



Limits: Understanding the importance in real-life situations in calculus

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Abstract

The concept of limits is the foundation of calculus and is essential for understanding continuous change and solving real-life problems. The purpose of this study is to understand the limit concept and to explore its relevance in mathematics and other real-world problems. This study aims to understand limit's role in calculus, how it is applied in disciplines, the challenges faced by learners in conceptualizing idea of limits, and improving that conceptualization. This study was qualitative research and relied on thematic content analysis of peer-reviewed journals and literature. Upon analysis, five categories were established: conceptualization, importance, applications, teaching, and challenges. Among the findings, it was noted that limits act as prerequisites to derivatives, integrals and continuity, and have applications in physics, engineering, economics, etc. The study advocates the application of structure and flexibility of thought in comprehending and relating the idea of a limit to real-life situations.

Keywords: Limits, Calculus, Conceptual understanding, Real-life applications, Thematic content analysis

Introduction

Calculus is the one of the most important branches of mathematics that provides a systematic approach for understanding and analyzing change. It functioned as the building blocks in solving different problems including motion, growth, optimization, and continuous variation across in different fields such as engineering, economics, physics, medicine, and technology. The most important to calculus is the limits, which characterize the value that a function approaches as the independent variable approaches a specific point. Mathematically, a limit expressed as;

$$\lim_{x \rightarrow 2} f(x) = L$$

Which means that as the value of (x) gets closer to (a), the function (f(x)) approaches the value (L). For example,

$$\lim_{x \rightarrow 2} (x+3) = 5$$

Because as (x) approaches 2 from either side, the value of the function (x+3) approaches 5. This example demonstrates that the limit focuses on the values of a function approach rather than directing the value emphasizing by direct substitution.

This concept forms the mathematical foundation of continuity, derivatives, and integrals, making it important for understanding advanced mathematical concepts and explaining continuously changing occurrences. Studies performed across various educational data constantly acknowledge the limits as one of the most important ideas in calculus because it connects elementary mathematical ideas with more advanced analytical reasoning (Viirman *et al.*, 2022; Biza *et al.*, 2022) [9, 1].

Beyond their assumption, limits provide mathematical tools for visualize and analyzing real-world procedures. They are used to explain immediate rates of change, describe the behavior of continuously changing systems, and establish mathematical models that support scientific investigation and technological development. In engineering and physics, limits provide the basis for analyzing motion, acceleration, and changing physical quantities, while in economics they support the analysis of minimal cost, peripheral revenue, optimization, and decision making under changing conditions. These applications show that understanding limits enables the learners to connect mathematical theory with problems encountered in professional practice and everyday life (Rathnayake & Jayakody, 2023; Tonra *et al.*, 2025) [6, 7].

Recent educational research has also emphasized the importance of developing conceptual understanding rather than relying exclusively on procedural computation. Although many students successfully perform algebraic manipulations when solving limit problems, they frequently experience difficulty explaining the mathematical meaning of the limit concept. Jameson *et al.* (2023) [4] found that misconceptions commonly arise when learners interpret how functions approach a particular value. Similarly, Chand *et al.* (2024) [2] reported that many university students demonstrate acceptable procedural performance while showing limited conceptual understanding. Trapezanlidis and Nikolantonakis (2026) [8] likewise observed that first-year university students often depend on memorized procedures instead of mathematical reasoning. Collectively, these studies suggest that meaningful learning requires balancing procedural fluency with conceptual understanding to enable students to apply limits in unfamiliar situations.

Recent studies have emphasized that students develop a stronger understanding of limits when instruction promotes conceptual reasoning alongside procedural competence. Opportunities to explore graphical, numerical, symbolic, and contextual representations help learners recognize how functions behave as they approach specific values instead of relying solely on algebraic procedures. Hong (2023) ^[3] noted that widely used calculus textbooks vary considerably in the learning opportunities they provide for developing conceptual understanding of limits, while Nordlander (2022) ^[5] demonstrated that instructional approaches emphasizing conceptual reasoning improve students' understanding of limit concepts. Likewise, Rathnayake and Jayakody (2023) ^[6] highlighted that familiar real-life situations strengthen students' intuition and reduce misconceptions by making abstract ideas more meaningful. These findings indicate that effective instruction should encourage students to explain mathematical relationships and connect limits with practical situations rather than simply applying computational techniques.

The gathered literature constantly identifies limits as the foundation of higher-level calculus and mathematical reasoning. Viirman *et al.* (2022) ^[9] describe that demonstrating limits is important for continuity of learning, derivatives, and integrals because these concepts are properly mean through limits. Similarly, Biza *et al.* (2022) ^[1] emphasized that meaningful calculus learning depends on students' ability to connect essential concepts with advanced mathematical ideas. Tonra *et al.* (2025) ^[7] further argued that dealing with learning obstacles through carefully designed instruction promotes deeper conceptual understanding and improves students' ability to reason mathematically. Collectively, these studies demonstrate that a solid understanding of limits strong analytical thinking and prepares learners to solve mathematical and real-world problems including continuous change.

Although recent studies have examined students' misconception, conceptual understanding, and instructional approaches related to limits, least studies have integrated the broader importance of limits across mathematics and real-life applications. Existing literature has focused primarily on improving students' performance in solving limit problems while giving comparatively less attention to explaining how limits support scientific investigation, engineering design, economic analysis, and other situations involving continuous change. As a result, many learners continue to view limits as isolated computational procedures rather than mathematical tools with broad practical value. Resolving this gap provides a more understanding perspective on the importance of limits and highlights their role in strengthening mathematical reasoning across different disciplines.

Therefore, this study aims to analyze the concept of limits and understand their importance in real-life situations. Specifically, it seeks to explain the role of limits in calculus, identify their applications across various fields, and describe how they contribute to mathematical problem solving and reasoning. Through qualitative content analysis of recent scholarly literature, this study aims to promote a deeper appreciation of limits and encourage meaningful understanding of their importance both within and beyond the mathematics classroom.

Statement of the problem

This study aims to examine the concept of limits and determine their importance in real-life situations in calculus.

Specifically, it seeks to answer the following questions:

1. What is the concept of limits in terms of:
 - The basic meaning of limits;
 - How a function approaches a specific value; and
 - The role of limits in calculus?
2. What is the importance of limits in mathematics and other fields in terms of:
 - Understanding derivatives and integrals;
 - Explaining rates of change and motion; and
 - Solving mathematical and scientific problems?
3. How are limits applied in real-life situations in terms of:
 - Physics and engineering;
 - Economics and business; and
 - Everyday phenomena involving change and growth?
4. How does the concept of limits contribute to mathematical reasoning and problem solving in calculus?
5. What insights and recommendations can be drawn to promote a deeper appreciation and understanding of the importance of limits in real-life situations?

Methods and Research design

Research design

In this study, a descriptive and analytical qualitative research design was used and qualitative content analysis was performed to study the concept of limits and their importance in real life situations. Descriptive method was used to present and summarize existing knowledge about definitions, characteristics and applications of limits and analytical method was used to compare, synthesize and interpret findings from scholarly literature. The primary method employed was qualitative content analysis, which sought to identify recurring themes, patterns, and relationships within the selected studies. In this way, the researchers managed to acquire a thorough insight into the role of limits in calculus and their usage in different fields.

Research materials

The study utilized secondary sources of data that include peer-reviewed journal articles, scholarly books, and academic publications on the notion of limits in calculus. The study included academic journals, books, and scholarly articles published between 2021 and 2026 according to the relevance of the concepts, mathematical properties, educational significance, and real-life applications of limits in calculus. The sources used were only peer-reviewed and academically recognized, to ensure the credibility, reliability and quality of the information analyzed.

Research procedure

The study followed these procedures:

- Researchers collected relevant academic journals, books, research articles and other scholarly documents related to the concept of limits in calculus and their application in real life situations.

- The documents recovered were screened for relevance, credibility, publication period, and consistency with the objectives of the study. We only analyzed sources that fulfilled the defined selection criteria.
- The selected documents were thoroughly scrutinized for relevant information concerning the definition, mathematical properties, applications, conceptual difficulties and educational importance of limits. Major areas. Relevant information was extracted and coded under these areas.
- Codes with similar meanings were grouped into broader categories which were organized into major themes that describe the concept of limits, its importance in calculus, applications in real life, conceptual challenges experienced by learners, and instructional approaches that foster meaningful understanding.
- The synthesized findings were interpreted and presented according to the objectives of the study to provide a comprehensive explanation of the significance and applications of limits in mathematics and in different real-life situations.

Data analysis

The study used thematic content analysis to categorize, arrange, and explicate the data collected from the selected academic literature. The collected documents were read through several times to identify recurring ideas, concepts, and patterns related to the objectives of the study. Relevant information was coded and classified into major themes: the idea of limits, their importance in calculus, practical uses, conceptual difficulties encountered by students, and teaching strategies that promote meaningful understanding.

Similarities, differences and relationships between selected studies were used to interpret identified themes. Not only did the analysis summarize individual sources, but it synthesized agreements, contrasting perspectives, and emerging patterns to provide a comprehensive explanation of the importance of limits in mathematics and their applications in various real-life contexts. Throughout the analysis, the themes were checked and rechecked to ensure that they corresponded to the aims of the study.

Information from different peer-reviewed scholarly sources was compared to ensure consistency and accuracy of interpretations in order to enhance credibility and dependability of the findings. The researchers kept an audit trail through documentation of the processes of source selection, coding, categorization and thematic interpretation. The alignment of objectives, extracted data, identified themes and final interpretations throughout the study enhanced the transparency and rigor of the analysis.

Result and Discussion

Results

This chapter presents the findings obtained through thematic content analysis of selected scholarly literature on the concept of limits and their importance in real-life situations. The reviewed studies were systematically examined through repeated reading, coding, and categorization of relevant information. Meaningful statements related to the objectives of the study were identified and coded according to recurring concepts, including the concept of limits, mathematical significance, real-life applications, conceptual challenges, and instructional strategies. Similar codes were grouped into broader categories, resulting in five major themes that formed the basis of the analysis.

Table 1: Summary of emergent themes from the qualitative content analysis

Theme	Key findings	Supporting literature
Concept of Limits	Limits describe the value approached by a function and serve as the conceptual foundation of continuity, derivatives, and integrals.	Viirman <i>et al.</i> (2022); Biza <i>et al.</i> (2022); Hong (2023)
Importance of Limits in Mathematics	Limits explain rates of change, continuity, accumulation, and mathematical reasoning that underpin higher-level calculus.	Viirman <i>et al.</i> (2022); Biza <i>et al.</i> (2022); Tonra <i>et al.</i> (2025)
Applications of Limits in Real-Life Situations	Limits support mathematical modeling in engineering, physics, economics, and other disciplines involving continuous change.	Rathnayake & Jayakody (2023); Tonra <i>et al.</i> (2025); Viirman <i>et al.</i> (2022)
Conceptual Challenges in Learning Limits	Students often demonstrate procedural proficiency but experience difficulty developing conceptual understanding of limits.	Jameson <i>et al.</i> (2023); Hong (2023); Trapezanlidis & Nikolantonakis (2026)
Instructional Strategies for Meaningful Understanding	Conceptual discussions, multiple representations, inquiry-based instruction, and contextual applications improve students' understanding of limits.	Nordlander (2022); Rathnayake & Jayakody (2023); Tonra <i>et al.</i> (2025)

1. Concept of limits

1.1 Definition of limits

Based on the reviewed literature, a limit refers to the value that a function gets closer to as the input or independent variable approaches a particular value. It does not mainly consider the actual value of the function at that point but instead focuses on the behavior of the function as it moves nearer to the specified value. Most of the reviewed sources presented a similar explanation, showing that limits are one of the basic concepts needed to understand continuity, derivatives, and integrals.

1.2 How a function approaches a specific value

The reviewed studies revealed that many students find it difficult to understand how a function approaches a certain value. Instead of focusing on the behavior of the function, students often depend on direct substitution or memorized procedures. Researchers suggested that using different representations, such as graphs, tables, equations, and real-life examples, helps students better understand how functions behave as they get closer to a given point.

1.3 Role of limits in calculus

The reviewed studies identified limits as one of the first concepts that students need to understand in calculus. It serves as the basis for learning continuity, derivatives, and definite integrals. Without a clear understanding of limits, students may find it more difficult to study advanced calculus topics. Because of this, researchers consider limits an essential part of learning calculus.

2. Importance of limits in mathematics and other fields

2.1 Understanding derivatives and integrals

Reviewed studies suggested that students should first develop a strong understanding of limits before studying other topics in calculus.

2.2 Explaining rates of change & motion

Additionally, they stated that the use of limits is helpful in determining how things are changing at one point in time to another. Limits are commonly used in the field of physics in order to determine motion, and in engineering to observe continuous changes within systems. In addition to being used in physics and engineering; limits assist scientists and engineers to provide more accurate conclusions when assessing various physical processes.

2.3 Solving Math & Science problems

In addition to providing information on rates of change and motion, the reviewed literature identified several other ways that limits are utilized in math and science problem solving. Examples include developing mathematical models, forecasting future events, and analyzing systems with continuous variables. Due to its ability to develop mathematical models, forecast future events, and analyze systems with continuous variables; limits are seen as an essential tool in mathematics across multiple disciplines of science and technology.

3. Applications of limits - real-world situations

3.1 Physics & Engineering

As discussed previously, the literature evaluated by this researcher demonstrated that limits were utilized to assess the rate of change of objects in physics and engineering. This includes observing an object's speed and acceleration over a given period of time; analyzing a fluid's behavior; and assessing the stability of a structure. Each of these examples has assisted professionals to create more accurate calculations and better designs in the fields of physics and engineering.

3.2 Economics & Business

Limitations were also shown to be applicable in economics and business. Marginal costs, marginal revenues, profits and forecasting future trends in a particular marketplace are a few examples of where limits may be applied. Additionally, applying limits has helped business professionals and economists to make more informed decisions regarding planning, decision-making and forecasting.

3.3 Everyday phenomena involving change and growth

The reviewed studies also illustrated how limits are present within a variety of daily experiences involving gradual change such as; population trends, disease progression, climate or weather conditions, technology advancement and temperature changes. By relating limits to these real-world examples, learners can better understand that the concept is not limited to solving mathematical problems but is also useful in explaining events and processes that occur around them.

4. Contribution of limits to mathematical reasoning and problem solving

The literature highlighted the importance of limits in developing students' mathematical thinking and problem-solving abilities. A clear understanding of limits allows learners to examine mathematical relationships, analyze the behavior of functions, and solve calculus problems with greater confidence. The reviewed studies also emphasized that combining conceptual knowledge with procedural skills helps students apply mathematical ideas more effectively in both classroom activities and real-life situations.

5. Insights and Recommendations

The findings suggest that teaching limits should focus not only on computation but also on helping students understand the underlying concepts. Learning activities may become more meaningful when teachers use graphs, numerical examples, symbolic expressions, verbal explanations, and real-life situations together. Providing opportunities for discussion, reasoning, and practical application can also help students correct misconceptions and develop a deeper understanding of the topic.

The reviewed literature also recommended connecting lessons on limits with examples from physics, engineering, economics, and everyday experiences. Doing so enables students to recognize the practical value of the concept beyond mathematics. In addition, future researchers may explore new teaching strategies and technology-supported approaches that can improve students' understanding of limits and increase their interest in learning calculus.

Overall, the reviewed literature showed that limits are more than a mathematical procedure used for solving equations. They serve as a fundamental concept that supports logical reasoning, scientific investigation, and effective problem solving across different fields of study.

Discussion

The present study examined the importance of limits in calculus through a qualitative content analysis of recent scholarly literature. The thematic analysis revealed that limits are fundamental to understanding higher-level mathematics because they serve as the basis for continuity, derivatives, integrals, and the analysis of continuously changing quantities. Beyond their theoretical significance, the findings demonstrate that limits support mathematical reasoning, scientific inquiry, engineering applications, and economic analysis. The reviewed studies also identified persistent conceptual difficulties among

learners and highlighted instructional approaches that promote deeper understanding through contextual learning and conceptual reasoning. Together, these findings provide a comprehensive explanation of why limits remain one of the most essential concepts in calculus.

The analysis indicates that limits function as the conceptual foundation of calculus because they provide the mathematical framework for defining continuity, instantaneous rates of change, and accumulation. Without the concept of limits, derivatives and integrals cannot be rigorously established. This explains why the reviewed studies consistently recognize limits as indispensable for developing mathematical reasoning and solving problems involving continuous change (Viirman *et al.*, 2022; Biza *et al.*, 2022) ^[9, 1].

The findings likewise highlight the importance of limits in developing mathematical reasoning and problem-solving skills. The reviewed studies consistently describe limits as essential for explaining rates of change, continuity, and accumulation, which form the theoretical basis of differential and integral calculus. Tonra *et al.* (2025) ^[7] further emphasized that addressing students' learning obstacles through carefully designed instruction improves conceptual understanding and mathematical reasoning. Although the reviewed studies examined different aspects of calculus education, they converge on the conclusion that limits are indispensable for interpreting mathematical relationships and solving complex problems involving continuous change. This agreement across the literature strengthens the conclusion that limits should be viewed as a central mathematical concept rather than a procedural topic.

The analysis also demonstrates that limits extend beyond classroom mathematics through their applications in engineering, physics, economics, and other disciplines involving mathematical modeling. Rathnayake and Jayakody (2023) ^[6] showed that connecting mathematical ideas with authentic situations improves students' appreciation of abstract concepts, while Tonra *et al.* (2025) ^[7] emphasized that contextual learning helps students recognize the practical value of limits. These findings suggest that presenting real-life applications strengthens conceptual understanding because learners are better able to relate mathematical principles to situations encountered in professional practice and everyday life. Consequently, integrating authentic examples into calculus instruction helps bridge the gap between mathematical theory and practical application.

Another important finding concerns the persistent gap between procedural proficiency and conceptual understanding. Although many students successfully perform algebraic procedures, the reviewed literature indicates that they often experience difficulty explaining the mathematical meaning of limits or interpreting the behavior of functions. Jameson *et al.* (2023) ^[4], Hong (2023) ^[3], and Trapezanlidis and Nikolantonakis (2026) ^[8] consistently identified misconceptions arising from an overreliance on memorized computational techniques. Rather than contradicting one another, these studies collectively demonstrate that procedural success does not necessarily indicate conceptual

understanding. This finding highlights the importance of designing learning experiences that encourage reasoning, interpretation, and mathematical explanation alongside computational accuracy.

The reviewed literature further suggests that effective instruction promotes meaningful understanding by integrating conceptual discussions, multiple mathematical representations, inquiry-based learning, and authentic real-life contexts. Nordlander (2022) ^[5] demonstrated that instructional approaches emphasizing conceptual reasoning improve students' understanding of limits, while Rathnayake and Jayakody (2023) ^[6] reported that familiar contexts reduce misconceptions and strengthen intuitive reasoning. Similarly, Tonra *et al.* (2025) ^[7] emphasized that instructional designs addressing identified learning obstacles support deeper conceptual understanding. Collectively, these findings indicate that meaningful learning occurs when students actively construct mathematical understanding instead of relying exclusively on memorized procedures. Such approaches not only improve academic performance but also prepare learners to apply calculus concepts in broader scientific and professional contexts.

Overall, the findings address the objectives of this study by demonstrating that limits are fundamental to calculus, essential for mathematical reasoning, and widely applicable across various disciplines. The synthesis of recent scholarly literature further indicates that meaningful understanding develops when students balance procedural fluency with conceptual reasoning and connect mathematical ideas with authentic situations. These findings reinforce the importance of instructional practices that cultivate critical thinking and enable learners to appreciate the practical significance of limits beyond the mathematics classroom.

Conclusion

This study examined the concept of limits and their importance in real-life situations through a qualitative content analysis of selected scholarly literature published between 2021 and 2026. The findings demonstrated that limits are a fundamental concept in calculus because they provide the mathematical foundation for continuity, derivatives, integrals, and the analysis of continuously changing quantities. The reviewed literature consistently recognized that a clear understanding of limits is essential for developing mathematical reasoning and higher-level problem-solving skills.

The analysis further revealed that limits have broad applications beyond mathematics. They play a significant role in fields such as physics, engineering, economics, and other disciplines that involve continuous change and mathematical modeling. These applications demonstrate that limits are practical mathematical tools that support scientific investigation, engineering design, economic analysis, and decision making in real-life situations.

The study also found that many learners experience conceptual difficulties when studying limits despite demonstrating procedural proficiency. The reviewed literature indicated that students often rely on memorized computational techniques

without fully understanding the underlying mathematical concepts. This finding highlights the importance of instructional approaches that balance procedural fluency with conceptual understanding.

Furthermore, the analysis identified contextual learning, visual representations, and meaningful real-life applications as effective instructional strategies for improving students' understanding of limits. These approaches enable learners to connect abstract mathematical concepts with authentic situations, resulting in deeper understanding and greater appreciation of calculus.

Overall, the findings confirm that limits are not merely computational procedures but serve as the conceptual foundation of calculus and an essential tool for understanding and analyzing real-life phenomena involving continuous change. By synthesizing recent scholarly literature, this study provides a broader understanding of the significance of limits and emphasizes the need for instructional practices that promote meaningful learning and practical application.

Recommendation

Based on the findings and conclusions of the study, the following recommendations are proposed:

- Mathematics teachers should integrate real-life applications, visual representations, and contextual examples into calculus instruction to strengthen students' conceptual understanding of limits.
- Students should focus on developing conceptual understanding alongside procedural skills to improve their ability to solve mathematical problems and apply limits in unfamiliar situations.
- Schools and educational institutions should encourage instructional approaches that promote active learning, critical thinking, and meaningful connections between mathematical concepts and real-life experiences.
- Curriculum developers should incorporate authentic examples and interdisciplinary applications of limits into learning materials to demonstrate their relevance across different fields.
- Future researchers should conduct empirical studies involving students and teachers to examine the effectiveness of different instructional strategies for improving conceptual understanding of limits. Further research may also investigate the application of limits in emerging fields such as data science, artificial intelligence, and environmental modeling.

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