused	Anxiety (Ax)
Researcher	Pay attention to the position of the three bedrooms that you drew! Where is the door to bedroom 2?		
Indah's	I was initially confused about where to place the three bedrooms. The important thing is that they are the correct size**. It turns out that bedroom two logically does not have an entrance.**	It turns out that bedroom two logically does not have an entrance	Plausibility (P)

Table 8: Excerpts From Interviews With Subjects With High Working Memory Capacity And High Math Anxiety

Table 8

Indah has sketched a flat, non-rectangular shape with an area of $168m^2$. As an angled trapezoid, then, using mathematical concepts as an area, he created the space requested in the question according to his initial knowledge of mathematical concepts. All rooms created have met the requirements. However, after being confirmed in depth. The position of the adjacent bedrooms made Indah forget that, logically, this position was incorrect. After further confirmation, he, without realizing it, did not think that the position of the 2nd room was proper because people could not pass the 2nd room. Indah could not give a logical reason why the three rooms were side by side; what Indah had in mind was that the area of all the rooms did not meet the area requirements. However, in reality, the door to the second room could not be opened because there was no access.

DISCUSSION AND CONCLUSION

The regression test results explain the relationship between working memory capacity and mathematics anxiety on the creative reasoning performance of prospective mathematics teachers. The Adjusted R-squared value reflects approximately 18% of the variance as a predictor of creative reasoning. This finding is supported by the theory that working memory capacity positively affects mathematics performance. In addition, working memory capacity appears to positively affect mathematics performance in the form of basic and advanced mathematics and problem-solving skills. In contrast, mathematics anxiety hurts advanced mathematics and problem-solving skills (Juniati & Budayasa, 2020b). Cognitive independence affects basic mathematics abilities but does not affect advanced mathematics abilities. Working memory capacity positively affects mathematics performance in basic and advanced mathematics and problem-solving skills. In contrast, mathematics anxiety negatively affects advanced mathematics and problem-solving skills (Juniati & Budayasa, 2022).

The test results show that the confidence interval X_1=(0.2799, 0.9289) shows that we are very confident that X_1 has a significant favorable influence on the dependent variable. The confidence interval X_2 = (-0.294, 0.3428) indicates that we cannot conclude that X_2 has a significant effect, so it can be concluded that working memory capacity and mathematics anxiety influence a person's creative reasoning performance. Someone who has low math anxiety is more successful in solving geometry problems compared to someone with higher math anxiety, and someone with excessive levels of mathematics anxiety can hinder their performance in solving geometric problems (Wahyuni et al., 2024). From the regression test results, it can be concluded that X_1 and X_2 are independent variables that influence the dependent variable because the p-value is below 0.05. This study is consistent with previous research on the relationship of working memory to mathematics learning and achievement in children (Alloway & Alloway, 2010).

The interviews revealed the fluency and flexibility of the subject's creative reasoning. Subjects with high working memory capacity can see the novelty of their ideas from the way they sketch plans according to the requirements specified in the problem. Subjects can identify problems well and connect previously known mathematical concepts to create answers. Apart from that, the subject also provides logical arguments to support the correctness of the answers that have been made. Apart from that, the subject also uses mathematical formulas in the form of areas of triangles and quadrilaterals so that answers are made using appropriate mathematical concepts.

As their proposed new ideas demonstrate, subjects with high working memory capacity show flexibility and fluency in their creative reasoning processes. They meet the requirements for designing rooms even though the size of each room is different. This logical argumentation underlies the selection and application of new ideas in solving problems. Apart from that, they also developed a systematic and structured spatial plan. The use of the Pythagorean theorem formula in designing non-rectangular land plots shows that they use the correct mathematical basis to support their creative reasoning, and the variance they use to position the room without sacrificing the specified conditions shows the fluency of thinking and flexibility that supports it their creative reasons.

However, subjects with high math anxiety do not think about the extent to which their work is correct; their focus is only on fulfilling the requirements for the problem, so anxiety interferes with their cognitive performance, causing a deadlock in thinking, the subject is unable to provide logical reasons related to the position of the room created. So, the subject's anxiety hurt his cognitive performance. This is indicated by initial confirmation that subjects with low math anxiety are doubtful about being able to complete the task. This anxiety interferes with cognitive performance. Losing focus caused him to fail to complete the question successfully, even though he understood the meaning of the question. Upon closer inspection, it is clear that he sketched a floor plan with three bedrooms grouped. Even though the size of the room created by the subject meets the requirements, the subject placing the bedroom in an adjacent corner of the house will leave one bedroom without an entrance. The subject realized that the position of the bedroom was incorrect even though the size was correct. These results indicate that the creative reasoning process in subjects with high memory capacity can be disrupted by mathematics anxiety, both with high and low levels of mathematics anxiety. Subjects can answer systematically, identify known mathematical concepts and connect these concepts as a problem-solving strategy. Apart from that, every strategy or idea that is made is accompanied by logical arguments to support the correctness of the answers made but is less able to overcome the anxiety felt due to pressure and doubt due to limited time to solve the questions so that the answers given are less precise and the arguments given are less valid.

Subjects with high working memory capacity have much information and regularly create solutions with new ideas accompanied by reasonable arguments. Working memory capacity supports cognitive performance in understanding, reasoning, and solving problems (García-Santillán et al., 2016). However, high math anxiety due to stressful situations and limited working time interferes with concentration, resulting in less accurate answers. The level of mathematics anxiety of prospective mathematics teachers is relatively high and significantly impacts mathematics performance (Juniati & Budayasa, 2020b).

Reasoning is essential in solving mathematical problems. The cognitive system plays a massive role in this process. It performs its function of searching for appropriate information to solve problems. Information that is owned and stored in memory is recalled according to needs when faced with a problem. The amount of information stored in memory is directly proportional to the ease of responding to solving problems. Memory has different capacities in each person (Friso-Van Den Bos et al., 2013). Differences in a person's work capacity impact differences in that person's cognitive performance. Because the more information one has, the easier it will be for a person to solve the mathematical problems they face.

Creative reasoning as a person's cognitive domain can be disturbed due to anxiety. Anxiety makes it difficult for a person to concentrate and not focus on problems, which has an impact on cognitive activities. Something that is usually easy for someone can become difficult because of excessive anxiety. Anxiety about mathematics causes a decrease in academic achievement in mathematics tasks, thus preventing students from achieving good results in the learning process (Miller & Bichsel, 2004). Mathematics anxiety can be described as doubt, uncertainty, and a lack of courage regarding mathematical abilities. It negatively influences arithmetic skills and mathematics performance (Friso-Van Den Bos et al., 2013). As a result, the problem-solving process becomes less flexible and systematic, and mathematical concepts cannot be identified and connected to solve problems. High mathematics anxiety made it even harder for the subjects to sketch their plans systematically and organise. Mathematics anxiety can hurt mathematical problem-solving. Not only does it cause cognitive deficits, but it also evokes a physiological reaction (Palengka et al., 2019). This shows that a person's anxiety can hinder thinking. These findings are consistent with the research results (Strohmaier et al., 2020). This showed that individuals with high mathematical anxiety are less systematic and logical in providing arguments, even though they provide proof to back their proposed ideas. They formulate assumptions based on inaccurate arguments. Working memory is limited, limiting a person's ability to process information. Working memory capacity is important for many cognitive processes, including understanding, reasoning, and problem-solving. It appears to positively impact mathematics performance, including basic and advanced mathematics skills and problem-solving skills, while mathematics anxiety has a negative effect.

The results showed that working memory capacity and mathematics anxiety significantly influenced the creative reasoning performance of prospective mathematics teachers. Prospective mathematics teachers with high working memory capacity demonstrate flexibility and fluency in generating ideas, can identify and connect previously known mathematical concepts, and can provide logical arguments to support the correctness of the strategies created. However, both high and low mathematics anxiety was found to interfere with cognitive performance in solving more complex problems. Losing focus on solving problems results in unsystematic answers and an inability to provide logical arguments for the answers made.

This research provides additional information for prospective teachers and mathematics teachers on developing creative reasoning as initial knowledge when teaching mathematics to students. It can also help teachers prepare lessons to increase students' working memory capacity. Mathematics educators should incorporate structured problem-solving exercises that build working memory capacity while gradually reducing anxiety through scaffolded support and positive reinforcement.
The results of this creative reasoning research have contributed a lot to education. One of them is in designing learning strategies. Mathematics teachers can design creative reasoning-based

mathematics learning with an innovative and flexible approach by presenting contextual problems; teachers can create mathematical problems relevant to students' daily lives. This can increase students' interest and motivation to think creatively when solving problems and providing opportunities for students to form groups and discuss, which provides space for students to collaborate to find new ideas for solving problems and improve critical thinking skills. Designing learning with the use of visual aids, manipulatives, or mathematical software to help students understand more abstract concepts. Providing opportunities for students to explore various approaches to solving problems. Ask open-ended questions that encourage students to think deeper and explore new ideas. Open-ended questions allow students to argue and explore mathematical concepts more deeply.

The results of this study indicate that working memory capacity and math anxiety contribute to creative reasoning. However, there are still other unmeasured factors that play a role in creative reasoning. Therefore, further research is needed that explores additional cognitive and environmental influences such as cultural differences in creative reasoning, creative reasoning in the context of collaborative problem solving, how positive and negative emotions affect creative reasoning, how individuals and groups adapt, learn, and grow after experiencing failure in a creative context. By exploring these aspects, creative reasoning research can become more comprehensive and relevant to societal and world developments.

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