Curriculum and Teaching Methodology (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/curtm.2025.080225
ISSN 2616-2261 Vol. 8 Num. 2

Case study on student-centered limit teaching utilizing Matlab software

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Keywords: Matlab; Limit; Case; Student-Centered

Abstract: In the context of student-centered teaching philosophy, focusing on limit problems in higher mathematics and utilizing Matlab software with its visual features, program-based operation and analysis can assist students in analyzing the inherent patterns and complexity of complex problems. This approach cultivates students' core competencies, aids them in thinking systematically and rigorously about real-world problems, and ultimately enhances student engagement in the teaching process.

1. Introduction

The "student-centered" teaching mode focuses on student development, student learning, and learning outcomes [1]. It can be seen that the "student-centered" teaching philosophy places greater emphasis on making students the main body of thinking and learning, stimulating their enthusiasm, intrinsic motivation, and potential, enabling them to become the primary learners in the classroom, cultivating autonomous learning habits, and fostering independent innovation abilities. This is conducive to inspiring students' innovative spirit and cultivating their core competencies and key abilities.

The concept of limits and the limit-based thinking method are the cornerstones of advanced mathematics. However, because students are just starting to learn advanced mathematics, they have not yet formed the idea of infinite change. The direct explanation of ε-N, ε-δ, and ε-X definitions [2] often leaves students with a vague understanding, how to vividly and display the limit process, stimulate students' interest in learning, and enable them to grasp it easily is a challenge.

There are many articles on teaching advanced mathematics using MATLAB. Article [3] uses numerical computation and depicts intuitive function graphs to assist in teaching, allowing students to explore through experiments. Articles [4] and [5] conduct MATLAB-assisted simulations of two important limit processes. The above discussions involve relatively little on visualization, which can provide students with visual impact and enhance their understanding of mathematical concepts. Based on research, the National Training Laboratory in Maine, USA, has proposed a theory of modern learning styles known as the "Learning Pyramid" [6][7]. If students only listen to lectures, the retention rate is only 5%. Combining audio-visual and demonstration can increase this to 50%, and adding hands-on practice can boost the retention rate to 75%. MATLAB provides many

functions related to animation, making it relatively easy to create animations for visual teaching. By combining image thinking and abstract thinking through visualization, which aligns with cognitive laws, it can enhance students' enthusiasm for learning limits and provide a deeper understanding of the abstract concept of limits.

Based on the above analysis, taking the content of "limits" in advanced mathematics as an example, Matlab is introduced into the teaching and practice of limits. Through dynamic, visual, and vivid teaching processes, student participation in the classroom is increased, classroom efficiency is improved, and students' learning enthusiasm is enhanced. This demonstrates the "student-centered" teaching approach in advanced mathematics.

2. The application of MATLAB in teaching limits

Traditional limit teaching typically involves teachers lecturing and students practicing, with tasks being relatively simple and content being independent, which is not conducive to students' mastery and understanding, let alone application. Matlab's notable feature is its ability to display changes graphically, allowing students to have an intuitive understanding of conclusions and thereby discover the intrinsic connections and laws of complex problems. Unlike traditional teaching modes, limit teaching based on Matlab is a teaching mode that combines computer-assisted instruction with traditional teaching methods. This approach draws on both traditional teaching and computer-assisted instruction to inspire students and unleash their creativity, guiding them to actively think about the origins, applicability, and extensions of mathematical problems. When learning new knowledge, students can analyze examples through their own thinking, which may be more beneficial for their learning and mastery of mathematical concepts. Programming experiments with examples enable students to understand the context and specific applications of each knowledge point, facilitating their understanding and cultivating their observation skills, application awareness, and exploratory spirit.

There are mainly two ways to implement animations in Matlab: one is to display dynamic graphics in a relatively simple manner, by calling the geffram function to generate each frame, placing them in the graphics buffer, and using the movie command to play multiple frames within a second, taking advantage of the brief persistence of human vision. The other method is real-time motion, which utilizes the erase-mode property in graphics rendering to keep most of the pixel colors in the graphics window unchanged while only updating some pixel colors to create a moving image. Matlab integrates numerous powerful functions into an easy-to-use windowed environment, simplifying extremely complex problems and representing one of the most advanced scientific computing software currently available. It can be said that it allows us to view problems from the shoulders of giants.

2.1.Visualization as the independent variable approaches 0

Taking the function $y = \frac{\tan x - \sin x}{x^3}$ as an example, we use “limit” to canculate its limit,

```
syms x
y=(tan(x)-sin(x))./x.^3
LimitF=limit(y,x,0)
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Next, we create a visualization graph for the limit, where the red solid line represents the process as x approaches 0, and the blue dotted line shows the change in the function as x tends to 0. The

dynamic change process is shown in Figure 1.

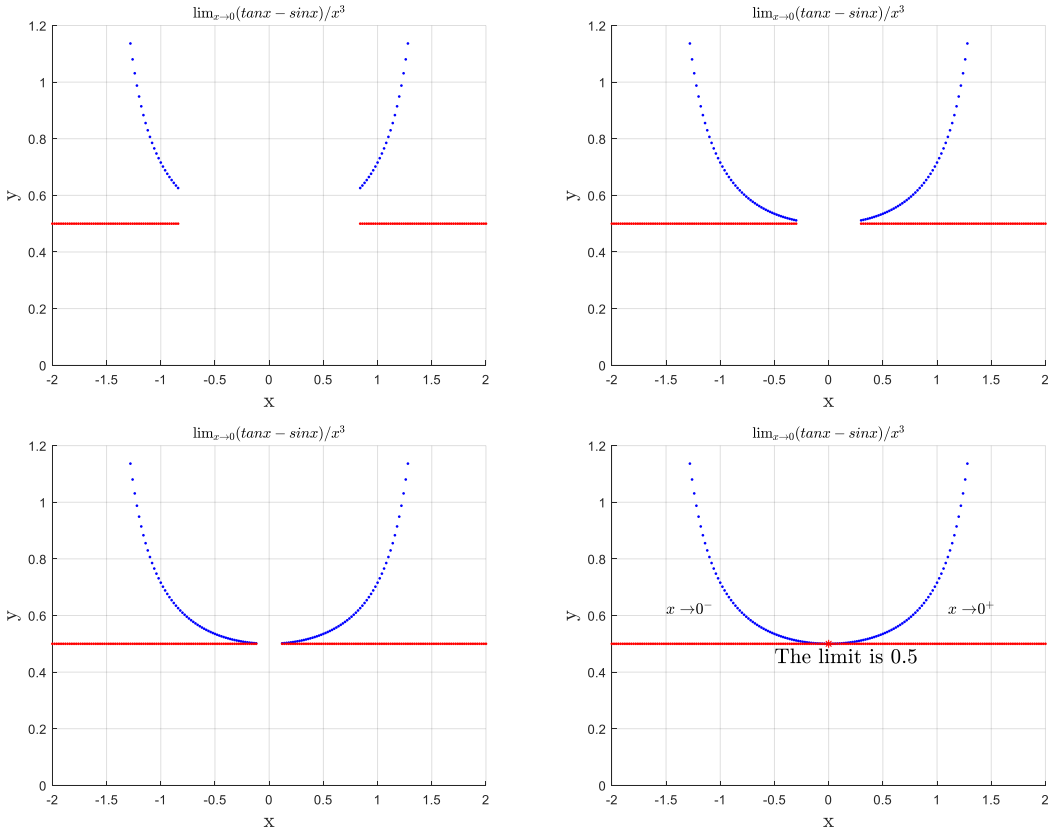

Figure 1 The visualization graph of $\lim\limits_{x\to 0} \dfrac{\tan x - \sin x}{x^3}$

From the dynamic graph in Figure 1, it can be seen that as x approaches 0 from the left, f(x) gets infinitely close to 1/2; and as x approaches 0 from the right, f(x) also gets infinitely close to 1/2. Moreover, the closer x gets to 0, the faster f(x) tends to 1/2 (at this point, the curve becomes steeper). Figure 1 fully demonstrates the process of a limit.

2.2. Visualization as the independent variable approaches $+\infty$

Taking the function $y = \arcsin\left(\sqrt{x^2 + x} - x\right)$ as an example, we Observe the trend of the function as the independent variable x changes to 50, 100, 1000, and 10000, with the results shown in Figure 2.

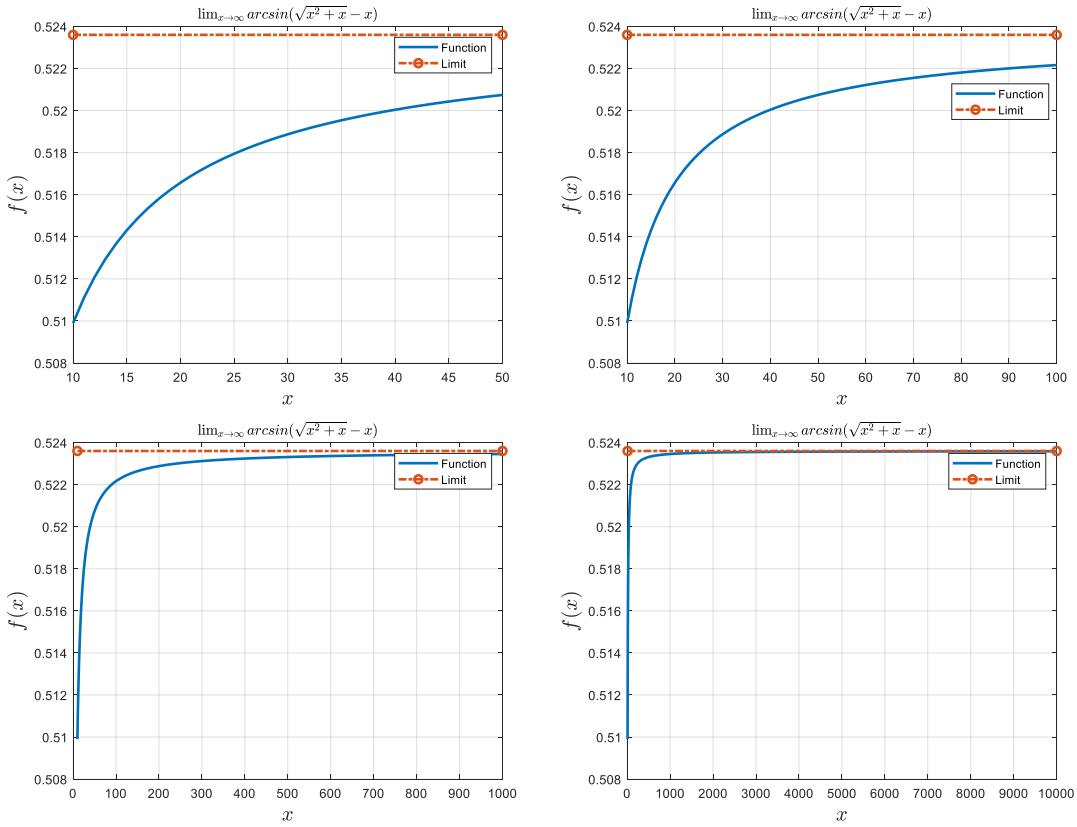

Figure 2 The visualization graph of $\lim\limits_{x\to+\infty} arcsin\left(\sqrt{x^2+x}-x\right)$

From the dynamic graph in Figure 2, it can be seen that as the independent variable takes real values and approaches $+\infty$, it gets infinitely close to pi/6. The computational results are fully consistent with the visualization process, and the visualization provides a more intuitive representation.

3. Conclusions

MATLAB is a scientific computing language with powerful capabilities in computation, analysis, and graphical processing. In the teaching of advanced mathematics courses, the introduction of MATLAB software provides an efficient means and great convenience for multimedia-assisted instruction. Traditional teaching in advanced mathematics courses places a strong emphasis on theory, making it difficult for students to understand abstract concepts and weak in spatial imagination. Based on MATLAB's visualization capabilities, dynamic visual designs can aid in the teaching of advanced mathematics, improve classroom efficiency, foster students' imaginative space, cultivate their divergent thinking, mathematical observation skills, and analytical abilities, and deepen their understanding and mastery of knowledge. This article demonstrates the convenience and intuitiveness of visual teaching using MATLAB, which is easy to operate and draw conclusions, helping students understand the process of limits, stimulating their enthusiasm and interest in learning, enhancing their awareness of the importance of mathematical knowledge, and broadening their horizons. It also cultivates students' interest in learning mathematics and allows them to further consolidate the knowledge points they have learned. This approach plays a significant role in cultivating students' awareness of the integration of mathematics and geometry, as well as their image thinking, effectively assisting them in analyzing practical problems,

enhancing student participation in the teaching process, and fully embodying the "student-centered" teaching philosophy.

Acknowledgements

This work was supported by Project of Educational and Teaching Reform of Beijing Institute of Petrochemical Technology (No.ZD202306002).

References

[1] Zhao Juming. (2023)Student-centered approach: The way forward for contemporary undergraduate education reform. Peking University Press.
[2] Department of mathematics, Tongji University.(2014) Advanced mathematics. Higher Education Press.2014.
[3] Xu Liang, Cheng Qingqing, Wang Ning.(2023)Using MATLAB to improve students' ability to solve practical problems . Research and practice of innovation and entrepreneurship theory. (12):168-170.
[4] Hua Yuchun.(2016) Two important limits of MATLAB animation demonstration . Journal of Higher Education, (15):148-149.
[5] Han Dong, Wang Ruopeng, Wang Xianhua(2024).MATLAB-based Visualization for Teaching Two Important Limits [J] .Curriculum and Teaching Methodology. Vol. 7 Num. 5:126-130.
[6] Fan Huihui.(2015) Promoting "active learning" in the classroom through innovative teaching models.. Teaching and research, 38(3):8-10.
[7] Sun Haiying, Li Wenzheng.(2018) Using mathematical experiments as a platform to cultivate students' awareness and ability of mathematical application. Education and Teaching Forum.(22):279-280.