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CORRELATION BETWEEN STUDENTS' MEMORY CAPACITY AND LEARNING OUTCOMES ACHIEVEMENT IN FOURTH-GRADE STUDENTS AT SDN POJOK KLITIH JOMBANG CITY

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Abstract

Memory capacity is an important cognitive component in students' ability to receive, retain, and process information during learning. This capacity is particularly relevant to mathematics learning, in which students are required to retain concepts and retrieve previously learned information to support their understanding of new material. This study examines the relationship between students' memory capacity and mathematics learning outcomes among fourth-grade students at SDN Pojok Klitih, Jombang City. A quantitative approach with a correlational design was employed, involving 32 fourth-grade students. The data were analyzed through normality and linearity tests, followed by Pearson's Product-Moment correlation and a t-test at the 0.05 significance level. The findings indicate that students' memory capacity was in the high category, with a mean score of 81.09, while their mathematics learning outcomes were likewise categorized as high, with a mean score of 76.31. The correlation analysis revealed a positive and statistically significant relationship between memory capacity and mathematics learning outcomes (r = 0.429, p = 0.014), indicating a moderate association between the two variables. This finding was further supported by the t-test, which yielded a calculated t-value of 2.601, exceeding the critical value of 2.042. These results demonstrate that memory capacity is significantly associated with students' mathematics learning outcomes. The findings highlight the relevance of cognitive factors, particularly memory capacity, in understanding variations in mathematics achievement among elementary school students.

Keywords: *Memory Capacity; Mathematics Learning Outcomes; Cognitive Ability; Elementary Education; Correlational Study.*

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INTRODUCTION

Mathematics learning at the elementary school level is not merely concerned with the ability to perform calculations, but also involves a series of cognitive processes that enable students to retain, process, and use information appropriately. When solving mathematical problems, students need to activate previously acquired knowledge, maintain relevant information, connect concepts, and select procedures appropriate to the demands of the problem. Thus, success in learning mathematics cannot be understood solely through mastery of content or instructional strategies, but also through the cognitive capacity that supports the learning process. One capacity that holds an important position in the above process is memory. In the perspective of cognitive psychology, memory allows information obtained through learning experiences to be encoded, stored, and retrieved when that information is needed. Nofindra positions memory as an important part of the learning process because information that has been learned cannot be used optimally if students experience difficulties in retaining and recalling that information.[1]

However, viewing memory merely as the ability to "recall" information is still too simplistic to explain its role in mathematics learning. In more complex cognitive processes, especially when students solve mathematical problems, information not only needs to be stored but also maintained and manipulated during the ongoing thinking process. The concept of working memory becomes relevant in this context because it refers to the cognitive capacity to temporarily maintain information while simultaneously using it in ongoing mental activities. Baddeley explains that working memory is a cognitive system that enables individuals to maintain information and use it to support ongoing thinking activities.[2] This perspective serves as an important foundation because mathematics learning in elementary school-aged children often requires students to remember previous information while processing new information simultaneously.

The relationship between memory and mathematical ability has received fairly strong empirical support in the international literature. The meta-analysis by Friso-van den Bos et al. on research with elementary school-aged children showed that various components of working memory have a significant relationship with mathematics performance. Interestingly, the relationship is not entirely uniform. The strength of the relationship can differ according to the memory component measured and the characteristics of the mathematical tasks used.[3] These findings indicate that memory is not merely a supporting ability outside the mathematical process, but rather part of the

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[1] Rudi Nofindra, "Ingatan, Lupa, Dan Transfer Dalam Belajar Dan Pembelajaran," *Jurnal Pendidikan Rokania* 4, no. 1 (2019): 21–34.

[2] Alan Baddeley, "Working Memory: Looking Back and Looking Forward," *Nature Reviews Neuroscience* 4, no. 10 (2003): 829–39, https://doi.org/10.1038/nrn1201.

[3] Ilona Friso-van den Bos et al., "Working Memory and Mathematics in Primary School Children: A Meta-Analysis," *Educational Research Review* 10 (2013): 29–44, https://doi.org/https://doi.org/10.1016/j.edurev.2013.05.003.

cognitive infrastructure involved when students understand and solve mathematical tasks.

More recent findings strengthen this argument. Zhang, Tolmie, and Gordon, through a meta-analysis of 46 studies with 11,224 students aged 6–12 years, found a positive and significant moderate-level correlation between working memory and arithmetic ability. Their analysis also showed that this relationship is influenced by the working memory domain, student age, and type of mathematical operation. Verbal working memory, for example, showed a stronger relationship with arithmetic ability compared to visuospatial working memory.[4] These findings demonstrate that the relationship between memory and mathematics is not singular or simple in nature. The ability to remember becomes relevant because mathematics requires students to maintain information, activate prior knowledge, and integrate various representations during the problem-solving process.

Other evidence in the elementary education context also shows similar patterns. Studies on the relationship between working memory and mathematical skills in elementary school students found a significant correlation between the two variables.[5] Furthermore, recent research on executive functions and mathematics performance in elementary school students positions working memory, along with inhibitory control, cognitive flexibility, and planning, as part of the cognitive infrastructure of mathematics learning. This research synthesized 37 empirical studies published between 2009 and 2025, demonstrating that the relationship between executive functions and mathematics performance has become a consistently developing research agenda.[6]

Nevertheless, the relationship between memory capacity and mathematics learning outcomes needs to be placed proportionally. Learning outcomes are essentially multidimensional constructs that are not determined by a single cognitive ability alone. Motivation, attention, prior knowledge, learning strategies, instructional characteristics, classroom environment, as well as social and family support can interact in shaping students' academic achievement.[7] Therefore, the relationship found between memory and learning outcomes cannot be automatically interpreted as a causal relationship. Even meta-analytic evidence shows that the strength of the relationship between working memory and mathematics can change according to task characteristics, age,

[4] Yuxin Zhang et al., "The Relationship between Working Memory and Arithmetic in Primary School Children: A Meta-Analysis," *Brain Sciences* 13, no. 1 (2022): 22, https://doi.org/10.3390/brainsci13010022.

[5] Cesar Hernández Suárez et al., "Memoria de Trabajo y Habilidades Matemáticas En Estudiantes de Educación Básica," Scientific and Technological Education, *Revista Científica* 40, no. 1 (2021): 63–73, https://doi.org/10.14483/23448350.15400.

[6] Antonio Alejandro Espinoza-Ortiz and Kattya Mineska Guerrero-Jiménez, "Executive Functions and Mathematics Performance in Primary School Students: A Systematic Review," *International Journal of Educational Research Open* 10 (2026): 100562, https://doi.org/https://doi.org/10.1016/j.ijedro.2025.100562.

[7] Tika Meldina, "Implementasi Model Learning Start with A Question Strategi Meningkatkan Keterampilan Bertanya Siswa Sekolah Dasar," *TERAMPIL: Jurnal Pendidikan Dan Pembelajaran Dasar* 6, no. 2 (2019): 211–19; N. K. Roestiyah and Yumiati Suharto, *Strategi Belajar Mengajar* (PT. Bina Aksara, 2020).

and the memory domain used.[8] This position is important for correlational research because memory is positioned as one cognitive aspect related to mathematical achievement, not as the sole determinant of learning success.

This issue becomes increasingly relevant when associated with the characteristics of mathematics learning in elementary schools. Mathematics material is cumulative in nature, meaning that understanding new concepts is often built upon previously acquired knowledge. In the topic of equivalent fractions, for example, students are not only required to recognize the symbolic form of fractions but also need to understand the relationship between numerator and denominator and maintain previously learned procedures and concepts when facing different types of problems. Difficulties in maintaining relevant information can disrupt the continuity of the thinking process. In other words, the issue of memory in mathematics learning is not merely a matter of the ability to store facts, but relates to students' ability to reuse knowledge as a cognitive resource when facing new tasks.[9]

The empirical context of this research stems from the learning conditions in grade IV at SDN Pojok Klitih, Jombang Regency. Based on initial observations and interviews with the classroom teacher documented in the study, some students still experienced difficulties in remembering concepts and procedures for solving mathematical problems. This condition became relevant to investigate because at the same time, mathematics learning requires students to reuse previously learned information when solving new problems. Observation results also showed that previous instruction was still more oriented toward content delivery rather than the explicit development of students' cognitive abilities. This situation does not necessarily prove that low learning achievement is caused by weak memory, but it provides an empirical basis for testing whether the two variables indeed have a relationship in the context of the class being studied.

On the other hand, available previous research discusses the importance of memory in learning in general or efforts to improve memory through learning interventions. Nofindra, for example, discusses the functions of memory, forgetting, and transfer in the learning process,[10] while Mones examined efforts to improve fourth-grade students' memory through structured practice and exercises.[11] International literature has progressed further by examining the relationship between working memory and mathematical ability through correlational studies and meta-analyses.[12] However, empirical evidence that specifically examines the relationship between memory ability

[8] Zhang et al., "The Relationship between Working Memory and Arithmetic in Primary School Children."

[9] Bos et al., "Working Memory and Mathematics in Primary School Children: A Meta-Analysis."

[10] Nofindra, "Ingatan, Lupa, Dan Transfer Dalam Belajar Dan Pembelajaran."

[11] Anselmus Yata Mones, "Upaya Meningkatkan Daya Ingat Siswa Kelas IV Melalui Penerapan Metode Praktek Dan Latihan Terstruktur Pada Mata Pelajaran Pendidikan Agama Katolik (Studi Lapangan Di SD Negeri Nunbai, Timor NTT)," Articles, *Selidik (Jurnal Seputar Penelitian Pendidikan Keagamaan)* 1, no. 1 (2020): 19–29.

[12] Bos et al., "Working Memory and Mathematics in Primary School Children: A Meta-Analysis."

and mathematics learning outcomes in elementary school students in specific local contexts remains important, especially when the measurement of memory and learning outcomes is conducted on the same group of students and in specific learning materials.

This research is not intended to prove that memory is the single cause of success in learning mathematics, but rather to empirically examine whether there is a relationship between students' memory capacity and mathematics learning outcomes. This focus is important because most discussions of memory in education tend to stop at the theoretical argument that memory is needed in learning, while the empirical relationship needs to be tested in concrete learning contexts. Using a correlational design with fourth-grade students at SDN Pojok Klitih, this research attempts to bridge the cognitive psychology perspective on memory with the reality of mathematics learning achievement at the elementary school level.

Based on this framework, this study aims to analyze the relationship between students' memory capacity and mathematics learning outcomes of fourth-grade students at SDN Pojok Klitih, Jombang Regency. Specifically, this research is directed to identify the level of students' memory capacity, describe the achievement of mathematics learning outcomes, and determine the direction, strength, and significance of the relationship between the two variables. Thus, this research is expected not only to provide empirical evidence in the context of the school being studied but also to enrich the discussion regarding the position of cognitive factors in mathematics learning at the elementary school level.

RESEARCH METHOD

This study employs a quantitative approach with a correlational design to analyze the relationship between students' memory capacity and mathematics learning outcomes. Memory capacity is positioned as variable X, while mathematics learning outcomes serve as variable Y. The correlational design was chosen because the research is directed to identify the direction, strength, and significance of the relationship between the two variables without providing treatment or manipulation to the research subjects. This approach allows the relationship between scores to be analyzed as it occurs in the natural learning context, but it is not intended to prove causal relationships. Because Pearson correlation is used to estimate the linear relationship between two quantitative variables, examination of linearity and data characteristics becomes an important part before hypothesis testing is conducted.[13]

The research was conducted at SDN Pojok Klitih, Jombang Regency, in the even semester of the 2024/2025 academic year. The research population consisted of 444 students, with 32 fourth-grade students as research subjects. Fourth grade was chosen because students had already received material on equivalent fractions, which served

[13] Joost C. F. De Winter et al., "Comparing the Pearson and Spearman Correlation Coefficients across Distributions and Sample Sizes: A Tutorial Using Simulations and Empirical Data.," *Psychological Methods* 21, no. 3 (2016): 273–90, https://doi.org/10.1037/met0000079.

as the context for measuring mathematics learning outcomes. Subject selection was conducted purposively based on the suitability of class characteristics with the research objectives.[14] If all fourth-grade students totaling 32 were involved, then the characteristics of this procedure substantively constituted total sampling at the class level. This condition simultaneously limits the generalizability of the findings, so the results are primarily understood in the context of fourth-grade students at SDN Pojok Klitih and cannot be directly generalized to all elementary school students.

Data collection was conducted using two test instruments. Memory capacity was measured through an essay test that identified students' ability to remember and express previously learned information, while mathematics learning outcomes were measured through a multiple-choice test on the topic of equivalent fractions. Instrument quality was evaluated through validity, reliability, difficulty level, and discriminating power tests. Item validity was analyzed using Pearson Product-Moment correlation at the 5% significance level, while the internal consistency of the instrument was tested using Cronbach's Alpha with a coefficient of 0.620.[15] This evaluation was necessary to ensure that the obtained scores had adequate measurement quality because the interpretation of relationships between variables depends on the accuracy and consistency of the scores.[16] Conceptually, memory in this study refers to students' ability to receive, retain, and recall previously learned information. This construct is distinguished from working memory, which specifically relates to the ability to simultaneously maintain and manipulate information in ongoing cognitive processes.[17]

Data were analyzed using IBM SPSS Statistics version 24 through descriptive analysis, prerequisite checks, and hypothesis testing. Descriptive analysis was used to obtain minimum, maximum, mean, and standard deviation values.[18] Memory capacity scores from 32 students had a minimum value of 33, maximum of 93, mean of 81.09, and standard deviation of 14.407, while mathematics learning outcomes had a minimum value of 26, maximum of 100, mean of 76.31, and standard deviation of 18.564. Before correlation analysis was conducted, the data were examined through normality and linearity tests to ensure the suitability of data characteristics with the parametric analysis used. The relationship between memory and mathematics learning outcomes was then tested using Pearson Product-Moment correlation at the significance level $\alpha = 0.05$ with two-tailed testing. The correlation coefficient was used to determine the

[14] De Winter et al., "Comparing the Pearson and Spearman Correlation Coefficients across Distributions and Sample Sizes."

[15] Andy Field, *Discovering Statistics Using IBM SPSS Statistics* (SAGE Publications, 2018).

[16] American Educational Research Association et al., *Standards for Educational and Psychological Testing* (American Educational Research Association, 2014).

[17] Baddeley, "Working Memory: Looking Back and Looking Forward."

[18] Kim F. Nimon, "Statistical Assumptions of Substantive Analyses Across the General Linear Model: A Mini-Review," *Frontiers in Psychology* 3 (2012), https://doi.org/10.3389/fpsyg.2012.00322.

direction and strength of the relationship, while the significance value was used to determine the statistical significance of the relationship.[19]

The research hypothesis consists of H_0, which states that there is no significant relationship between memory capacity and mathematics learning outcomes, and H_1, which states that there is a significant relationship between the two variables. The significance of the correlation coefficient was strengthened through a t-test with degrees of freedom $n - 2 = 30$. The calculated t-value of 2.601 was compared with the t-table value of 2.042 at the 5% significance level. The correlation coefficient of 0.429 was interpreted as a positive relationship with moderate strength based on the classification used in this research. This relationship is understood as a statistical association and is not interpreted as evidence of causality.[20] Because the research was conducted in one class at one school, the interpretation of findings is also limited to the context of the population studied. The entire research process observed principles of student identity confidentiality, institutional permission, and use of data for academic purposes.[21]

RESULTS AND DISCUSSION

Descriptive Characteristics of Data

Descriptive analysis was used to obtain an overview of the distribution of scores for memory capacity and mathematics learning outcomes before the relationship between the two variables was tested inferentially. The research involved 32 fourth-grade students at SDN Pojok Klitih. Memory capacity had a minimum score of 33 and a maximum of 93, with a mean of 81.09 and a standard deviation of 14.407. Meanwhile, mathematics learning outcomes had a minimum score of 26 and a maximum of 100, with a mean of 76.31 and a standard deviation of 18.564.

Table 1. Descriptive Statistics of Research Variables

Statistic	Memory Capacity	Mathematics Learning Outcomes
N	32	32
Minimum	33	26
Maximum	93	100
Mean	81,09	76,31
Standard deviation	14,407	18,564
Range	60	74

Source: Research data, processed using IBM SPSS Statistics 24.

[19] Guillaume A. Rousselet and Cyril R. Pernet, "Improving Standards in Brain-Behavior Correlation Analyses," *Frontiers in Human Neuroscience* 6 (2012), https://doi.org/10.3389/fnhum.2012.00119; De Winter et al., "Comparing the Pearson and Spearman Correlation Coefficients across Distributions and Sample Sizes."

[20] Haldun Akoglu, "User's Guide to Correlation Coefficients," *Turkish Journal of Emergency Medicine* 18, no. 3 (2018): 91–93, https://doi.org/10.1016/j.tjem.2018.08.001.

[21] H. Shafeeq Ahmed, "Correlation and Causation for Cardiothoracic Surgeons: Part 4—Distinguishing Relationships in Data," *Indian Journal of Thoracic and Cardiovascular Surgery* 41, no. 3 (2025): 371–80, https://doi.org/10.1007/s12055-024-01889-1.

Descriptively, the average memory capacity score was higher than the average mathematics learning outcome score. However, this mean difference cannot be interpreted as evidence that memory capacity automatically produces better mathematical achievement. Rather, the variation in scores provides more important information. The memory capacity score range of 60 points indicates considerable individual differences, while the learning outcome range of 74 points shows even greater heterogeneity in mathematical achievement.

The difference in standard deviations also reveals an interesting pattern. The spread of mathematics learning outcome scores (SD = 18.564) was greater than the spread of memory capacity scores (SD = 14.407). This means that although the student group generally had relatively high memory scores, their mathematical achievement was not uniform. This pattern indicates that learning outcomes are likely shaped by a combination of several factors, with memory being only one relevant aspect.

These descriptive findings simultaneously provide empirical justification for conducting correlational analysis. If all students had nearly identical scores on both variables, the relationship between them would be difficult to identify. Conversely, the individual variation observed in the data allows the research to test whether differences in memory capacity systematically align with differences in mathematics learning outcomes.

Distribution and Tendency of Memory Capacity

Descriptive analysis shows that the memory capacity of fourth-grade students at SDN Pojok Klitih, Jombang Regency, was in the high category. Based on the analysis results using IBM SPSS Statistics version 24, the minimum value was 33, the maximum value was 93, the mean was 81.09, and the standard deviation was 14.407. Based on the score categorization results, this mean value falls into the high category, so it can be concluded that most students had good memory capacity.

These results indicate that students already possessed quite good ability to receive, store, and recall information related to the topic of equivalent fractions. This ability is an important asset in the learning process because students are able to connect previously possessed knowledge with the material being studied. Thus, students' thinking processes do not depend solely on conceptual understanding, but also on the ability to remember previously acquired information.

Table 2. Descriptive Output of Memory Capacity Data

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Memory Capacity	32	33	93	81,09	14,407
Valid N (listwise)	32				

Source: Research data, processed using IBM SPSS Statistics 24.

The mean memory capacity of 81.09 indicates a tendency toward relatively high scores. Nevertheless, the minimum value of 33 shows that there were students with achievement far lower than the group tendency. Thus, the main characteristic of the memory capacity variable is not only its average level, but also the presence of ability gaps among students.

This condition has important implications for learning. Memory plays a role in enabling students to maintain previously acquired information and access it again when that information is needed. In mathematics learning, this function becomes relevant because new knowledge is often built upon previously learned concepts and procedures. Students who can effectively access prerequisite knowledge have more cognitive resources available when facing new problems.

However, the ability to remember is not identical to mathematical understanding. Students may remember a procedure without necessarily understanding the reason for its use. Therefore, relatively high memory scores should be understood as a cognitive condition that can support learning, not as a direct measure of success in understanding mathematics.

Achievement of Mathematics Learning Outcomes

Mathematics learning outcomes showed a mean of 76.31, with the lowest score of 26 and the highest of 100. The range of 74 points indicates considerable differences in achievement in mastering the measured material. The standard deviation of 18.564 further strengthens the indication that students' mathematical ability in the research group was not homogeneous.

Table 3. Statistical Distribution of Mathematics Learning Outcomes

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Learning Outcomes	32	26	100	76,31	18,564
Valid N (listwise)	32				

Source: Research data, processed using IBM SPSS Statistics 24.

The maximum score of 100 shows that some students were able to achieve excellent mastery, while the minimum score of 26 indicates students still experiencing substantial difficulties. Therefore, the mean of 76.31 is not sufficient to describe the overall classroom condition. This mean should be read as a group tendency situated between fairly diverse individual achievements.

This variation is also important for understanding the relationship between memory and learning outcomes. If mathematical achievement were influenced by only one cognitive factor, a very strong relationship pattern would likely be observed. However, education is a multidimensional process. Prior knowledge, conceptual understanding, attention, motivation, learning strategies, learning experiences, and characteristics of the learning environment can all contribute to learning outcomes. Thus, the relationship between memory and mathematics is theoretically more appropriately understood as one part of a network of mutually interacting factors.

Relationship between Memory Capacity and Mathematics Learning Outcomes

Testing the relationship using Pearson Product-Moment correlation yielded a correlation coefficient (r) = 0.429 with a significance value of p = 0.014. With 32 students, this relationship had 30 degrees of freedom. The positive coefficient indicates that the direction of the relationship between the two variables is unidirectional: the higher the memory score, the higher the tendency for mathematics learning outcome scores. The p value of 0.014 is below the significance threshold of 0.05, so this relationship is statistically significant.

Table 4. Pearson Correlation between Memory Capacity and Mathematics Learning Outcomes

Correlations			
		Memory Capacity	Learning Outcomes
Memory Capacity	Pearson Correlation	1	0,429*
	Sig. (2-tailed)		0,014
	N	32	32
Learning Outcomes	Pearson Correlation	0,429*	1
	Sig. (2-tailed)	0,014	
	N	32	32

*. *Correlation is significant at the 0.05 level (2-tailed).*

Source: Research data, processed using IBM SPSS Statistics 24.

The results of this study indicate that the higher the memory capacity possessed by students, the higher the tendency for mathematics learning outcomes achieved. Conversely, students with lower memory capacity tend to obtain lower learning outcomes. This shows that memory capacity is one of the internal factors that contributes to students' success in the mathematics learning process.

The findings of this research align with cognitive psychology theory, which explains that memory is an important component in the learning process. Information received by students is processed, stored, and then recalled when needed to solve a problem. Therefore, the ability to remember plays an important role in helping students understand interconnected mathematical concepts.

This research also supports previous studies stating that memory ability has a positive relationship with student learning achievement. Students who have better memory ability tend to more easily understand learning materials, remember formulas, and apply previously learned concepts when solving problems. Thus, memory capacity not only plays a role in remembering information but also supports thinking ability, understanding concepts, and solving mathematical problems.

Nevertheless, the correlation coefficient (r) of 0.429 indicates that the relationship between memory capacity and learning outcomes is in the moderate category. This indicates that mathematics learning outcomes are not only influenced by memory capacity but also by other factors, such as learning motivation, learning interest, initial ability, learning strategies applied by the teacher, learning environment, and parental support. Therefore, improving mathematics learning outcomes needs to be conducted comprehensively through the development of various aspects that influence students' learning processes.

Overall, the results of this research provide empirical evidence that memory capacity has a significant relationship with mathematics learning outcomes of fourth-grade students at SDN Pojok Klitih, Jombang Regency. These findings are expected to serve as a basis for teachers to develop learning strategies capable of training students' memory abilities, such as review activities, use of interesting learning media, gradual problem-solving exercises, and learning that connects new concepts with previous learning experiences so that student learning outcomes can be improved.

Every individual has different memory abilities, and the nature of memory possessed by each person is not the same. The nature of memory is divided into four types, including:

- Simple and fast memory: This type of memory enables a person to quickly and easily store or memorize an impression.
- Broad and reliable memory: Individuals with this type of memory can obtain many impressions with a wide scope.
- Faithful memory: In this memory, the impression received remains intact as when it was received.
- Obedient memory: In this memory, recorded and stored impressions can be reproduced more quickly.

From these various types of memory characteristics, each individual does not possess the same memory characteristics as other individuals.

Discussion

Memory as a Cognitive Resource for Mathematics Learning

The main finding of this research shows that memory does not stand outside the process of learning mathematics but is related to the achievements produced by students. The correlation coefficient of $r = 0.429$ ($p = 0.014$) indicates a positive and significant relationship with moderate strength. This finding is interesting because it shows that students' ability to maintain and access previously learned information aligns with their achievement in mathematics learning. In other words, differences in memory ability among students are not entirely separate from differences in their mathematical achievement.

This relationship can be understood from the nature of mathematics as a cumulative field of knowledge. Understanding new concepts almost always builds upon previously acquired knowledge. When students work on equivalent fraction problems, for example, they are not only dealing with information contained in the problem but must also reactivate understanding of numerators, denominators, relationships between values, and previously learned procedures. Memory becomes important because knowledge that cannot be effectively accessed will be difficult to use as a basis for processing new information.

In this perspective, memory should not be understood merely as the ability to "memorize." The more important function is maintaining the availability of knowledge relevant to the thinking process. Students who can access prior knowledge more effectively have more cognitive capital ready to use when facing new problems. This is what makes the relationship between memory and mathematics learning outcomes theoretically plausible.

This finding is supported by the meta-analysis research of Friso-van den Bos et al., which showed that various components of working memory are related to mathematics performance in elementary school children. Interestingly, this research also showed that the strength of the relationship is not uniform and is influenced by the type of mathematics measure used.[22] Thus, this research strengthens the idea that memory processes are part of the cognitive infrastructure of mathematics learning, but their contribution is neither singular nor uniform.

Significant but Not Deterministic Relationship

What is even more interesting about this research is not merely the finding of a significant relationship, but the magnitude of the relationship being at a moderate level. The value of $r = 0.429$ indicates that memory has a fairly meaningful relationship with learning outcomes, but is not strong enough to explain mathematical achievement as a whole. The calculation of r^2 yields approximately 0.184, so there is about 18.4% shared variation that can be represented through the linear relationship of the two variables.

This figure conveys an important message: memory is important, but it is not the only story about success in learning mathematics. If memory ability were the sole determinant of learning outcomes, the relationship obtained should have been much stronger. Conversely, the moderate relationship shows that mathematical achievement is formed through the interaction of various cognitive resources and learning conditions.

This interpretation aligns with the research of Zhang, Tolmie, and Gordon, who through a meta-analysis of 11,224 children aged 6–12 years found a moderate relationship between working memory and arithmetic ability ($r = 0.312$). They also found that the strength of the relationship changes according to the working memory domain, student age, and type of mathematical operation.[23] This means that memory does not work as a single mechanism that automatically produces mathematical achievement. What is remembered, how information is maintained, and for what type of mathematical task the information is used all determine the strength of the relationship.

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[22] Bos et al., "Working Memory and Mathematics in Primary School Children: A Meta-Analysis."

[23] Zhang et al., "The Relationship between Working Memory and Arithmetic in Primary School Children."

In the context of this research, the finding of r = 0.429 can even be read as an indication that memory is one relevant cognitive resource, but it must work together with other abilities. Conceptual understanding, prior knowledge, attention, problem-solving strategies, motivation, and learning experiences can all play roles that are no less important. Because these variables were not measured in this study, it would be inappropriate to make memory the sole explanation for variations in learning outcomes.

From "Remembering" to "Using Knowledge"

The pedagogical implications of this finding should not be directed toward increasing rote memorization alone. If the relationship between memory and learning outcomes is only translated as the need to make students memorize more, then the meaning of the research findings becomes too narrow.

What is more important is creating learning that helps students access knowledge when that knowledge is needed. In mathematics learning, teachers can begin new lessons by activating prerequisite knowledge, using retrieval questions, providing cumulative practice, connecting new concepts with familiar representations, and gradually increasing the complexity of problems.

In the topic of equivalent fractions, for example, teachers should not only ask students to remember procedures but can ask them to explain again why two fractions have the same value, depict this relationship visually, and then use this concept to solve new problems. Thus, remembering activities become an entry point toward understanding, not the ultimate goal of learning.

Such an approach is important because the relationship found is at a moderate level. If only memory is strengthened while conceptual understanding and reasoning ability are neglected, the improvement in mathematical achievement is likely not optimal. The research findings actually point to the need to integrate retrieval, conceptual understanding, and mathematical reasoning in a single learning process.

Theoretical Contribution: Memory as Part of the Cognitive Ecology of Learning

The findings of this research can be read further by positioning memory as part of the cognitive ecology of mathematics learning. In this ecology, memory provides access to prior knowledge; attention determines which information is processed; conceptual understanding gives meaning to information; while problem-solving strategies determine how that knowledge is used.

With this framework, the relationship of r = 0.429 becomes plausible. Memory is positioned neither at the earliest nor the latest point in the learning process. It functions as a connecting mechanism between previous learning experiences and ongoing cognitive activity. The more available relevant knowledge is, the greater the opportunity for students to use it when facing new tasks. However, the availability of knowledge does not guarantee that the knowledge will be used appropriately.

This perspective also prevents the research from falling into cognitive determinism. Learning outcomes cannot be reduced to individual student abilities alone. Even if memory has a significant relationship with mathematical achievement, the quality of instruction still determines how cognitive capacity is activated and utilized.

Therefore, the main contribution of this research is not merely confirming the relationship between two variables, but strengthening the argument that mathematics learning needs to be understood as an interaction between students' cognitive resources and the pedagogical demands of the tasks they face.

Implications and Directions for Future Research

The research findings open space for subsequent research to move beyond simple correlations between memory and learning outcomes. Because $r = 0.429$ only explains part of the linear relationship between the two measures, future research can incorporate prior knowledge, attention, motivation, working memory, learning strategies, or conceptual understanding as additional variables. Thus, it can be determined whether the relationship between memory and mathematics persists after these factors are taken into account.

Future research also needs to distinguish between memory capacity and working memory. Both are often used interchangeably in educational discourse, but they are conceptually not identical. The meta-analysis by Zhang et al. shows that even within the working memory construct itself, there are differences in relationships based on verbal, visuospatial domains, and characteristics of mathematical tasks.

Longitudinal designs will also provide stronger contributions than cross-sectional correlational designs. By tracking students' development over time, research can test whether memory ability at one stage relates to the development of mathematical ability at a later stage. Meanwhile, experimental research can test a different question: not whether memory correlates with learning outcomes, but whether learning strategies designed to improve retrieval and retention actually result in improved mathematical understanding.

CONCLUSION

This research shows that students' memory capacity has a positive and significant relationship with mathematics learning outcomes of fourth-grade students at SDN Pojok Klitih. The correlation coefficient of $r = 0.429$ with a significance value of $p = 0.014$ indicates a moderate-strength relationship, which means that students with better memory capacity tend to obtain higher mathematical achievement. This finding is reinforced by the t-test results ($t = 2.601 >$ t-table $= 2.042$), so the research hypothesis is accepted. Thus, memory can be viewed as one cognitive resource that supports the mathematics learning process, particularly in maintaining and accessing knowledge needed during the learning process.

Nevertheless, the moderate-level relationship indicates that mathematics learning outcomes cannot be explained by memory alone. The ability to remember is part of a broader cognitive process that also involves conceptual understanding, prior knowledge, attention, learning strategies, motivation, as well as learning experiences and quality of instruction. Therefore, strengthening memory in mathematics learning should not be directed toward rote memorization alone, but toward students' ability to access previously learned knowledge and use it to understand concepts, build mathematical relationships, and solve new problems.

Ultimately, this research affirms that memory is an important cognitive resource, but not the sole determinant of success in learning mathematics. The pedagogical implication is the need for learning that integrates remembering activities with conceptual understanding, reasoning, and problem solving. Future research needs to expand the study by involving larger samples and considering other variables such as prior knowledge, conceptual understanding, attention, motivation, and learning strategies. Longitudinal or experimental approaches are also needed to gain a stronger understanding of how memory processes can be optimized to support the development of students' understanding and mathematical achievement sustainably.

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