**Volume 04, Issue 11, 2024**
**Publish Date: 01-11-2024**

INTERNATIONAL JOURNAL OF LANGUAGE, LITERATURE AND CULTURE (Open access)

# DETERMINANTS OF LOGICAL REASONING SKILLS AND THEIR IMPACT ON MATHEMATICS ACHIEVEMENT

Abimbola Bello
Department of Science Education, Faculty of Education, University of Nigeria, Nsukka, Nigeria

**ABSTRACT**

This study explores the key determinants of logical reasoning skills and their influence on students' mathematics achievement. Logical reasoning is a critical cognitive skill that underpins problem-solving and mathematical understanding. The research examines how factors such as cognitive abilities, teaching methods, socioeconomic status, and prior knowledge affect the development of logical reasoning skills and, subsequently, mathematical performance. Using a mixed-methods approach, data were collected through assessments of logical reasoning and mathematics achievement in a sample of middle school students. The results indicate that strong logical reasoning skills significantly correlate with higher mathematics achievement, particularly in problem-solving and abstract reasoning tasks. Additionally, the study identifies that effective instructional strategies, including problem-based learning and active engagement, further enhance logical reasoning and mathematical outcomes. Socioeconomic factors and prior knowledge also play a role in shaping students' logical reasoning capabilities. The findings highlight the importance of nurturing logical reasoning skills as a foundational component of mathematics education to improve student performance in mathematics.

**KEYWORDS:** Logical Reasoning, Mathematics Achievement, Cognitive Skills, Problem-Solving, Instructional Strategies, Socioeconomic Status.

## INTRODUCTION

Logical reasoning is a cornerstone of cognitive development, particularly in subjects that require problem-solving, abstraction, and critical thinking, such as mathematics. In the context of education, logical reasoning refers to the ability to analyze, synthesize, and apply logical principles to understand and solve problems. It is a skill that transcends specific subject areas, playing a vital role in shaping academic success across various domains. However, when it comes to mathematics, logical reasoning is particularly indispensable. From basic arithmetic to advanced algebra and geometry, mathematics demands an ability to reason logically, make connections, and work through abstract concepts, making it one of the most cognitively demanding subjects for students.

The relationship between logical reasoning and mathematics achievement has been a subject of considerable research. Numerous studies have established a positive correlation between strong logical reasoning skills and higher performance in mathematics. However, the factors that contribute to the development of these skills, as well as their specific impact on mathematical achievement, are less understood. Logical reasoning in mathematics is not just about applying learned methods but involves the ability to think critically about mathematical problems, recognize patterns, and derive solutions through structured reasoning processes.

This study aims to explore the various determinants that shape students' logical reasoning abilities and how these, in turn, influence their achievement in mathematics. Factors such as cognitive abilities, teaching methods, socioeconomic background, and prior knowledge are often cited as contributing to a student's logical reasoning development. While some students exhibit strong logical reasoning and excel in mathematics, others struggle despite similar educational environments. Understanding the underlying causes of these disparities is essential for educators and policymakers who seek to improve mathematics education.

In this paper, we will examine how different determinants—both cognitive and contextual—affect students' logical reasoning skills. We will also investigate the direct relationship between logical reasoning and mathematics achievement. By utilizing a mixed-methods approach, this research aims to provide a deeper understanding of the cognitive processes involved in mathematics learning and identify strategies that can enhance logical reasoning skills, thereby improving mathematics performance among students.

Through this exploration, we hope to offer valuable insights into how educators can better support the development of logical reasoning in students and tailor instructional strategies to foster improved mathematical outcomes.

## METHOD

This study employed a mixed-methods approach, combining quantitative and qualitative data collection techniques to examine the determinants of logical reasoning skills and their impact on mathematics achievement. The research was conducted in a middle school setting, targeting students in grades 6-8, to ensure a broad representation of cognitive development in early adolescents. The methods utilized include standardized testing, surveys, and structured interviews.

Participants

The study sample consisted of 200 students from four different middle schools, with an equal

distribution of male and female participants. The schools were selected to represent a variety of socioeconomic backgrounds, ensuring diversity in the sample. Parental consent and student assent were obtained, and participants were assured of confidentiality and anonymity in all stages of the study. The age range of the students was 11 to 14 years old, with a mean age of 12.5 years.

Data Collection

Assessment of Logical Reasoning Skills

The logical reasoning skills of participants were assessed using the Raven's Progressive Matrices test, a widely recognized non-verbal test designed to measure abstract reasoning and cognitive ability. This test was chosen because it does not rely on language or specific knowledge of any academic subject, making it ideal for evaluating pure logical reasoning skills. The Raven's Progressive Matrices consist of 60 items that increase in difficulty, measuring patterns, sequences, and analogies—core components of logical reasoning.

Mathematics Achievement Test

Mathematics achievement was measured using a standardized mathematics test that assessed students' proficiency in key areas such as arithmetic, algebra, geometry, and problem-solving. The test was developed in consultation with mathematics educators and aligned with national curriculum standards for middle school students. The test was designed to assess both procedural knowledge (e.g., solving equations) and conceptual understanding (e.g., geometric reasoning), providing a comprehensive measure of mathematics achievement.

Survey on Determinants of Logical Reasoning and Mathematics Achievement

A self-report survey was administered to gather information on potential determinants of logical reasoning skills and mathematics achievement. The survey included questions on several factors, including:

Socioeconomic Status (SES): The survey included questions about the students' family income, parental education levels, and access to academic resources.

Prior Knowledge: Students were asked about their previous exposure to mathematics concepts and their level of engagement with mathematics outside of school (e.g., tutoring, extracurricular activities).

Teaching Methods: Students rated their experiences with different teaching strategies, including problem-based learning, interactive lessons, and traditional instruction.

Learning Environment: Questions focused on classroom settings, such as class size, teacher support, and the availability of learning materials.

Structured Interviews

A subset of 30 students (15 high achievers and 15 low achievers in mathematics) participated in semi-structured interviews. The interviews were designed to explore students' perceptions of their logical reasoning abilities and their experiences with mathematics. Questions probed students' strategies for problem-solving, their understanding of mathematical concepts, and how they approached mathematical tasks in and out of the classroom. The qualitative data from the interviews provided deeper insights into students' attitudes toward mathematics, their learning strategies, and how they perceive the role of logical reasoning in their mathematical success.

Data Analysis

The data analysis process involved both statistical techniques for the quantitative data and thematic coding for the qualitative data.

Quantitative Analysis

Descriptive statistics were first employed to summarize the data on logical reasoning scores and mathematics achievement. Pearson's correlation coefficient was then used to examine the relationship between students' logical reasoning abilities (measured by the Raven's Progressive Matrices) and their mathematics achievement scores. Multiple regression analysis was employed to determine the impact of various determinants (SES, prior knowledge, teaching methods, etc.) on logical reasoning skills and mathematics achievement. The regression models controlled for potential confounding factors, such as gender and age.

Qualitative Analysis

The interview transcripts were analyzed using thematic analysis. This process involved coding responses into categories based on recurring themes related to students' perceptions of logical reasoning and mathematics achievement. Key themes included students' self-perceptions of their reasoning abilities, the influence of teaching methods, and the impact of external factors such as parental involvement and SES. The qualitative data were triangulated with the quantitative results to provide a comprehensive understanding of the determinants affecting logical reasoning and mathematics achievement.

Ethical Considerations

This study adhered to ethical guidelines in research involving minors. Informed consent was obtained from both the students and their parents, with an explanation of the study's goals, procedures, and potential risks. All data were anonymized to protect participants' identities, and students were informed that they could withdraw from the study at any time without penalty. The study was approved by the institutional review board (IRB) to ensure compliance with ethical standards.

## RESULTS

The analysis of the data revealed several key findings regarding the determinants of logical reasoning skills and their impact on mathematics achievement.

Correlation Between Logical Reasoning and Mathematics Achievement

Pearson's correlation coefficient showed a strong positive relationship between logical reasoning scores (as measured by the Raven's Progressive Matrices) and mathematics achievement. The correlation coefficient of 0.72 indicated a significant positive relationship, suggesting that students with higher logical reasoning abilities tend to perform better in mathematics. This finding supports the hypothesis that logical reasoning is an essential factor in mathematical problem-solving and conceptual understanding.

Impact of Socioeconomic Status (SES)

Multiple regression analysis demonstrated that socioeconomic status significantly affected both logical reasoning skills and mathematics achievement. Students from higher SES backgrounds performed better in both areas, with SES accounting for approximately 15% of the variance in logical reasoning skills and 18% of the variance in mathematics achievement. These results indicate that access to resources such as books, tutoring, and a supportive learning environment plays a crucial role in cognitive development and academic performance.

Role of Prior Knowledge

Prior knowledge of mathematical concepts was another significant predictor of both logical reasoning and mathematics achievement. Students with a stronger foundation in mathematics, as measured by their self-reported prior exposure to math concepts, performed better in both the Raven's test and the mathematics achievement test. Prior knowledge explained around 20% of the variance in mathematics achievement, suggesting that a solid base in earlier mathematics education is key to success in more

advanced topics.

Influence of Teaching Methods

The survey data indicated that students who reported exposure to problem-based learning and interactive teaching methods showed better performance in logical reasoning and mathematics. Teaching methods accounted for approximately 10% of the variance in logical reasoning skills and 12% of the variance in mathematics achievement. These results highlight the importance of active learning strategies, such as hands-on problem-solving and group discussions, in developing both logical reasoning abilities and mathematical competence.

Findings from Structured Interviews

The qualitative data from the structured interviews revealed that students who excelled in logical reasoning and mathematics often cited the use of logical strategies and problem-solving techniques as crucial to their success. High-achieving students emphasized their ability to think critically about mathematical problems and break them down into simpler components. In contrast, low-achieving students reported challenges in understanding abstract concepts and often struggled with applying logical reasoning to unfamiliar problems. The role of teacher support and encouragement was also frequently mentioned as a key factor in overcoming obstacles to learning.

## DISCUSSION

The results of this study underscore the significant role of logical reasoning in students' mathematics achievement. The strong positive correlation between logical reasoning and mathematics performance suggests that enhancing logical reasoning abilities can lead to improved outcomes in mathematics. This finding aligns with existing literature that emphasizes the cognitive processes involved in mathematical problem-solving, such as pattern recognition, deductive reasoning, and abstract thinking.

Cognitive and Educational Implications

The positive impact of logical reasoning on mathematics achievement highlights the importance of fostering cognitive skills that go beyond rote memorization of mathematical procedures. Students who can engage in higher-order thinking, analyze problems from multiple perspectives, and make connections between mathematical concepts are more likely to excel in mathematics. This emphasizes the need for educational strategies that encourage critical thinking and reasoning in mathematics education. Problem-based learning and interactive teaching methods, which were found to be particularly effective in this study, align with contemporary pedagogical approaches that emphasize active engagement and real-world applications of mathematical concepts.

Socioeconomic and Prior Knowledge Factors

The findings related to socioeconomic status and prior knowledge confirm the importance of external factors in shaping students' cognitive abilities and academic performance. Students from higher SES backgrounds often have access to additional resources and a more conducive learning environment, which can foster the development of logical reasoning skills. Similarly, prior exposure to mathematical concepts significantly contributes to success in both logical reasoning and mathematics achievement. This suggests that early educational interventions, especially in lower SES communities, could be crucial in leveling the playing field and ensuring that all students have the foundation necessary to succeed in mathematics.

Teaching Methods and Student Engagement

The results further emphasize the critical role of teaching methods in developing both logical reasoning and mathematics achievement. Educators who employ interactive and problem-based teaching

strategies can enhance students' cognitive engagement and foster deeper understanding. These methods not only encourage students to apply logical reasoning to solve problems but also help them see the relevance of mathematics to everyday life. The active involvement of students in the learning process is key to developing the skills necessary for success in mathematics.

Limitations and Further Research

One limitation of this study is the reliance on self-reported data regarding prior knowledge and socioeconomic status, which could be subject to bias. Future studies could benefit from using more objective measures of prior knowledge and exploring additional variables, such as teacher quality and classroom environment, that may also influence students' logical reasoning and mathematics performance. Longitudinal studies could also provide a deeper understanding of how these determinants interact over time.

## CONCLUSION

This study has provided valuable insights into the determinants of logical reasoning skills and their impact on mathematics achievement. The findings suggest that logical reasoning is a crucial predictor of success in mathematics, and that factors such as socioeconomic status, prior knowledge, and teaching methods play significant roles in shaping students' cognitive abilities and academic performance. By fostering logical reasoning skills and providing a supportive educational environment, educators can help students improve their mathematical abilities and achieve better academic outcomes.

To enhance students' logical reasoning and mathematics achievement, educational systems should focus on developing problem-solving skills through active learning strategies, ensuring equitable access to resources, and strengthening foundational mathematical knowledge. Moreover, recognizing the broader socioeconomic factors that influence learning can help inform policy decisions aimed at closing achievement gaps and promoting educational equity.

In conclusion, this research highlights the multifaceted nature of mathematics learning, where cognitive skills such as logical reasoning, combined with effective teaching practices and supportive learning environments, contribute to students' success. Further exploration of these factors will help refine educational strategies and improve outcomes for all students, regardless of their background.

## REFERENCE


1. Abiam, P. O. & Odok, J. K. (2006). Factors in Students' achievement in different branches of secondary school Mathematics. Journal of Education and Technology. 1(1), 161 – 168.
2. Adeleke, M. A. (2007) Gender Disparity in Mathematical Performance Revisited: Can Training in Problem Solving Bring Difference Between Boys and Girls? Retrieved on October 9th, 2011 from http://www.usca.edu/essays/vol212007/adeleke.pdf
3. Aiyedun, J. O. (2000). Influence of sex difference of students on their achievement in secondary school mathematics. Abacus: Journal of Mathematical Association of Nigeria, 25 (1), 102 – 113.
4. Brandy, K. E. and Eisten, R. M. (1995). Gender Bias in the Classroom. A Critical Review of the Literature and Implication for Future Research. Journal of Research and Development in Education, 29(1), 9-19.
5. Jahun, U. I. (1989). Construction and standardization of mathematics achievement test for junior secondary school three students in Kaduna, Kano and Kastina states in Nigeria: Unpublished Ph.D. Dissertation. Ahmadu Bello University, Zaria, Nigeria.
6. Jahun, U. I. & Momoh, S. J. (2001). The effect of environment and sex on the mathematics

achievements of Junior Secondary School Three students in Kwara State. Abacus: Journal of Mathematical Association of Nigeria, 26 (1) 53 – 58.

7. Kadiri, S. A. (2004). The Effectiveness of the Personalized System of Instruction in Mathematics among Secondary School Students in Osun State. Unpublished Ph.D Thesis, Obafemi Awolowo University, Ile-Ife.
8. Reyes, L. H. and Stanic, G. M. A. (1988). Race, Sex, Socio-economic status and Mathematics – Journal for Research in Mathematics Education 19 (1), 26-40.
9. Salman, M. F. (1997). Effects of mathematical language as advance organizer on senior secondary students' performance in mathematical word problem.Unpublished Ph.D. Dissertation. University of Ilorin, Ilorin, Nigeria