ISSN 2663-8169 Vol. 7, Issue 4: 141-145, DOI: 10.25236/IJNDE.2025.070420

Research on Teaching Reform of Higher Mathematics in Applied Undergraduate Institutions Based on STEM Teaching Concept

Wanna Zhou

School of Information Engineering, Xi'an Fanyi University, Xi'an, Shaanxi, 710105, China
490693998@qq.com

Abstract: *The STEM teaching concept emphasizes interdisciplinary integration, mainly cultivating students' ability to analyze and solve problems. This article starts from the problems of outdated teaching methods, neglect of combining with practical problems, and generally low learning abilities of students in higher mathematics teaching. It analyzes the necessity of integrating STEM teaching concepts and the requirements for cultivating applied talents into higher mathematics classroom teaching, the reform of higher mathematics classroom teaching, and the improvement of students' comprehensive quality. It points out that STEM teaching concepts can be integrated into higher mathematics classroom teaching through the reform of teaching content, teaching methods, and evaluation systems. Finally, taking the concavity and convexity of functions as an example, research is conducted through the implementation of specific classroom teaching cases, aiming to comprehensively improve students' learning interest, ability to analyze and solve problems, teamwork ability, and practical hands-on ability, and comprehensively enhance students' comprehensive quality, Cultivate high-quality applied talents.*

Keywords: *STEM Teaching Concept, Teamwork Ability, Practical Hands-On Ability, Applied Talents*

1. Introduction

Applied undergraduate colleges mainly cultivate high-quality applied talents with strong practical abilities and innovative spirit, who can adapt to social development. Advanced mathematics courses are general education courses for science and engineering majors in applied undergraduate colleges, which cultivate students' logical thinking ability, analytical and problem-solving skills, and are the foundation of professional course learning. At present, higher mathematics courses are still traditional teaching, mainly emphasizing the explanation of theoretical knowledge, which is disconnected from practical application. At the same time, it also ignores the intersection and integration of mathematics with other disciplines, which is not in line with the cultivation of applied talents.

The STEM teaching concept is the cross integration of Science, Technology, Engineering, and Mathematics, breaking down disciplinary boundaries and cultivating students' comprehensive literacy and problem-solving abilities in an interdisciplinary manner. The teaching concept is to integrate real problems into higher mathematics, problem oriented, and focus on students' hands-on practical abilities. STEM teaching concept involves teachers posing complex engineering problems, and students solving practical problems through collecting relevant information, analyzing the problems, establishing mathematical models, and other steps, gradually improving students' logical thinking and problem-solving abilities.

In order to meet the requirements of society for the cultivation of applied talents and make the advanced mathematics courses serve the specialties, colleges and universities integrate the STEM teaching concept into advanced mathematics. Colleges and universities should change the existing traditional teaching mode and explore the teaching mode of advanced mathematics suitable for application-oriented undergraduate colleges and universities. Reference [1] combines the teaching of Newton Leibniz formula to explore higher mathematics teaching based on STEM teaching concept ; Reference [2] takes first-order ordinary differential equations as an example to explore the teaching mode of integrating STEM teaching concept into higher mathematics; Reference [3] explores the teaching strategies of higher mathematics courses in vocational colleges under the STEM concept; Reference [4] explores strategies for integrating STEM philosophy into higher mathematics in applied

ISSN 2663-8169 Vol. 7, Issue 4: 141-145, DOI: 10.25236/IJNDE.2025.070420

undergraduate institutions; Reference [5] combines STEM concept and applies Python language and ArcGIS software to mathematical modeling, cultivating the ability of college students to solve practical problems across disciplines; Reference[6] designed a STEM based blended learning model for engineering mathematics, which enhanced students' knowledge comprehension and logical thinking abilities. This article conducts research from four aspects: the problems existing in higher mathematics teaching, the necessity of integrating STEM teaching concept into classroom teaching, the ways of integrating STEM teaching concept into classroom teaching, and the implementation of classroom teaching cases.

2. Problems in the Teaching Mode of Higher Mathematics Classroom

At present, the teaching mode of higher mathematics courses is relatively outdated. Firstly, teachers mainly use traditional teaching methods, where teachers impart knowledge to students in a passive manner, while students passively receive knowledge. Students have poor class performance, low head up rate, lack effective interaction and initiative in the classroom, and gradually lose confidence in learning. In order to pass the exam, students memorize key points before the exam; Secondly, higher mathematics knowledge is closely related to practical problems, but often in the classroom teaching process, teachers only focus on imparting theoretical knowledge, neglecting the integration and application of mathematics with fields such as engineering and physics. Students' understanding of mathematics is just calculation problems, and they cannot understand the practical value of mathematics; Finally, due to the generally low mathematical learning ability of students in liberal arts colleges, their understanding and mastery of basic knowledge are not solid enough, and there are certain difficulties in the flexible application of knowledge. In order to ensure course progress and exam pass rates, teachers tend to prefer traditional teaching and are unwilling to spend more time and energy exploring application cases of mathematical knowledge.

3. The inevitability of integrating STEM teaching concept into higher mathematics classroom teaching

3.1. The STEM teaching concept is a requirement for cultivating applied undergraduate talents

The STEM teaching concept originated in the United States in the 1980s and is the abbreviation for the four disciplines of Science, Technology, Engineering, and Mathematics. It mainly emphasizes the interdisciplinary integration and aims to cultivate students' comprehensive and innovative abilities. At present, schools use the talent cultivation program under the OBE concept, which aims to cultivate high-quality interdisciplinary applied talents with innovative spirit and practical ability, guided by results and centered on students. The integration of STEM teaching concept into higher mathematics is in line with the requirements of OBE concept for the cultivation of applied talents and is an inevitable requirement for the cultivation of applied undergraduate talents.

3.2. The STEM teaching concept is an inevitable requirement for the reform of higher mathematics teaching

Higher mathematics courses focus on the imparting of pure theoretical knowledge, while traditional teaching is mainly taught by teachers, with students passively receiving knowledge and relatively weak in practice. At the same time, the integration of mathematics with other disciplines is relatively limited. At present, applied undergraduate colleges mainly focus on cultivating high-quality applied talents. The STEM teaching philosophy emphasizes the integration of multiple disciplines, focuses on the cultivation of practical abilities, combines mathematics with science, engineering, and technology, stimulates students' innovative practical abilities, and through interdisciplinary integration, enables students to have the ability to solve practical problems with multidisciplinary knowledge in the learning process of higher mathematics.

3.3. The STEM educational philosophy helps improve students' comprehensive quality

In the rapidly developing society of technology, there is a need for applied talents with comprehensive qualities, and the STEM teaching concept is to cultivate students' comprehensive qualities through interdisciplinary integration. Integrating STEM teaching concepts into higher mathematics can effectively combine mathematical knowledge with engineering knowledge. For

ISSN 2663-8169 Vol. 7, Issue 4: 141-145, DOI: 10.25236/IJNDE.2025.070420

example, introducing optimization problems in engineering in the classroom, students can start from reality, establish mathematical models through group discussions, analyze and solve them, and draw conclusions. During this process, students' innovative thinking ability, teamwork ability, and practical hands-on ability were cultivated, comprehensively improving their overall quality.

4. Ways to integrate STEM teaching concept into higher mathematics classroom teaching

4.1. Reform of Higher Mathematics Teaching Content

At present, the teaching content of higher mathematics classrooms focuses on the teaching of theoretical knowledge and the proof of theoretical knowledge. Students are limited to knowing how to solve mathematical problems and cannot combine mathematics with practical problems to solve practical problems. They lack the ability to solve problems and feel that mathematics has nowhere to go. Therefore, based on the STEM teaching concepts, combining mathematics with science, engineering, and technology, designing cases related to advanced mathematics and professional knowledge, and cultivating students' problem-solving abilities through project-based teaching. For example, when explaining the extremum of multivariate functions, the heat dissipation problem of electronic products can be introduced. The design of heat sinks needs to consider factors such as heat dissipation area and material cost. Therefore, it is necessary to establish a multivariate function relationship and use the solution of multivariate function extremum to seek the optimal value; At the same time, when explaining the definition of definite integral, students can also search for a leaf everywhere on campus and use the calculation of leaf area as a project to complete the mathematical model of the leaf area problem in groups. Students can solve practical problems in life out of curiosity. By incorporating interesting cases, students' interest in learning has been stimulated, their problem-solving abilities have been exercised, and they have also come to understand the practicality of mathematics. Mathematics is everywhere in life.

4.2. Reform of Higher Mathematics Teaching Methods

At present, higher mathematics is mainly taught through traditional lecture style teaching, with a single teaching method and a lack of practical elements. The STEM teaching concept is to integrate multiple disciplines, thus changing the traditional lecture style teaching and designing problem oriented, interdisciplinary project-based teaching. For example, for software engineering students, after learning differential equations, they can integrate advanced mathematics with computers and assign project-based practical assignments to predict population growth trends in a certain area. Through project-based teaching, students' hands-on abilities have been exercised, the integration of mathematics and professional knowledge has been enhanced, and their innovation and teamwork abilities have been cultivated.

4.3. Reform of the Evaluation System for Higher Mathematics Teaching

At present, our university's higher mathematics evaluation system includes summative evaluation and process evaluation. Process evaluation consists of five parts: preview the lessons before class, classroom performance, post class homework, stage tests, and notes. However, these five parts are all evaluated solely by the teacher and cannot reflect students' self-evaluation and mutual evaluation. Therefore, it is necessary to establish diversified evaluation standards in higher mathematics courses, combining teacher evaluation, student self-evaluation, and student mutual evaluation to promote mutual learning among students. At the same time, in terms of homework after class, on the basis of the original theoretical homework, project-based homework in the form of creating PPT courseware, course reports, establishing mathematical models, etc. will be added in groups, and project reports will be presented. Through mutual evaluation between groups and between members, students' practical ability, innovation ability, and teamwork ability will be exercised, their comprehensive quality will be improved, and their learning situation will be comprehensively understood. Summative assessment mainly evaluates students' situation through final exams.

5. Practical examples of integrating STEM teaching concept into higher mathematics

Mathematics originates from life and serves it. We should approach things around us with a discerning eye, discovering mathematics and beauty from them. Study the concavity and convexity of

ISSN 2663-8169 Vol. 7, Issue 4: 141-145, DOI: 10.25236/IJNDE.2025.070420

functions based on the design of the Hong Kong Zhuhai Macao Bridge.

5.1. Create a context and ask questions

The Hong Kong Zhuhai Macao Bridge connects Hong Kong, Zhuhai, Guangdong, and Macau, China, crossing the Lingdingyang waters of the South China Sea to the west, covering a total distance of 55 kilometers. It is hailed by The Guardian as one of the "Seven Wonders of the New World". By observing the top view of the Hong Kong Zhuhai Macao Bridge, it can be found that there is a section of the bridge deck that is curved, rather than designed as the shortest straight line between two points. Why is this?

5.2. Group discussion to guide students to form relevant knowledge systems

Students discuss in groups, while the teacher is the organizer of the classroom. The group searched for relevant information to understand the characteristics of underwater organisms and the direction of ocean currents, and what is the relationship between these and the curvature of the bridge deck? What is the connection with higher mathematics? The teacher encourages students in a timely manner based on the answers they find, stimulating their ability to explore.

5.3. Answer questions and cultivate STEM literacy

Through group discussions and exchanges, it can be concluded that the winding bridge deck is designed to protect Chinese white dolphins and follow the direction of ocean currents, protecting animals and the natural environment. The teacher guides students to observe the plane shape of the bridge deck, connects any line segment between any two points on the image, and observes the relationship between the selected segments of any two points and the image. The teacher summarized the characteristics of the image and concluded that the function where the line segment of any two points is located below the image is called a convex function; The function where the line segment of any two points is located above the image is called a concave function.

The teacher raised the question again, and the group discussed it again. What is the relationship between concave convex functions and derivative? The teacher guides the students to make tangents to any point of the concave convex function and observe the changes in the tangents?

After intense discussion, the group concluded that the slope of the tangent of a concave function increases with the increase of x, while the slope of the tangent of a convex function decreases with the increase of x. By utilizing the monotonicity of functions, it can be concluded that the derivative of a concave function is a monotonically increasing function, while the derivative of a convex function is a monotonically decreasing function. The teacher guides students to further think that if the derivative function is a monotonically increasing function, it means that the derivative function of the derivative function is greater than zero, that is, the second derivative of the function is greater than zero. Similarly, if the derivative function is a monotonically decreasing function, it means that the derivative function of the derivative function is less than zero, that is, the second derivative of the function is less than zero.

The teacher summarized the results through student discussion and identified the key content of this lesson, which is the determination of the concavity and convexity of functions. If a function is continuous on a certain interval and has first and second derivatives within the interval, then the second derivative is greater than zero within the interval, and the graph of the function on the interval is concave; If the second derivative is less than zero within the interval, the graph of the function on the interval is convex. Finally, through specific example analysis, deepen the application of determining the concavity and convexity of functions.

5.4. Teaching Reflection and Evaluation

Throughout the entire teaching process, starting from the design of the Hong Kong Zhuhai Macao Bridge deck, mathematics is linked to practical engineering problems. Students realize the close connection between mathematics and science, technology, and engineering. Through the implementation of scenarios, group discussions, and hands-on operations, students experience the practical application value of mathematics. At the same time, it also enhances students' interest in learning, ability to analyze and solve problems, practical skills, and comprehensively improves their comprehensive quality.

ISSN 2663-8169 Vol. 7, Issue 4: 141-145, DOI: 10.25236/IJNDE.2025.070420

6. Conclusions

The STEM teaching concept is a new teaching concept, and the reform of higher mathematics teaching based on the STEM teaching concept is in line with the requirements of talent cultivation in applied undergraduate colleges and is an important way to cultivate high-quality innovative talents. On the basis of the existing problems in higher mathematics classroom teaching at present, this article analyzes the necessity of integrating STEM teaching concepts into higher mathematics classrooms, and proposes ways to integrate STEM teaching concepts into higher mathematics classrooms. Finally, through specific case studies, it is demonstrated that integrating STEM teaching concepts into higher mathematics teaching can effectively improve students' learning interest, cultivate their innovation ability, teamwork ability, and hands-on practical ability, and provide effective ways for teaching reform.

Acknowledgements

This work was supported by the 2024 Education and Teaching Reform Research Project of Xi'an Fanyi University (J24B30).

References

[1] Wang Xiangping. Study on Classroom Teaching Mode of Higher Mathematics Based on STEM Concept—A Case Study of Newton-Leibniz Formula [J]. Research and Practice of Innovation and Entrepreneurship Theory, 2022, (22): 165-167.

[2] Liu Zhixiu, Huang Xiaojie. Teaching Design and Practice of Differential Equations of First Order Ordinary from the Perspective of STEM [J]. Journal of Jiangxi Vocational and Technical College of Electricity, 2019, 32 (6): 48-49.

[3] Dong Zhihua. Research on Teaching Strategies for Higher Mathematics Courses in Vocational Colleges under the STEM Concept [J]. University, 2024, (26):160-163.

[4] Xu Yan. Research and Practice on Higher Mathematics Teaching Reform in Applied Undergraduate Colleges Based on STEM Teaching Concept [J]. Inner Mongolia Coal Economy, 2020, (13): 219-220.

[5] Suo Qifeng, Luo Jiaojiao, Wang Muyixiong. Innovative ability cultivation of college students based on STEM: A case study of ArcGIS and Python applied to higher mathematics [J]. Educational Studies, 2024, 30(07): 105-107.

[6] Qin Hui. Research on Design and Evaluation of Blended Teaching Model in Engineering Mathematics Based on STEM [J]. Journal of Jingdezhen University, 2024, 39(03): 124-129.