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Research Management Cell,
Tribhuvan University, Sanothimi Campus, Sanothimi, Bhaktapur

Exploring Cognitive Skills and Academic Achievement in Geometry among Secondary Level Students in Nepal

Shree Prasad Ghimire (Principal Author)
Assistant Professor, Department of Mathematics Education
Tribhuvan University-Mahendra Ratna Campus, Tahachal
shreeprasad.ghimire@mrc.tu.edu.np
ORCID iD: https://orcid.org/0009-0002-9697-2949

Krishna Chandra Paudel (corresponding author)
Assistant Professor, *Department of Mathematics Education*
Tribhuvan University-Mahendra Ratna Campus, Tahachal
kcpaudel@trinitycollege.edu.np
ORCID iD: https://orcid.org/0000-0003-3381-0248

Abstract

Cognitive skills are essential for conceptual learning in geometry. In this study, the students' cognitive skills and academic achievement in learning geometry under four levels of cognitive domains have been explored through a mixed-method approach. Comprehensive analysis of the performance of students in geometry through achievement test have been used on the basis of Bloom's Taxonomy for Secondary Level Curriculum of Nepal in order to explore the cognitive skills of students. The achievement scores of geometry achievement test from the 32 students of grade IX in an institutional school located in Kathmandu district have been analyzed. The achievement scores were analyzed under gender, age, and correlations between different cognitive levels. The results of this study shows that the students' have high level of competencies in knowledge level problems (mean score: 8.59 out of 10) and faced greater challenges in higher ability thinking skills (mean score: 3.19 out of 10). Similarly, the scores based on gender pattern with male students' performance is higher in knowledge and application levels, whereas female students have better performance in understanding and higher ability levels. It is further suggested that the specific opportunities for targeted instructional interventions to enhance students' skills and achievement across all levels of cognitive domains, particularly in fulfilling the gap between conceptual understanding and practical aspects.

Keywords: *Assessment, cognitive complexity, performance analysis, geometry, educational measurement*

Introduction

Students' engagement, retention, and application of knowledge in education across different levels of cognitive domains has become a critical part of successful teaching and learning (Anderson et al., 2001). To find the variety of cognitive processes related to students' understanding, and thorough evaluation measures beyond one dimension assessments are necessary due to the complexity of mathematical learning, especially in geometry (Van de Walle et al., 2019). In order to obtain a more pictures of learning outcomes, current educational research highlighted the significance of assessing students' performance across various levels of cognitive difficulty (Webb, 2002; Marzano & Kendall, 2007). Besides giving educators with useful information to guide instructional decisions and raise students' accomplishment, this multifaceted approach in assessment is accepted in educational frameworks (Stronge, 2018). The study based on the theoretical framework of important educational systems. The updated version of Bloom's Taxonomy by Anderson and Krathwohl (2002) suggest a hierarchical framework for comprehending cognitive tasks ranging from simple memory to intricate assessment and production. The development of assessment techniques that measure various degrees of cognitive engagement has benefited significantly from this method (Krathwohl, 2002). Furthermore, Webb's (2002) depth knowledge paradigm, which highlighted the difference between content complexity and cognitive demand, delivered supplementary insights on the cognitive complexity useful for various task. The significance of assessing mathematical literacy across several cognitive domains is further supported by the OECD's Programme for International Student Assessment (PISA) framework that defines mathematical competency as the capacity to formulate, apply, and interpret mathematics in a different context (OECD, 2021). This worldwide viewpoint focused on the multidimensional evaluation in mathematics education that is accepted widely.

Significance of Research

There are special opportunities and challenges for cognitive development in geometry education. Students studying geometry must develop logical thinking, abstract conceptualization, and visual-spatial reasoning, in contrast to other mathematical fields that mostly depend on computational processes (Battista, 2007). Similarly, Clements and Battista (1992) found that, geometric thinking changes at different stages, from formal deduction to visual recognition, demanding instructional strategies that simultaneously target several cognitive characteristics. The importance of this study determines its examination of students' performance in four levels of cognitive domain related to geometry instruction. This study adds to the expanding of the research on differentiated teaching and personalized learning strategies in mathematics education by looking along age factors, gender disparities, and achievement patterns (Tomlinson, 2017). In this context, this study has formulated the following research questions.

Research Questions

The main purpose of this study was to address the following research questions:

1. What is the overall achievement pattern of students in geometry across different cognitive domains?
2. How do performance patterns differ between male and female students across cognitive domains?
3. What relationships exist between age of students and their achievement across different cognitive complexity levels?

Review of Literature

This section explores the theoretical association of the literature related to the cognitive aspect of learning geometry and its importance for cognitive development of students. The following theoretical review of literature shows the important of cognitive development in geometry learning.

Cognitive Complexity in Mathematics Education

Over the past few decades, academicians have developed increasingly complicated frameworks to describe how pupils process mathematical information, leading to a considerable evolution in the concept of cognitive complexity in mathematics education. Four stages of cognitive complexity are distinguished by Webb's (2002) such as: Depth of Knowledge model: it helps in expanded thinking, skills and concepts, recall and replication with strategic thinking. This framework gives teachers as a means to create tests and lessons that cater to various cognitive demands. It also has had a significant impact on mathematics education.

According to Stein et al. (2009), students' learning outcomes are substantively impacted by the degree of cognitive load in mathematics problems. Their research on the mathematical tasks' framework demonstrated that higher-level cognitively demands the tasks to enhance conceptual knowledge and problem-solving skills. They also indicated that careful attention to task execution and classroom discourse is necessary to sustain a high cognitive demand during education. This knowledge was expanded by Brookhart (2010), who looked into how educators might evaluate higher ability levels in the classroom. According to Brookhart (2010), many teachers found it difficult to create tests that fairly measure intricate cognitive processes; instead, they frequently fell back on simpler recall exercises that didn't adequately represent students' actual mathematical aptitude.

Gender Differences in Mathematical Performance

The picture highlighted by the research on gender disparities in mathematics ability is nuanced and constantly changing. Male advantages in mathematical reasoning significantly in spatial and quantitative tasks, that were shown by early studies by Maccoby and Jacklin (1974). These findings have been challenged by more recent meta-analytic research, which has shown more complex trends of performance disparities connected to gender. In an examination data from international mathematics assessments, according to Hyde and Mertz (2009) found gender disparities in mathematical ability fluctuate greatly depending on the culture and educational setting. According to them, gender inequalities in mathematics achievement are primarily caused by sociocultural variables rather than inborn cognitive differences. Moreover, women generally perform better than men in all areas of academic achievement, including mathematics (Voyer & Voyer, 2014). They asserted, nevertheless, that performance patterns change greatly based on the particular cognitive demands of various mathematics tasks and evaluation styles.

Similarly, Ganley and Lubienski (2016) claimed that the association between gender and mathematical performance is largely mediated by these affective characteristics that explicitly look into gender variations in mathematical confidence and fear. According to them, addressing the emotional and motivational components of learning mathematics might be essential to reducing achievement differences associated with gender.

Age and Developmental Factors in Mathematical Learning

Educational psychology has conducted a great work of the study on the connection between age, cognitive development, and mathematics learning. According to Piaget's theory of cognitive development, students in formal operational periods emerges throughout adolescence, and mathematical comprehension follows predictable developmental stages (Inhelder & Piaget, 1958). The idea of universal developmental phases has been contested by more recent research, which places more emphasis on the need of domain-specific knowledge and educational experiences in mathematics learning (Carey, 2009). According to Siegler and Chen (2008), learning trajectories are significantly influenced by individual differences, and mathematical progress is characterized by overlapping waves of method use rather than distinct stages.

Likewise, Kaya et al. (2015) verbal abilities and academic achievement have strong correlation than nonverbal abilities. Moreover, readiness to learn is related to verbal abilities while the potential to learn is related to the nonverbal abilities. This study specifically looks into the association between age and mathematical skill in geometry. According to them, motivation, prior knowledge, and the quality of the education may have a greater impact on mathematics performance than developmental preparation.

Integrated Approaches to Cognitive Skill Development

The significance of integrated approach in the development of cognitive skills is being focused more and more in existing mathematics education research. Scholars support instructional practices that directly link to the knowledge, understanding, application, and higher-ability skills rather than treating various cognitive domains as different entities (King et al., 2013). The significance of iterative connection between procedural fluency and conceptual understanding in mathematics learning is established by Rittle-Johnson et al. (2015). Instead of having students move linearly through cognitive hierarchies, their findings implied that effective training should provide them to several opportunities to move freely between different forms of mathematical thinking. Willingham (2007) argued that content knowledge alone could not freely develop higher level thinking capabilities, which necessitate intentional training and practice. Besides scaffolding, numerous opportunities for application in a variety of circumstances might be necessary for the maximum development of complex cognitive skills.

Methodology

This section deals with research design, participants, and tools for data collection. data analysis procedures, including its conclusion of the study. To investigate students' performance trends in geometry education across several cognitive domains, this study used a quantitative descriptive research methodology. Using a cross-sectional methodology, this research investigated the correlations between age, gender, and cognitive ability by gathering data from achievement tests of students in a certain cross-sectional study. Given that it enables a methodological examination of current performance patterns without modifying instructional variables, the descriptive research design was a suitable selection for the goals of this study (Creswell & Creswell, 2017). By using this method, researchers have found special patterns and their connections in students who collected the data that might guide experimental research and future instructional interventions. Altogether thirty-two students studying in Grade IX from an institutional school in Kathmandu district made up the study sample. To guarantee equal representation across important demographic characteristics of the sample was carefully chosen as mentioned below:

Table 1.

Demographical Characteristics of the Sample

Gender		Age level	No. of Students	Mean Score	SD
Male	Female	13	5		
16	16	14	8		
Percentage		15	17	14.8	1.2
50%	50%	16	1		
		17	1		

In order to guarantee uniformity in teaching strategies and curriculum requirements, the institutional school was chosen. According to National Curriculum Framework 2015 for secondary level mathematics, all the students in the sample of the study has completed the specified course of geometry.

Construction of Geometry Achievement Test Items

For the use of students' performance in geometry, the teacher made achievement test items has constructed from the concept of geometry under four levels of cognitive domain. The constructed items were evaluated by the 4 experts (two university professors, and two schools' teachers). Researcher has calculated the p-value (difficulty level) and D- value (Discrimination index) of each of the items after taking the pilot test in any one of the schools other than sampled school. The items were selected after deletion and modification of items with its p-value ranges from 30% to 70% and D- value ranges from 0.30 to 0.70. The final items were constructed and applied for the achievement test in geometry (Ghimire, 2025). The achievement test items were constructed by considering the Bloom's Taxonomy by Anderson et al, (2001) as follows:

1. Knowledge level (10 ×1 = 10 marks) Evaluation of fundamental idea identification, terminology recognition, and factual recall.
2. Understanding level (10 ×1 = 10 marks): Assessment of interpretation, explanation, and conceptual comprehension capabilities.
3. Application level (10×1 = 10 marks): Evaluation of problem-solving skills in known contexts and knowledge transfer to novel ones.
4. Higher Ability level (10 ×1 = 10 marks): Evaluation, synthesis, analysis, and creative thinking abilities assessment.

Each domain made an equal contribution to the final evaluation, which had a maximum possible score of 40 points. All cognitive levels are given the proper attention during the examination process.

Content Validity and Reliability

To guarantee content validity and reliability, the evaluation tool was subjected to rigorous validation processes. All assessment items were examined by a panel of three experts in mathematics education to ensure that they were appropriate for the grade level and in line with cognitive domain criteria. To guarantee accuracy and clarity, items were updated with the response of experts. A different sample of 30 students from a community school were participated in pilot testing to assess item difficulty, discrimination, and exploration of internal consistency of each item. The structures, levels and clarity of language were improved for the construction of better test items.

Data Collection Procedures

In the process of data collection, regular class structures were taken to minimize disturbance in instructional practices, and achievement tests were conducted during regular class hours over two weeks. Under the same conditions with uniform instructions and time allotments for each participant, students have completed the test. To guarantee uniformity in execution, the researcher observed and administered the test. In order to reduce test anxiety and promote genuine achievement, students were told that their performance would only be utilized for research and would not have an impact on their academic results.

Data Analysis

Descriptive as well as inferential statistical were used in data analysis of quantitative data with SPSS 27. The mean, standard deviations and frequency were calculated with the help of geometry achievement test (GAT). Further, the Pearson coefficient of correlations was used in analyzing the connection between various cognitive levels. The analysis of the performance of students was calculated in 0.05 level of significance to determine the statistical significance. Cohen's d was used to compute effect sizes to access the observed differences with its practical importance.

Results and Discussion

This section deals the findings of data based on the students' performance under four levels of cognitive domain. The analysis was done by considering the scores obtained by the students in the geometry achievement test.

Overall Performance Analysis

Significant trends in achievement across the evaluated cognitive domains are shown by analyzing the total performance of the students. The students' overall achievement rate was 55.1%, with mean score 22.06 out of 40 available points. The majority of students cluster around the mean performance level, as indicated by the standard deviation of 2.84 shows there was reasonably consistent performance across the student group. Further information on achievement trends were collected from the distribution of total scores. Out of the 26 students, (81.3%) received scores in the 20–24 range. 9.4% of students (n = 3) achieved scores of 25 or higher. Three students, or 9.4% of the total, received scores below 20.

According to this distribution, comparatively few students performed the achievement range, indicating most students showed adequate understanding of the examined topic. This trend suggests generally successful training, however there are possibilities to improve achievement across all performance levels (Hattie, 2009).

Performance in all Cognitive Domains

A distinct pattern of diminishing achievement as cognitive difficulty rises has been revealed by the examination of performance across several cognitive aspect. This finding aligns with established research on cognitive hierarchy and learning progression (Anderson et al., 2001; Webb, 2002). In this context, the following table 1 shows the students' performance in geometry in different cognitive levels.

Table 1.

Student Performance in different Cognitive Levels

Cognitive Domain	Mean	SD	Proficiency Level
Knowledge	8.59	1.24	59.4%
Understanding	6.16	1.89	50.0%
Application	4.13	1.76	31.3%
Higher Ability	3.19	1.45	37.5%

Students' performance in the Knowledge level was the best, averaging 59.4 % of the possible marks. This shows that students remember fundamental geometric concepts, vocabulary, and procedures and have successfully absorbed fundamental and factual information. The very low standard deviation (1.24) suggests that there was the consistent performance of students in this area. Performance in the understanding domain decreased to 50 % of potential points, and more variability (SD = 1.89), indicating more individual variance in conceptual comprehension skills. This trend suggest that the majority of students are able to recall facts, fewer are able to effectively that there was a strong conceptual comprehension of geometric principles. In the application level, only 31.3% of students reached competence levels, indicating a more significant decreased in performance. Similarly, there was very low-level performance of students in higher ability (37.5 %) but it is more than the application level. This shows that students have insufficient application skills in geometry in real life. This conclusion raises serious concerns about the difficulties of applying expertise to innovative problem-solving situations, which is consistent with Willingham's (2007) research on the subject. In comparison to the application level, slightly more students (37.5%) attained proficiency in the Higher Ability domain. This surprising trend could be a result of individual variances in analytical thinking skills or the design of the evaluation system and provided task.

Gender-based Performance Analysis

Complex patterns that differ greatly across cognitive domains are revealed by analyzing gender disparities in performance. With male students averaging 22.31 points (55.8%) and female students averaging 21.81 points (54.5%), the gender gap in overall performance was negligible. Statistical significance was not reached for this 0.50-point difference. The following table 2 represent the achievement of students according to their gender and cognitive domain.

Table 2.

Gender Differences by Cognitive Domain

Level of Cognitive domain	Mean and SD of boys	Mean and SD of Girls	Difference in Mean	Effect Size (d)
Knowledge	9.00 (1.03)	8.19 (1.33)	0.81 (M)	0.67
Understanding	5.94 (1.73)	6.38 (2.06)	0.44 (F)	-0.23
Application	4.44 (1.59)	3.81 (1.91)	0.63 (M)	0.36
Higher Ability	2.94 (1.34)	3.44 (1.53)	0.50 (F)	-0.35

Note: *Used by SPSS 27 with 0.05 level of significance*, *M= Male, F= Female*

Different patterns of cognitive capacities between genders have been revealed by the investigation. In the knowledge levels, male students showed statistically significant advantages (Mean 9.00, SD 1.03, d = 0.67), indicating better performance in tasks involving factual memory and fundamental concept recognition. In application level, male students also shown numerical advantages, although this difference was not statistically significant. Although these differences were not statistically significant, female students showed strengths in the understanding and higher ability level. According to the trend, male students did better on tasks requiring information recall and practical application, while female students perform better in conceptual comprehension and sophisticated analytical thinking. These results are somewhat consistent with Voyer and Voyer's (2014) meta-analytic study, which discovered that women generally did better than men on higher-level cognitive tests. The findings of the current study, however, point to a more complex pattern than is usually documented in the literature, with both genders displaying unique cognitive capabilities. Ghimire & Paudel (2024) found that High motivation, understanding of contents, self-paced learning, increase the achievement in mathematics.

Age-related Performance Patterns

Unexpected results from the examination of age-related performance patterns create doubt on widely held beliefs regarding cognitive task associated with development of child. Although these results were found in small sample sizes for specified age groups, they offer interesting new information for further study.

Table 3.

Age-Related Performance Analysis

Age (years)	n	Mean	SD	Mean (%)
13	5	22.40	2.30	56.0%
14	8	21.50	3.39	53.8%
15	17	21.56	2.96	53.9%
16	1	23.00	-	57.5%
17	1	22.00	-	55.0%

The youngest students with age 13 perform better with the group mean, attaining 56.0% which challenges the developmental theories. This research casts doubt on presumptions regarding age-related cognitive task benefits and increases the possibility that variables other than chronological age could be more important indicators of mathematical achievement. 14-year-olds did the worst performance i.e., 53.8%, while the largest group (15-year-olds) performed marginally worse at 53.9%. These trends imply that chronological age is not a good indicator of geometric achievement within the age range under study. Age did not significantly influence performance in this population, as demonstrated by the lack of statistically significant variations across age groups. This result is aligned with research by Kaya et al. (2015), which suggests that individual motivation, prior knowledge, and instructional quality may have a greater influence on mathematical performance than developmental preparation.

Correlation Analysis between Cognitive Domains

The relationships between various mathematical thought processes and the degree to which students acquire integrated cognitive skills can be understood through correlation analysis between various cognitive domains.

Table 4.

Correlation between Different Levels of Cognitive Domain

Levels of Cognitive Domain	Knowledge	Understanding	Application	Higher Ability
Knowledge	1.00	.34*	.52	.28
Understanding	.34*	1.00	-.12	.41*
Application	.52	-.12	1.00	.15
Higher Ability	.28	.41*	.15	1.00

Note 1. *Analyzed with SPSS 27 in 0.05 levels of significance*

** Represent the correlation is significant in 0 .05 level,*

Numerous significant patterns in the connections between cognitive domains are explored by the correlation analysis. The knowledge and application levels have the greatest positive connection (r =.52), indicating that students who have a solid foundation in factual knowledge are better equipped to situations involving problem-solving. Theoretical frameworks that stress the value of strong knowledge on efficient application skills are supported by this conclusion (Willingham, 2007). Although it is not a strong anticipate from hierarchical models of cognitive development, a moderately positive correlation between knowledge and understanding (r =.34, p <.05) suggests that factual information and conceptual understanding grow in complementary pattern. Students who exhibit excellent conceptual knowledge are more likely to succeed in difficult analytical tasks, according to the moderately positive correlation (r =.41, p <.05) between the knowledge and higher ability levels. This result is consistent with studies that highlight the value of profound conceptual knowledge for the development of higher-order thinking. Although, there is no statistically significant, the connection between the understanding and application levels is found surprisingly negative (r = -.12, p =.51). This surprising finding explores the possibility that some students may acquire comprehension and application skills on their own, that helps in applying teaching strategies that prioritize the different areas independently.

Conclusion

Multiple works decreased the capacity for processing the information and retain it for a long time that creates low performance in the work (Boere, Anderson, Hecker & Krigolson, 2024). Although this pattern is consistent with previous studies on cognitive hierarchies and learning development (Anderson et al., 2001; Webb, 2002), it also draws the attention to important instructional issues that need for precise interventions. The impressive performance in the knowledge area (85.9% of possible points) shows that the way that teaching is currently delivered supports factual learning and the acquisition of fundamental concepts. However, the significant declining in higher ability (31.9%), Understanding (61.6%), and Application (41.3%) performance suggests that students find it difficult to transition from memorization to deeper conceptual understanding and transfer of knowledge and skills. This pattern supports the findings of the study by Willingham (2007), who contends that learning content information alone is not sufficient to promote higher-order thinking skills; rather, specific training is necessary. The results imply that in order to support students in developing integrated cognitive skills that connect information, comprehension, and application, that gives more organized support. A remarkable difference that advantages more research is the comparatively higher performance in higher ability as opposed to application levels (31.9% vs. 41.3%). The nature of the assessment tasks may be reflected in this pattern, with higher ability items possibly offering more structured support for analytical thinking and application tasks requiring more autonomous knowledge transfer to new contexts. The study findings on gender-based performance patterns highlighted a more complex picture than is usually presented in the literature on mathematics education. While overall performance differences were minor, the different patterns of cognitive capabilities reveal substantial implications for personalized education.

The prominent performance advantage of male students in the Knowledge domain (d = 0.67), which might be due to their preferred methods of learning or to teaching strategies that emphasize factual recall and appreciation in tests. Nonetheless, the numerical advantages of female students in the understanding and higher ability level point to capabilities in analytical thinking and conceptual comprehension that should be acknowledged and used in instructional design. These results have the implication that both male and female students have unique cognitive talents that can support mathematical learning, which challenges conventional narratives about gender differences in mathematics. Teachers should think about how to build on these various strength patterns rather than concentrating on shortcomings in order to assist the growth of all students across cognitive areas. The trends found the consistent with the ones propounded by Ganley and Lubienski (2016), who stressed the significance of addressing emotional and motivational elements in the learning of mathematics. All children might benefit from instructional strategies that acknowledge and validate their unique cognitive abilities.

Common beliefs about age-related benefits in cognitive activities have called into question by the detection that younger students (age 13) scored better than average. This finding implies that, especially within the very small age range examined, chronological age may not be significant in predicting mathematical achievement as previously thought. This finding has significant consequences for educational practice, indicating that teachers should prioritize instructional quality and individual learning requirements over age-based goals. Younger pupils' excellent performance might be the result of things like individual cognitive powers that go beyond ideas of developmental stages, motivation, past knowledge, or educational experiences. The absence of notable age-related variations is consistent with recent studies that highlight the importance of domain-specific knowledge and educational experiences in mathematics learning (Carey, 2009).

These results indicate that individual characteristics and successful teaching methods might be more important predictors of success than age or expected developmental preparedness.

Important information about how children acquire integrated cognitive skills is revealed by the correlation analysis. Theoretical frameworks that stress the significance of knowledge bases for skill transfer are supported by the substantial positive correlation ($r = .52$) between knowledge and application, which implies that factual knowledge serves as a basis for problem-solving skills. Nonetheless, a significant instructional issue is the poor and negative association ($r = -.12$) between understanding and application level. This pattern suggests that students may be developing conceptual understanding and application skills in isolation rather than as integrated abilities. This conclusion suggests the necessity for methods that directly link conceptual learning with real-world application, which has important ramifications for instructional design. Though not as strong as one might anticipate, the moderate association between understanding and higher ability ($r = .41$) suggests that conceptual comprehension fosters analytical thinking. This implies that there may be chances to use focused teaching techniques to improve the relationships between conceptual knowledge and sophisticated reasoning abilities.

Implications for Instructional Practice

The conclusions of this study highlighted a number of significant implications for geometry instructional practices.

Explicit Higher-Order Thinking education. The need for explicit education in higher level thinking skills is indicated by the fall in performance throughout cognitive complexity levels. Instead of trusting that students would acquire analysis, synthesis, and assessment skills solely from content knowledge, educators should offer systematic guidance to help students develop these abilities.

Integrated Skill Development. The necessary requirement for effective teaching strategies that specifically link various forms of mathematical thinking. It is indicated by the weak connections found between several cognitive areas. Teachers' ought to create lessons that support students in bridging the gaps between their knowledge, comprehension, and application abilities. It helps for the unique patterns of cognitive strengths between the sexes focused for the possible advantages of using instructional tactics that are tailored to each individual. Teachers should identify and build on various patterns of strength while offering support for areas of relative weakness, rather than viewing gender differences as scarcities.

Individual-Centered. Since there aren't any significance age-related distinctions, instructional preparation that prioritize meeting to each student's unique learning needs over age-based expectations. Instead of making chronological age the main consideration in instructional design, educators should concentrate on diagnostic evaluation and individualized support.

Transfer Skill Development. The application domain comparatively poor performance indicates that transfer skills needed to develop special attention. Teachers should give students several chances to use their knowledge in different settings while providing the appropriate support and scaffolding.

This thorough examination of students' performance in geometry in different cognitive areas offers important and novel perspectives on the complex relationships between geometry learning and students' success. The study highlights the student cohort's advantages and disadvantages, with obvious implications for teaching methods and educational policies. Helping students transition from memorization to deeper conceptual engagement and skill transfer is a fundamental difficulty in mathematics education, as seen by the persistent performance loss that occurs as the rises of cognitive complexity. Students need extra help to build integrated cognitive abilities that connect understanding, application, and higher ability thinking skills, even while they demonstrate great basic knowledge.

According to the study, gender-based performance patterns, male and female students each have unique cognitive capabilities that should be acknowledged and used to their advantage in instructional design. Teachers should think about ways to build on different strength patterns to assist the mathematical growth of all kids rather than seeing these variances as limitations. The discovery that chronological age is not a significant predictor of performance within the range under study calls into question accepted notions about developmental readiness and raises the possibility that learning experiences, individual characteristics, and instructional quality may have a greater influence on mathematical achievement than age-based expectations. Importantly, both the encouraging relationships and the distressing gaps in skill integration that have been revealed by the correlation patterns among cognitive levels. Although application skills seem to be supported by knowledge, the limited correlation between comprehension and application indicate important areas for instructional development through strategies that link conceptual learning to real-world problem-solving.

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