International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Geometric Proof Struggles on Academic Achievements in Mathematics Among Third Year College Students

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Abstract

This study examines the struggles of third-year college students in solving geometric proofs and their impact on academic performance, understanding of geometric concepts, and overall attitudes toward mathematics. Employing qualitative methods, the research identifies specific challenges such as difficulties in understanding abstract geometric principles, limited logical reasoning skills, and a lack of connection between theory and application. Key contributing factors include insufficient prior exposure, gaps in foundational knowledge, and traditional instructional methods. The study also explores the influence of these struggles on students' confidence, motivation, and attitudes, revealing that persistent difficulties often lead to reduced self-esteem, decreased engagement, and heightened anxiety.

Additionally, the strategies employed by students to overcome these challenges are analyzed, ranging from collaborative learning and the use of visual aids to structured problem-solving routines. While some strategies are perceived as effective, others highlight the need for targeted interventions to address underlying issues. The findings underscore the importance of adopting innovative teaching approaches, incorporating interactive tools, and fostering supportive learning environments to enhance students' proficiency in geometric proofs and their overall mathematical competence. This research contributes to the understanding of how struggles with geometric proofs shape students' learning experiences and provides actionable recommendations for educators to improve instruction in this critical area of mathematics.

Keywords: Geometry, Proof, Struggles, Academic Achievement

INTRODUCTION

A key component of teaching mathematics, particularly in higher education, where students are expected to hone their analytical, logical, and problem-solving skills, is the use of geometric proofs. Geometric proof is one of the more difficult ideas, and mathematical challenges become more complex as students' progress through their academic careers. Geometry requires spatial reasoning, but the ability of creating strong proofs may be quite difficult for pupils, especially in third-year college, where advanced mathematical proficiency is demanded.

Mamiala et. al (2021) indicated that the students worry that they might answer poorly when they are asked any Geometry question. The results also revealed that students were worried and concerned about their poor performance in Geometry. More than half (61%) of the students felt inadequate as far as Geometry

is concerned. The results also revealed that 71% of the students indicated that they were worried that they might give a wrong answer when the teacher asked questions. It is recommended that teachers be trained on how to present Geometry in a flexible manner that accommodates students' basic understanding of the subject.

In this situation, it becomes crucial to comprehend how these difficulties affect academic performance. Many third-year college students struggle to understand geometric proofs, especially those studying mathematics or related fields. In addition to impairing their understanding of geometry, these difficulties might also have wider effects on how well they perform in math classes as a whole. The connection between students' academic performance and their difficulties answering mathematical problems has been pointed up in earlier studies, but little is known about the precise impact of difficulties with geometric proof.

Juman et.al (2022) the study revealed that students had greater difficulties in learning Geometry such as drawing diagrams for a given geometric problem and applying more than one theorem to solve a given Geometry problem. Furthermore, Students' disinterest in the Geometry component and their family background affects their Geometry learning. Additionally, results from the teaching experiment indicate that the student-based learning approaches are more effective than conventional methods for teaching Geometry.

The purpose of this study is to evaluate how geometric proof difficulties affect third-year college students' academic performance in mathematics. The research aims to give a better knowledge of how issues in this area may influence overall academic success by examining the factors that contribute to these struggles—from cognitive challenges to instructional methods—and evaluating their effects on performance. The study will also look at methods that can help students get beyond these challenges, improve their mathematics skills, and achieve better academic results.

The study's conclusions will advance the field of mathematics education by providing information on how to handle geometric proof problems in college-level courses. In order to create an atmosphere where students can flourish and succeed more in their mathematical pursuits, the research aims to provide guidance for curriculum development and instructional strategies.

Statement of the Problem

This study aims to examine the struggles with geometric proofs and their connection to the academic performance of third- year college students in mathematics. Specifically, it seeks to address the following questions:

1. What specific challenges do third- year college students encounter when solving geometric proofs, and what factors contribute to these difficulties?
2. How do struggles with geometric proofs shape students' understanding of geometric concepts and their overall learning experience in mathematics?
3. In what ways do struggles with geometric proofs influence students' confidence, motivation, and attitudes toward mathematics as a subject?
4. What strategies or approaches do students use to overcome difficulties in solving geometric proofs, and how effective do they perceive these strategies to be?

Methodology

Research Design

This study utilized a phenomenological research design, a qualitative approach used to analyze the struggles faced by third-year college students in solving geometric proofs. The design enabled the identification of specific challenges, contributing factors, and the effectiveness of strategies students employed, providing a comprehensive understanding of their experiences and attitudes.

Research Participants

The participants of the study were 10 third-year college students enrolled in mathematics-related courses at one of the local colleges in Panay. The participants were purposively selected based on their enrollment in geometry courses where geometric proofs are a major component. The group included students with varying levels of academic performance to ensure diverse perspectives.

Research Locale

The participants of the study were 10 third-year college students enrolled in mathematics-related courses at one of the local colleges in Panay. The participants were purposively selected based on their enrollment in geometry courses where geometric proofs are a major component. The group included students with varying levels of academic performance to ensure diverse perspectives.

Research Instrument

Data collection involved a combination of tools to ensure depth and accuracy. A structured questionnaire was used to assess the challenges students face, their strategies for overcoming difficulties, and their perceptions of the effectiveness of these strategies. Additionally, open-ended questions were included to gather qualitative data on students' attitudes, experiences, and insights.

Data Gathering Procedure

The data gathering process for this study was conducted systematically to ensure comprehensive and reliable results. Initially, the research instrument, consisting of a structured questionnaire and open-ended questions, was prepared and subjected to a validity testing. This preliminary step, allowing the researcher to assess the clarity and the validity of the questions.

Following this, the finalized questionnaire was administered to the participants during scheduled classroom sessions. The researcher provided clear instructions to ensure that the students understood the purpose of the study and the procedure for completing the questionnaire. Participants were encouraged to respond honestly, particularly in the open-ended sections, where they were asked to share detailed insights about their challenges, strategies, and experiences with geometric proofs. The researcher was present throughout the data collection to address any queries and clarify doubts, fostering a supportive and non-intimidating environment.

Once the questionnaires were collected, the data was organized and analyzed. Qualitative responses from the items were processed to identify trends and patterns related to the difficulty's students have encountered and the effectiveness of their strategies. Simultaneously, qualitative responses were carefully reviewed, coded, and categorized to uncover recurring themes and unique perspectives. This qualitative analysis provided a well-rounded understanding of the struggle's students face with geometric proofs and their broader implications for learning.

Results and Discussion

Challenges with Geometric Proofs

The study revealed several challenges of a third-year college students face when solving geometric proofs.

A prominent difficulty lies in understanding abstract geometric concepts, as many students struggle to visualize relationships between geometric elements and interpret diagrams accurately. This gap often leads to confusion and errors in constructing logical arguments required for proofs.

Student A, D, E, F, G, H and J stated that "Geometric proofs are complicated when it comes to reasoning and memorizing since it has a lot of theories, postulates and axioms. Sometimes the given figures are complicated".

Student B, C, and I stated that "They cannot easily understand some terms and statements in proving geometric proofs"

This supports the study of Matheou A. A., & Panaoura Rita (2021) which indicated that students had plenty of difficulties to solve tasks related to geometric proof which were presented to them verbally and without any figure.

Another critical challenge is the lack of connection between theoretical knowledge and practical application. While students may memorize geometric postulates and theorems, they often fail to apply these principles effectively in proofs. This disconnection is compounded by a limited proficiency in logical reasoning, a skill integral to structuring proofs. Students frequently encounter difficulty in formulating deductive steps, identifying relevant theorems, and justifying each part of the proof coherently.

Student E "when solving geometry, it's quite hard for me because sometimes I forgot what theorems, axioms and postulates that I will going to use in proving a statement.

This supports the study of Al Masri, Hanan Moukhtar (2013) which indicates that students' difficulties when constructing and formulating geometric proofs were related to difficulties in understanding the proof, setting proof plans, understanding applying mathematical concepts, comprehending mathematical text, and writing mathematical text.

Moreover, several factors contribute to these struggles. Insufficient prior exposure to geometric proofs during earlier stages of education leaves students unprepared for the rigorous demands of college-level geometry. Foundational knowledge gaps, particularly in algebra and logic, further hinder their ability to approach proofs systematically.

Student A, B, C, D, E, F, G, H, I and J mentioned "They lack prior knowledge about geometric proofs, and sometimes, they lack reviews and understanding of several concepts in geometry.".

Instructional methods also play a significant role. Traditional teaching strategies that emphasize rote learning over critical thinking fail to equip students with the skills needed to navigate the complexities of geometric proofs. Limited use of interactive or exploratory teaching tools, such as dynamic geometry software, further restricts students' ability to engage with geometric concepts intuitively.

Impact on Confidence and Motivation

Moreover, psychological factors, such as test anxiety and a lack of confidence in their mathematical abilities, were observed to exacerbate these difficulties. Students often perceive proofs as overwhelming due to their unfamiliar structure and the level of precision required. Time constraints during problem-solving assessments also increase pressure, leading to incomplete or incorrect proofs.

Student A, B, C, D, E, F, H, I and J mentioned that "It affects their confidence in solving geometric because of a doubt if their answers are correct or not"

This supports the study of Mamiala et. Al (2021) which indicates that the students worry that they might answer poorly when they are asked any Geometry question. The results also revealed that students were worried and concerned about their poor performance in Geometry. More than half (61%) of the students

felt inadequate as far as Geometry is concerned. The results also revealed that 71% of the students indicated that they were worried that they might give a wrong answer when the teacher asked questions.

Reflection on Learning Experiences

The findings highlight the need for targeted interventions to address these challenges. Integrating step-by-step proof strategies into the curriculum can help students build confidence and develop logical reasoning skills incrementally. The use of technology, such as interactive geometry software, can make abstract concepts more tangible, fostering better comprehension and application. Additionally, revisiting foundational topics and incorporating collaborative learning opportunities could enhance students' ability to approach proofs systematically. Lastly, creating a supportive learning environment that reduces anxiety and builds confidence is essential to improving performance in geometric proofs.

Student A, B, C, D, E and H mentioned that "The instructor or a professor should discuss it articulately and use simple words that could be easily to understand".

Student F, G, I and J mentioned "The lesson in geometry especially in proving, must be taught clearly and use a step-by-step process during the discussion".

Impact of Struggles with Geometric Proofs on Students' Understanding and Learning Experience

The challenges faced in solving geometric proofs significantly influence students' understanding of geometric concepts and their overall learning experience in mathematics. Students who encounter difficulties with proofs often develop fragmented knowledge, leading to misconceptions about fundamental geometric principles. For instance, their inability to link axioms and theorems to practical applications creates gaps in their conceptual framework, limiting their capacity to see geometry as a coherent system.

Furthermore, struggles with proofs can affect students' confidence and attitude toward mathematics. Repeated failures in constructing proofs may result in frustration, diminishing their motivation to engage with the subject. This negative perception can extend beyond geometry, impacting their broader mathematical learning experience and reducing their willingness to tackle complex problems.

Despite these challenges, the process of grappling with proofs also presents opportunities for growth. When adequately supported, students can develop critical thinking, logical reasoning, and problem-solving skills. However, these positive outcomes are contingent upon effective instructional methods that address their struggles and build a supportive learning environment.

Influence of Struggles with Geometric Proofs on Confidence, Motivation, and Attitudes Toward Mathematics

Struggles with geometric proofs have a profound impact on students' confidence, motivation, and overall attitudes toward mathematics as a subject. Students who face consistent difficulties in solving proofs often experience a decline in self-confidence. This erosion of confidence stems from repeated failures, making them question their mathematical abilities and feel less capable of tackling challenging problems.

These struggles also diminish students' motivation to engage with mathematics. A lack of success in constructing proofs can lead to frustration and disinterest, as students perceive the subject to be overly complex or inaccessible. Without intervention, this reduced motivation may extend to other areas of mathematics, further impeding their academic progress.

Moreover, students' attitudes toward mathematics are shaped by their experiences with proofs. Negative experiences can foster feelings of anxiety or aversion, causing them to view mathematics as intimidating

or irrelevant to their lives. Conversely, when struggles are addressed effectively, students may develop resilience and a more positive perspective, seeing challenges as opportunities for growth rather than barriers.

Strategies and Approaches Used by Students to Overcome Difficulties in Solving Geometric Proofs

Students employ a variety of strategies to address the challenges they face in solving geometric proofs. One common approach is seeking help from peers or instructors. Collaborative learning allows students to clarify concepts, exchange problem-solving techniques, and build confidence in their understanding. However, the effectiveness of this approach often depends on the availability of knowledgeable peers or the accessibility of instructors.

Another frequently used strategy is reviewing class notes, textbooks, or online resources. Students may revisit examples of solved proofs to understand the logical steps required. While this strategy helps reinforce theoretical knowledge, it is often perceived as moderately effective, especially if students lack the foundational skills to connect concepts independently.

Some students adopt trial-and-error methods, attempting various approaches until they arrive at the correct solution. While this approach can lead to occasional success, it is generally inefficient and may reinforce misconceptions if not guided by a clear understanding of geometric principles.

More proactive students may use visual aids and diagrammatic representations to simplify problems and gain insights into geometric relationships. This approach is widely regarded as effective, as it helps students conceptualize abstract ideas and plan their proofs systematically.

Lastly, developing structured problem-solving routines, such as breaking proofs into smaller steps or identifying key theorems first, is another strategy. Students who adopt this method tend to perceive it as highly effective, as it fosters logical reasoning and reduces the cognitive load associated with complex proofs.

Conclusion

This study sheds light on the significant challenges third-year college students faces in solving geometric proofs and the broader implications for their mathematical understanding and academic experiences. Key findings reveal that students struggle with abstract concepts, logical reasoning, and the application of geometric principles, largely due to gaps in foundational knowledge and limited exposure to proofs in earlier education. These struggles negatively impact their confidence, motivation, and attitudes toward mathematics, often resulting in math anxiety and reduced engagement. However, strategies such as collaborative learning, the use of visual aids, and structured problem-solving routines were identified as moderately effective in helping students navigate these difficulties.

The relevance of these findings lies in their implications for educational practices. Addressing the identified challenges requires a shift toward more interactive and supportive teaching approaches. Recommendations include integrating dynamic geometry tools into the curriculum, providing step-by-step workshops on proof construction, and fostering a growth-oriented mindset to reduce math anxiety and build confidence. By creating a more engaging and supportive learning environment, educators can help students overcome these struggles and develop stronger mathematical skills.

Actionable outcomes of this research include the need for targeted interventions at both the curriculum and instructional levels. Schools should prioritize early exposure to geometric reasoning, ensure consistent reinforcement of foundational skills, and adopt innovative teaching strategies to make geometric proofs

more accessible and relevant. Additionally, educators are encouraged to use collaborative and visual-based learning techniques to enhance students' conceptual understanding and problem-solving capabilities. Future research should explore the long-term effects of these interventions and examine how contextual factors, such as institutional support and cultural attitudes toward mathematics, influence student outcomes. By addressing these areas, educators and policymakers can create a more effective and inclusive framework for teaching geometry, fostering mathematical competence and confidence among learners.

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