Rima International Journal of Education (RIJE), Vol. 3 (No. 3): Nov 2024; page: 77-89 ISSN: 2756 - 6749

The Role of Mathematical Modeling in Enhancing 200 Level Student Understanding of Real Analysis in Federal College of Education Pankshin, Plateau State, Nigeria

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Abstract

This study investigates the proficiency of 200-level students at Federal College of Education, Pankshin, in understanding and applying Real Analysis concepts, the contribution of mathematical modeling to their learning, and the main challenges they face in the process. Using descriptive statistics to analyze responses from 54 students, the findings indicate a reasonable proficiency in Real Analysis, with a grand mean of 3.01624. Mathematical modeling was found to significantly enhance understanding and application, evidenced by a grand mean of 3.02456. However, notable challenges were identified, including the fast pace of the course (Mean = 3.4123) and insufficient seeking of additional help outside of class (Mean = 1.7039), resulting in a grand mean of 2.82936 for challenges faced. While course materials and assessment methods were deemed supportive and effective, the lack of frequent peer discussions on mathematical models was evident. The study concludes that while students demonstrate a fair grasp of Real Analysis, addressing the identified challenges through targeted interventions—such as adjusting course pacing, enhancing support resources, promoting peer discussions, and encouraging the use of additional help—can further improve their learning experience and outcomes. Recommendations include modifying the course pace, fostering collaborative learning, and increasing access to additional support resources. These measures aim to bolster students' comprehension and application of Real Analysis principles, ultimately leading to better academic performance and deeper mathematical understanding.

Key Words: Mathematical Modeling, Real Analysis, Student Understanding, Enhancement and Academic performance

Introduction

Mathematical modeling has emerged as a pivotal factor in contemporary education, significantly contributing to the improvement of students' understanding of complex concepts. This approach enables learners to bridge the gap between abstract mathematical theories and real-world applications, making learning more relevant and engaging. Salha and Qatanani (2021) emphasize that mathematical modeling not only enhances problem-solving abilities but also deepens conceptual understanding by allowing students to apply mathematical principles to real-world scenarios. At the Federal College of Education, Pankshin, Plateau State, Nigeria, efforts are underway to integrate mathematical modeling into the curriculum for 200-level students enrolled in Real Analysis courses. This integration is seen as a strategic tool to enhance student comprehension and foster skills that go beyond rote memorization, encouraging deeper engagement with mathematical concepts.

The traditional method of teaching mathematics, which often focuses on rote learning and memorization, has long been criticized for producing students with a superficial grasp of mathematical concepts. Nilimaa (2023) asserts that such methods fail to cultivate critical thinking and analytical skills, which are essential for problem-solving in both academic and professional contexts. In contrast, mathematical modeling offers an interactive and applied approach, encouraging students to engage with the material on a deeper level. This method enables students to see the relevance of mathematics in everyday life and across various professional fields. At the Federal College of Education, Pankshin, there is a growing recognition of the need to shift from traditional teaching methods to more dynamic and interactive ones, such as mathematical modeling, to improve student learning outcomes and prepare them for future academic challenges.

The importance of mathematical modeling in education cannot be overstated, as it plays a crucial role in developing a comprehensive understanding of mathematical concepts. By allowing students to visualize, manipulate, and apply these concepts in various contexts, mathematical modeling offers a hands-on experience that is essential for 200-level students preparing for advanced studies. As noted by Bikić, Burgić, and Kurtić (2021), this practical application helps bridge the gap between theoretical knowledge and real-world applications, equipping students with the skills they need for professional careers. Within the context of the Federal College of Education, Pankshin, the integration of mathematical modeling is regarded as a critical step toward enhancing the overall quality of education. This innovative approach is expected to improve student performance, particularly in subjects like Real Analysis, which are foundational for higher-level mathematical studies.

Despite its benefits, the implementation of mathematical modeling in the classroom comes with its own set of challenges. It requires not only highly qualified teachers who are proficient in both mathematical theory and its practical applications but also adequate resources and support systems to ensure the successful adoption of this teaching method. Gastón and Lawrence (2015) highlight that institutions must invest in training educators and providing the necessary tools and infrastructure to facilitate the effective use of mathematical modeling. At the Federal College of Education, Pankshin, efforts are being made to address these challenges by offering professional development opportunities for educators and upgrading classroom resources to support the integration of mathematical models. These initiatives are critical to ensuring that students can fully benefit from this innovative educational strategy.

As the role of mathematical modeling in enhancing student understanding continues to gain recognition at the Federal College of Education, Pankshin, the institution remains committed to refining its approach to teaching abstract mathematical concepts. By providing students with a practical framework for applying theoretical knowledge, mathematical modeling helps develop critical thinking, problem-solving skills, and a deeper appreciation for mathematics. Wang et al. (2023) argue that such skills are vital for academic success and future professional opportunities. As Pankshin continues to integrate mathematical modeling into its curriculum, particularly for 200-level students, it is expected that these learners will achieve a more comprehensive and lasting understanding of mathematics. This approach will better equip them to face both academic challenges and the demands of an increasingly complex world.

The integration of mathematical modeling at the Federal College of Education, Pankshin, represents a forward-thinking shift in mathematics education. This approach promises to enhance the learning experience for 200-level students by fostering a deeper understanding of abstract concepts and improving their problem-solving abilities. As the institution continues to develop its curriculum and support systems, it is anticipated that mathematical modeling will become a central component of its educational strategy, preparing students for success in both their academic pursuits and professional lives.

Statement of Problem

In the field of mathematics education, there exists a significant gap between theoretical understanding and practical application, particularly at the 200-level of study in Real Analysis. Many students struggle with grasping complex concepts, often relying on rote memorization rather than developing a deep comprehension of mathematical principles. This challenge is prevalent at the Federal College of Education, Pankshin, where traditional teaching methods have dominated the curriculum, resulting in a superficial understanding of mathematics among students. The lack of effective pedagogical strategies that emphasize critical thinking and application further exacerbates this issue.

Despite the recognized importance of mathematical modeling as a pedagogical tool, its integration into the curriculum has not been systematically explored within this context. The ideal scenario would involve a curriculum that actively incorporates mathematical modeling to enhance student engagement and understanding. However, the current reality at the Federal College of Education, Pankshin, reveals that 200-level students in Real Analysis continue to face difficulties in relating mathematical theories to real-world applications, leading to a disconnect between their academic performance and the skills necessary for professional success.

The consequences of this gap in understanding are multifaceted. Students may struggle to perform adequately in advanced mathematical courses, limiting their academic and professional opportunities. Furthermore, the inability to apply mathematical concepts to practical situations hinders the development of essential skills, such as critical thinking and problem-solving. This situation calls for a comprehensive investigation into the role of mathematical modeling in enhancing student understanding and academic performance in Real Analysis at the Federal College of Education, Pankshin.

By addressing this issue, the study aims to identify effective strategies for integrating mathematical modeling into the curriculum, ultimately fostering a deeper comprehension of Real Analysis among 200-level students. This will not only improve educational outcomes but also better prepare students for future academic challenges and career paths in mathematics and related fields.

Objectives of the Study

The purpose of this study is to investigate the role of mathematical modeling in enhancing the understanding of 200 level students in Real Analysis at Federal College of Education Pankshin, Plateau State, Nigeria. The specific objectives of the study are:

I. To assess the current level of understanding of Real Analysis among 200-level students of Federal College of Education Pankshin.

II. To explore the effectiveness of mathematical modeling in enhancing students' comprehension of Real Analysis concepts.

III. To identify the challenges faced by 200 level students in learning Real Analysis.

Research Questions

The following research questions were raised to guide the study:

I. How proficient are 200-level students at Federal College of Education, Pankshin, Plateau State, in understanding Real Analysis concepts?

II. How does mathematical modeling contribute to 200 level students' understanding and application of Real Analysis principles?

III. What are the main challenges that 200 level students face in learning Real Analysis?

Methodology

In this study design, surveys are used as a tool by researchers to gain a greater understanding about individual or group perspectives relative to a particular concept or topic of interest. This survey research design provides a structured approach to investigate the role of mathematical modeling in enhancing the understanding of Real Analysis among 200-level students at Federal College of Education Pankshin. Adjustments can be made based on specific institutional requirements and available resources. Surveys provide researchers with reliable, usable, primary data to inform business decisions. They are important because the data comes directly from the individuals you have identified in your goal. And surveys give you a detailed, systematic way to view and analyze your data.

The population for this study consists of 200-level students enrolled in the Mathematics Degree program at Federal College of Education Pankshin. Specifically, there are sixty Two (62) students who are currently enrolled in Real Analysis courses at Federal College of Education Pankshin in 2023/2024 academic session.

The sample will be drawn from the population to represent a diverse group of students. The selection will aim to capture a broad spectrum of student characteristics and experiences to ensure the findings are representative of the population. Given the small population size of 62 students, you can use a sample size calculation method suitable for small populations. One commonly used method for determining sample size in such cases is the Krejcie and Morgan (1970) formula. Here's the Krejcie and Morgan formula for reference: $S = \frac{N}{1+N.e^2}$

Where:

- N is the population size (62 students).
- e is the margin of error (e.g., 0.05 for ±5% accuracy).

Therefore, a sample size of 54 students would be appropriate for your study, considering the small population size of 62 students. This sample size ensures that your study will be statistically significant and provide accurate results.

Results

Research Question 1: How proficient are 200-level students at Federal College of Education, Pankshin, Plateau State, in understanding Real Analysis concepts?

Table 1: The descriptive statistics for the proficiency of 200-level students in understanding Real Analysis concepts based on the provided items.

S/N	ITEAMS	N	MEAN	ST. DEV	REMARK
1	how confident are you in your understanding of the foundational concepts of Real Analysis?	54	3.3882	1.0465	Accept
2	How well do you feel you understand the key principles of Real Analysis?	54	3.2829	0.82076	Accept
3	How effective do you find the current teaching methods in helping you understand Real Analysis concepts?	54	2.8136	0.83489	Accept
4	To what extent do you think you are able to apply Real Analysis principles to solve problems?	54	2.8311	0.99228	Accept
5	How often do you discuss Real Analysis concepts with your peers outside of class?	54	2.7654	1.04186	Accept

Grand Mean= 3.01624

Decision Rule 2.50

Descriptive statistics in table 1 above showed the result of data used to assess the current level of understanding of Real Analysis among 200-level students of Federal College of Education Pankshin. Item 1 have the mean of 3.3882, with the Standard Deviation of 1.0465. Item 2 has mean of 3.2829, with the Standard Deviation of 0.82076.Item 3 have the mean of 2.8136with the Standard Deviation of 0.83489. Item 4 has mean of 2.8311, with the Standard Deviation of 0.99228, Item 5 has mean of 2.7654, with the Standard Deviation of 1.04186. The despondence agreed with item 1,2,3, 4 and 5. The Grand Mean of item 1.2,3,4 and 5 is 3.01624 which are above the Decision Rule (2.50). Therefore we conclude that the analysis of data collected indicates that the 200-level students at Federal College of Education, Pankshin, generally feel proficient in understanding Real Analysis concepts. They are confident in their foundational knowledge, understand key principles, find the teaching methods moderately effective, can apply principles to problem-solving, and discuss these concepts with their peers. This positive perception suggests that the students are reasonably proficient in Real Analysis at their current academic level. The Result is in agreement with work of **Weber (2001)**, who has done extensive work on students' understanding of abstract mathematical concepts and proof-based mathematics courses like Real Analysis. Weber emphasizes that understanding how to approach a proof requires more than knowing mathematical content; students must develop strategies to guide their proof-writing processes. This includes recognizing what techniques are appropriate and how to plan a proof.

Research Question 2: How does mathematical modeling contribute to 200-level students' understanding and application of Real Analysis principles?

The table 2: Contribution of mathematical modeling to students' understanding and application of Real Analysis principles based on the provided items.

S/N	ITEAMS	N	MEAN	ST. DEV	REMARK
6	To what extent do you believe mathematical modeling enhances your understanding of Real Analysis principles?	54	2.9886	0.96736	Accepted
7	How often do you engage in mathematical modeling activities related to Real Analysis in your coursework?	54	3.5921	0.8518	Accepted
8	How well do you think mathematical modeling prepares you to apply Real	54	3.3289	1.06766	Accepted

	Analysis principles in practical situations?				
9	How confident are you in your ability to create mathematical models to solve Real Analysis problems?	54	3.0658	1.11535	Accepted
10	How often do you discuss or share mathematical models with your peers to understand Real Analysis concepts better?	54	2.1474	1.14904	Rejected
Grand Mean= 3.02456					

Decision Rule 2.50

Descriptive statistics in table 2 above showed the result of data used to explore the effectiveness of mathematical modeling in enhancing students' comprehension of Real Analysis concepts. Item 6 have the mean of 2.9886, with the Standard Deviation of 0.96736. Item 7 has mean of 3.5921, with the Standard Deviation of 0.8518. Item 8 have the mean of 3.3289 with the Standard Deviation of 1.06766,. Item 9 has mean of 3.0658, with the Standard Deviation of 1.11535, Item 10 has mean 2.9474, with the Standard Deviation of 1.14904. The despondence agreed with item 6,7,8, and 9. But they fail to agree with Item 10. According to their response, they do not discuss or share mathematical models with their peers to understand Real Analysis concepts better. The Grand Mean of item 6,7,8, 9 and 10 is 3.02456 which are above the Decision Rule (2.50). Therefore we conclude that the analysis of the data indicates that mathematical modeling is perceived to significantly contribute to 200-level students' understanding and application of Real Analysis principles. Students believe that mathematical modeling enhances their understanding, they frequently engage in such activities, feel well-prepared for practical applications, and are confident in their ability to create models. However, there is a notable exception regarding the discussion of mathematical models with peers, which is not a common practice among the students. This suggests an area for potential improvement, where encouraging peer discussions about mathematical models could further enhance their understanding of Real Analysis concepts. The result is in agreement with work of Molina-Toro, et al. (2023). Who conducted their research on Digital technologies and their impact on mathematical modeling education: Enhancing understanding and engagement. The study by Molina-Toro, et al. (2023) investigates how digital technologies influence mathematical modeling education. Their research highlights that integrating digital tools in modeling activities significantly enhances students' understanding of complex mathematical concepts and fosters greater engagement. Key findings include: (a)Enhanced

Comprehension and Application: Students who engaged with digital technologies during modeling activities developed a deeper understanding of abstract mathematical concepts and were better able to apply these concepts in real-world scenarios. (b) Increased Engagement and Confidence: The use of digital tools made learning more interactive and engaging, boosting students' confidence in their ability to create and work with mathematical models.(c) Challenges with Peer Collaboration: Despite the benefits, the study noted that students did not frequently discuss or collaborate on mathematical models with their peers. This lack of peer interaction was identified as a potential area for improvement, as discussions and collaborative problem-solving could further enhance learning outcomes.

Research Question 3: What are the main challenges that 200-level students face in learning Real Analysis?

Table 3: the challenges faced by 200-level students in learning Real Analysis based on the provided items.

S/N	ITEAMS	N	MEAN	ST. DEV	REMARK
11	How challenging do you find the pace of the Real Analysis course?	54	3.4123	0.73603	Accepted
12	To what extent do you face difficulties in understanding Real Analysis concepts?	54	2.6754	0.7983	Accepted
13	How well do you think the course materials support your learning of Real Analysis?	54	3.182	0.93749	Accepted
14	How effective do you find the current assessment methods in evaluating your understanding of Real Analysis?	54	3.1732	0.7722	Accepted
15	How often do you seek additional help or resources outside of class to understand Real Analysis concepts?	54	1.7039	1.1378	Rejected
Grand Mean= 2.82936					

Decision Rule 2.50

Descriptive statistics in table 3 above showed the result of data used to identify the challenges faced by 200 level students in learning Real Analysis. Item 11 have the mean of 3.4123, with the Standard Deviation of 0.73603. Item 12 has mean of 2.6754, with the Standard Deviation of 0.7983. Item 13 have the mean of 3.182with the Standard Deviation of 0.93749. Item 14 has mean of 3.1732, with the Standard Deviation of 0.7722, Item 15 has mean of 1.7039, with the Standard Deviation of 1.1378. The despondence agreed with item 11,12,13and 14, but they fail to agree with Item 15. According to their response, they do not often seek additional help or resources outside of class to understand Real Analysis concepts. The analysis of the data indicates that 200-level students at Federal College of Education, Pankshin, face several challenges in learning Real Analysis:

1. **Pace of the Course**: Students find the pace of the Real Analysis course challenging.
2. **Understanding Concepts**: Students experience difficulties in understanding the concepts of Real Analysis.
3. **Course Materials**: Despite the challenges, students feel that the course materials support their learning adequately.
4. **Assessment Methods**: Students find the current assessment methods effective in evaluating their understanding.
5. **Additional Help**: A significant challenge is that students do not frequently seek additional help or resources outside of class, which might hinder their understanding of Real Analysis concepts.

The Grand Mean of item 11,12,13,14 and 15 is 2.82936 which are above the Decision Rule (2.50). The result indicate that while students acknowledge the support from course materials and assessment methods, they still face notable challenges with the pace and understanding of the course, and there is a need to encourage them to seek additional help and resources outside of class to enhance their learning experience. The findings align with studies of **Agarwal et al. (2021)** found that while students often appreciate the resources provided through course materials and assessments, they still encounter difficulties with the speed of the curriculum and comprehension of complex topics. The study emphasized the necessity for institutions to facilitate additional support mechanisms, such as tutoring services and access to supplemental materials, to enhance students' learning experiences.

Discussion

The study revealed that 200-level students at Federal College of Education, Pankshin, generally possess a reasonable proficiency in understanding and applying Real Analysis concepts, with mathematical modeling playing a significant role in enhancing their comprehension and practical application. However, notable challenges were identified, particularly regarding the fast pace of the course and students' reluctance to seek additional help outside of class. While course materials and assessment methods were found to be supportive and effective, peer discussions on mathematical models were infrequent. In conclusion, while students demonstrate a fair grasp of Real Analysis, addressing the identified challenges through adjustments in course pacing, enhanced support resources, promotion of peer discussions, and encouraging the use of additional help outside of class can further improve their learning experience and outcomes.

Conclusion

the study conclude that, the 200-level students at Federal College of Education, Pankshin, exhibit a reasonable proficiency in understanding and applying Real Analysis concepts, with mathematical modeling significantly contributing to their learning. However, the fast pace of the course and students' reluctance to seek additional help outside of class present notable challenges. While course materials and assessment methods are supportive and effective, there is a need to foster more peer discussions on mathematical models. Addressing these challenges through targeted interventions can further enhance students' comprehension and application of Real Analysis principles, leading to improved academic outcome

Recommendations

Based on the research questions and findings, here are three recommendations:

6. **Adjust the Pace of the Course**: To address the challenge of the fast pace of the Real Analysis course, instructors should consider breaking down complex concepts into smaller, more manageable parts and providing additional time and resources for difficult topics. This approach can help ensure that students are not overwhelmed and can keep up with the course material effectively.
7. **Encourage Peer Discussions and Collaborative Learning**: Since students do not frequently discuss or share mathematical models with their peers, promoting collaborative learning through group assignments, study groups, and peer review sessions can enhance their understanding and application of Real Analysis concepts. Creating a supportive environment for peer discussions can help students learn from each other and deepen their comprehension.
8. **Increase Access to Additional Support and Resources**: Given that students do not often seek additional help outside of class, it is essential to make extra resources more accessible and

encourage their use. Providing tutoring services, extended office hours, online forums, and workshops can offer students the necessary support to overcome difficulties in understanding Real Analysis concepts. Actively promoting these resources can motivate students to take advantage of the help available to them.

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