

# A Systematic Review on Challenges and Possibilities Inteaching and Learning of Basic Calculus

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## Abstract—

This systematic review explores the challenges and opportunities surrounding basic calculus education, highlighting its pivotal role in developing students' mathematical proficiency and problem-solving skills while seeking to identify obstacles faced by educators and learners and exploring strategies to enhance the teaching and learning experience. This systematic review explores the intricate landscape of basic calculus education, aiming to identify key obstacles faced by educators and learners while also exploring the potential avenues for enhancing the teaching and learning experience. This study utilized a systematic literature review method to synthesize existing literature concerning the challenges and possibilities in teaching and learning Basic Calculus. Results showed three themes, such as (1) Student Engagement and Distractions; (2) Technology Integration and Conceptual Understanding; and (3) Time Constraints and Teaching Practices While low engagement, weak foundations, and traditional teaching methods hamper calculus success, incorporating active learning, visualization tools, and addressing student needs can create a more engaging and effective learning environment. In short, by embracing these solutions, instructors can empower students to develop a deeper understanding of calculus.

**Keywords—** Basic Calculus; Challenges; Possibilities; Teaching; Learning; Systematic review

## I. INTRODUCTION

Basic calculus serves as a foundational pillar in mathematics, providing essential tools for understanding change and motion (Bowers & Doerr, 2001). In the realm of education, the teaching and learning of basic calculus present both challenges and opportunities that significantly impact students' mathematical proficiency and problem-solving skills. This systematic review explores the intricate landscape of basic calculus education, aiming to identify key obstacles faced by educators and learners while also exploring the potential avenues for enhancing the teaching and learning experience.

The study of basic calculus is crucial for students pursuing various disciplines, including mathematics, physics, engineering, economics, and more. However, the complexity of calculus concepts often poses significant challenges for both educators and students. Understanding these challenges is essential for developing effective teaching strategies that cater to diverse learning styles and abilities. By examining the obstacles encountered in teaching and learning basic calculus, educators can tailor their approaches to address specific difficulties faced by students, ultimately fostering a deeper understanding of this fundamental mathematical subject (Nasir et al., 2018).

While challenges exist in teaching and learning basic calculus, there are also numerous possibilities for improving the educational experience. This systematic review aims to uncover innovative methods, technologies, and pedagogical approaches that can enhance student engagement, comprehension, and retention of calculus concepts. By identifying these possibilities, educators can adapt their instructional practices to create a more dynamic and effective learning environment that empowers students to master basic calculus with confidence.

Through a comprehensive analysis of existing literature on the challenges and possibilities in teaching and learning basic calculus, this systematic review seeks to provide valuable insights for educators, curriculum developers, policymakers, and researchers in the field of mathematics education. By synthesizing current knowledge and highlighting areas for improvement, this study aims to contribute to the ongoing dialogue surrounding effective strategies for teaching and learning basic calculus, ultimately benefiting both educators and students striving for mathematical excellence.

## II. LITERATURE REVIEW

Basic calculus is a fundamental component of mathematics education, providing essential tools for understanding change and problem-solving across disciplines (Bowers & Doerr, 2001). However, research consistently shows that students face difficulties in mastering calculus due to low engagement, weak prior knowledge, and an overreliance on procedural learning rather than conceptual understanding. Studies by Zimmerman (2002) and Svanum and Bigatti (2009) further emphasize that self-regulation and active engagement are critical factors influencing students' success. These findings highlight the limitations of traditional lecture-based instruction and the need for more effective teaching approaches.

In response, the integration of technology has emerged as a promising strategy to enhance learning. Tools such as GeoGebra have been shown to improve students' conceptual understanding through dynamic visualization and interactive exploration (Bhagat & Chang, 2015; Ziatdinov & Valles, 2022). Collaborative and technology-supported environments also encourage active participation and deeper learning (Takaci & Marić, 2015). Similarly, student-centered pedagogies—such as problem-solving, group work, and inquiry-based learning—have been found to significantly improve engagement and retention (Huang et al., 2008; Keynes & Olson, 2000; Nasir et al., 2018). Despite these advancements, many studies focus either on pedagogy or technology alone, with limited research examining their combined effect.

Moreover, external factors such as digital distractions and time constraints continue to hinder effective learning (Chen & Yan, 2016; Sansone, 2017), further emphasizing the need for structured and purposeful instructional design. While existing literature identifies key challenges and potential solutions, gaps remain in integrating multiple digital tools, conducting empirical studies, and addressing context-specific needs, particularly in Philippine classrooms.

Addressing these gaps, the present study adopts a technology-enhanced, student-centered approach by integrating tools such as GeoGebra and Desmos within a pedagogical framework like TPACK. By employing a quasi-experimental design, this research aims to provide empirical evidence on how combined digital tools can improve students' conceptual understanding and engagement in calculus. In doing so, it contributes to bridging the gap between theory and practice and offers context-relevant insights for improving mathematics instruction.

## III. METHODOLOGY

The goal of doing a systematic review was to offer a thorough grasp of the opportunities and difficulties associated with teaching and learning basic calculus. The inclusion criteria focused on peer-reviewed articles published in English within the last decade, emphasizing insights into the challenges and possibilities in teaching and learning Basic Calculus. A thorough search strategy included electronic databases such as Google Scholar and ResearchGate, along with pertinent journals and books, using specific search terms such as "Challenges in Teaching and Learning of Basic Calculus", "Possibilities in Teaching and Learning of Basic Calculus", and "Systematic Review on Challenges and Possibilities in Teaching and Learning Basic Calculus".

A significant number of articles were found during the first search phase, which were then filtered through based on titles and abstracts to determine relevancy. A comprehensive assessment of thirty-eight articles was conducted with the goal of gaining an understanding of the opportunities and obstacles associated with teaching and studying Basic Calculus. Recurring themes and patterns were found in this thorough examination, providing a thorough picture of the opportunities and obstacles associated with teaching and learning basic calculus. This methodical approach, which synthesized a variety of literature, enabled a comprehensive comprehension of the intricate dynamics at work and offered insightful information about the subtleties of opportunities and obstacles in Basic Calculus teaching and learning.

#### IV. RESULTS AND DISCUSSION

##### Theme 1: Student Engagement and Distractions

The study highlights concerns regarding student engagement in calculus, with only about 25% of Calculus I students successfully completing the course nationally (Svanum & Bigatti, 2009). Students' lack of preparation, motivation, and reliance on memorization hinder their success (Zimmerman, 2002). Distractions like cell phones, social media, and video games further impact learning (Chen & Yan, 2016). Strategies to address these challenges include active learning approaches, such as problem-solving in class, encouraging reflection, and engaging students in discussions and group work to foster a more interactive learning environment (Huang et al., 2008)

##### Theme 2: Technology Integration and Conceptual Understanding

The integration of technology, specifically GeoGebra software, plays a significant role in enhancing conceptual understanding in mathematics education (Bhagat & Chang, 2015). Studies have shown that GeoGebra facilitates teaching and learning by providing visual and dynamic representations of mathematical concepts, enabling students to engage actively in the learning process (Ziatdinov & Valles, 2022). This software allows students to explore abstract geometrical concepts efficiently, visualize mathematical relationships, and interact with mathematical ideas in a more hands-on manner. By using GeoGebra, educators can create a more interactive learning environment, where students can work collaboratively, explore concepts beyond traditional methods, and develop a deeper understanding of mathematical principles, ultimately improving their achievement and perception of mathematics (Takaci & Marić, 2015)

##### Theme 3: Time Constraints and Teaching Practices

The research delves into the challenges faced by both students and instructors due to time constraints in college calculus courses. Factors like student gender, previous calculus experience, and teaching practices influence students' opportunities to learn (Sansone, 2017). Recommendations include preparing students before entering calculus, engaging in student-centered instruction, and creating more positive learning opportunities through discussions and group work (Keynes & Olson, 2000). Addressing these challenges is crucial in introductory college calculus courses to cater to diverse student populations and enhance learning outcomes in STEM fields.

#### V. CONCLUSION

Calculus education faces hurdles with low completion rates due to student unpreparedness, distractions, and a reliance on memorization. Additionally, time constraints and traditional teaching methods can hinder deep conceptual understanding. However, research also highlights promising solutions: active learning approaches, technology like GeoGebra software, and addressing student needs through preparation and diverse teaching practices.

Calculus instructors should consider incorporating active learning strategies, such as in-class problem-solving and group work, to foster engagement. Additionally, utilizing technology like GeoGebra can enhance visualization and student interaction with mathematical concepts. By addressing these challenges and implementing these solutions, educators can create a more positive and successful learning environment for students in introductory calculus courses.

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