Advances in Educational Technology and Psychology (2025)
Clausius Scientific Press, Canada
DOI: 10.23977/aetp.2025.090208
ISSN 2371-9400 Vol. 9 Num. 2

Exploration of Optimization and Interdisciplinary Integration Path of Teaching Model of Advanced Mathematics in Engineering Management Major

Bo An[1,a], Xiaojing Wang[2,b,*]

[1]Institute of Technology, Xi'an Siyuan University, Xi'an, Shaanxi, China
[2]Basic Department, Xi'an Siyuan University, Xi'an, Shaanxi, China
[a]2226576815@qq.com, [b]1017411047@qq.com
**Corresponding author*

Keywords: Engineering Management, Advanced Mathematics, Teaching Model, Interdisciplinary Integration, Teaching Optimization

Abstract: The teaching of the traditional engineering management major "Advanced Mathematics" over-focuses on theoretical derivation and lacks connection with engineering scenarios such as engineering cost and progress management, resulting in insufficient application ability of students in mathematics tools. This study proposes a reform framework for "three-dimensional integration": in terms of teaching philosophy, students are the center, and the integration of project-based learning and virtual reality are adopted; in terms of content system, a "mathematics tool chain-engineering problem domain" mapping model is built, and core modules such as calculus and matrix operations are connected to cost optimization and risk assessment and other professional scenarios, and embed cutting-edge content such as data analysis and machine learning; in terms of implementation guarantee, a case library is developed for schools and enterprises to jointly build, a dual-teacher team of "mathematics + engineering" is formed, and a multi-dimensional evaluation system of "process observation + ability assessment" is innovated. In terms of interdisciplinary integration, the construction of "Mathematics + X" course group is proposed, and digital twin scenarios are integrated based on BIM technology to realize closed-loop training in mathematical modeling and engineering decision-making. In the future, we will deeply develop an adaptive learning platform, promote the deep embedding of mathematics teaching into the smart construction site management system, and cultivate compound talents who "build the foundation of mathematics and physics and empower engineering" for the era of intelligent construction.

1. Introduction

Against the backdrop of innovation in the field of engineering, engineering management, as a comprehensive discipline, needs to integrate technical, economic and management factors to ensure the efficient promotion of projects. As a key basic course, advanced mathematics[1-3] runs through all aspects such as preliminary feasibility study, cost-benefit analysis, project implementation

progress, resource management, and later risk assessment and quality inspection. For example, cost control uses calculus derivative to build models to find the minimum cost value, while progress management relies on linear algebra to build scientific network diagrams. However, traditional higher mathematics teaching has obvious limitations, and excessive focus on theory and formula derivation is seriously disconnected from the actual engineering management, making it difficult for students to flexibly use knowledge to solve practical problems, and the phenomenon of "disconnection between learning and application" occurs. This not only dampens students' enthusiasm for learning, but also hinders the development of their comprehensive abilities. With the increasing demand for compound and innovative talents in the industry, optimizing the teaching model of advanced mathematics and promoting its interdisciplinary integration with engineering management majors has become an inevitable trend in education reform.

Foreign research started early and achieved remarkable results. For example, American universities such as Stanford University have introduced a large number of engineering practice cases in teaching, carried out project-based learning, organized students to participate in actual projects, and improved their practical and innovative abilities. MIT deeply integrates advanced mathematics with multidisciplinary subjects through interdisciplinary courses such as "engineering system design", guiding students to think from multiple angles and experience the synergistic effects of knowledge in different disciplines. Domestic universities such as Tsinghua University are also actively exploring teaching reforms, streamlining theoretical content, increasing application cases and practical links, and encouraging teachers to carry out interdisciplinary teaching research. However, current research still has shortcomings, such as difficulty in promoting innovative teaching methods, insufficient depth of interdisciplinary integration, and imperfect teaching evaluation system. Future research can focus on improving teaching models, deepening interdisciplinary integration[4-6], and innovating teaching evaluation systems to promote teaching development and innovation.

2. The significance and current situation of interdisciplinary integration in advanced mathematics teaching in engineering management major

2.1. The connotation and value of interdisciplinary integration

Interdisciplinary teaching requires teachers to have both high math theory and practical insights in engineering management, and be able to accurately refine the knowledge coupling points between the two. Teacher construction requires three measures: First, organize interdisciplinary training, invite engineering management experts to analyze mathematical application scenarios in BIM technology, and improve teachers' curriculum design capabilities; second, build a collaborative platform for industry, academia and research, encourage teachers to participate in practical projects such as smart construction sites, and accumulate practical experience in transforming engineering problems into mathematical models; third, form a "mathematics + engineering" mixed-edition teaching and research team, jointly develop a modular case library, form a full-chain capability improvement mechanism of "theoretical deconstruction-case research and development-teaching implementation", and cultivate a dual-teacher teaching team.

2.2. The fit between engineering management major and interdisciplinary integration of advanced mathematics

The interdisciplinary integration of engineering management major and advanced mathematics is mainly reflected in two dimensions: quantitative decision-making and systematic optimization. First, calculus and probability statistics provide mathematical support for project risk assessment, cost

dynamic prediction and construction period elasticity analysis. For example, using Monte Carlo to simulate quantification of uncertain risks, and optimizing resource allocation model through regression analysis. Second, linear algebra and operations research form the algorithm basis for engineering system optimization, matrix operations support the construction of multi-objective decision-making models, and the key path method in network planning technology realizes process logic deconstruction based on graph theory. Especially in intelligent construction driven by BIM technology, differential equations describe the dynamic evolution of engineering systems, and fuzzy mathematics deals with multi-attribute decision-making problems under complex constraints. This integration not only improves the accuracy of management decisions, but also promotes the transformation of engineering management from experience-driven to data-driven, which is in line with the cross-innovation trend of "mathematics +" in the construction of new engineering science, and provides algorithm support for cutting-edge fields such as smart construction sites and lean construction.

2.3. Current situation and issues of interdisciplinary integrated teaching

In the advanced mathematics teaching of engineering management majors, although interdisciplinary integration has begun, universities have tried to increase case analysis and hold mathematical modeling competitions to cultivate students' application abilities, there are still many problems. The depth of integration is not enough, and students do not dig deep into the internal connections when explaining the cases of calculus introduction, making it difficult for students to build a knowledge system. There is a shortage of teachers and a single subject background for teachers. The evaluation system is incomplete, and we emphasize knowledge over ability assessment. The lack of systematic curriculum settings and lack of teaching resources have led to a single teaching content and outdated methods for teachers, which cannot stimulate students' interest.

3. Teaching model optimization strategy

3.1. Changes in student-centered teaching philosophy

Although the traditional higher mathematics teaching is dominated by teachers, although the knowledge indoctrination model ensures the systematicity of knowledge, it suppresses students' subjectivity and personalized development, resulting in insufficient motivation to learn. Teaching reform should turn to the concept of "student subject" and achieve transformation through three paths: first, classroom teaching adopts case-driven and interactive exploration, such as combining practical problems such as cost optimization in engineering management to explain derivative applications, and stimulate in-depth thinking through group discussions; second, strengthen application capabilities through mathematical experiments and modeling practices, guide students to use tools such as Matlab to solve engineering problems, and cultivate data analysis and innovative thinking; finally, build an independent learning support system, guide students to formulate personalized learning plans, integrate online courses, academic papers and other diverse resources, and improve learning efficiency through learning methods guidance and experience sharing. This transformation can not only maintain the integrity of the knowledge system, but also effectively improve students' practical ability, innovation awareness and lifelong learning ability, and achieve the comprehensive development of comprehensive qualities.

3.2. Application of diversified teaching methods

There are three effective teaching methods in the higher mathematics teaching of engineering

management major. Project-based learning is student-centered and integrated into real project situations. For example, design engineering project cost control project, students use calculus and other knowledge modeling, analysis and optimization, stimulate learning interest and initiative, improve knowledge application and practical problem solving ability. Case teaching uses engineering problems as the carrier to drive knowledge transfer. For example, in the case of "Optimal design of bridge bearing structure", students combine calculus and mechanics knowledge and use Matlab to verify the scheme to strengthen interdisciplinary problem solving ability. Group discussions drive deep learning with engineering problems as anchors. For example, around the "optimal size design of building structures", students collaborate in modeling and analyzing constraints, deepen understanding of extreme value theory in discussions, train systematic engineering thinking, improve logical expression and teamwork ability, and transform abstract mathematical knowledge into a thinking tool for solving complex engineering problems.

3.3. With the help of modern educational technology

Information technology[7-8] is deeply integrated into advanced mathematics teaching in engineering management majors, and promotes innovation and upgrading of teaching models. Multimedia technology breaks through knowledge abstraction through intuitive visualization: through dynamic demonstration of the rotating surface generation process through 3D animation, presenting spatial analytical geometric concretely; combining engineering case videos to enhance knowledge transfer awareness. The online teaching platform builds an ubiquitous learning ecosystem, integrates videos, courseware and other resources to support independent review, and uses the discussion area to achieve diversified interaction to promote personalized guidance. Mathematical software expansion practice dimensions: Teachers use Matlab to dynamically solve differential equations and visualize the results to deepen concept understanding; students carry out experimental projects such as matrix operations and data processing through programming to cultivate computational thinking and innovation capabilities, and realize the teaching closed loop of "integration of learning and application".

3.4. Optimization and integration of teaching content

In the reform of advanced mathematics teaching for engineering management, we should integrate engineering cases and strengthen software teaching. Secondly, teachers should deepen core modules, design cases to consolidate the foundation and dynamically update the content, embed new mathematical methods, cultivate students' ability to deal with complex problems, and build a good curriculum ecology.

4. Interdisciplinary integration implementation path

4.1. Construction of integrated curriculum system

Guided by the needs of engineering management, the curriculum system of "goal - content - method" is constructed, focusing on mathematical modeling and decision making, integrating the content to map mathematics to engineering, adopting the mode of "modularity + virtual and real combination" and "double teacher", connecting the thinking of mathematics and engineering, and cultivating cross-type talents of intelligent construction.

4.2. Interdisciplinary teaching case development and implementation framework

4.2.1. Case Development Paradigm

Case development adheres to three principles. For demand precision, by aligning with the "Engineering Management Professional Certification Standard" and the intelligent construction position ability matrix, as in Table 1, a "mathematical tool - job demand" mapping model is set up. In terms of cutting - edge technology, BIM + digital twin integration creates parametric scenarios. Teaching adaptability uses modular design: basic cases for single skills, comprehensive for multi - disciplines, and innovative for competitions. These cases form an ability - advancing path to meet project needs and drive intelligent construction tech.

Table 1 Mathematical tool chain - Mapping model of engineering problem domain.

Case Type	Mathematical Tool	Engineering Scenario	Ability Development Goal
Cost control	Extremum of a multivariate function	Commercial complex project profit maximization	Multivariable optimal decision-making ability
Risk assessment	Probability distribution and regression analysis	Construction delay and material price fluctuation prediction	Data-driven risk management capabilities
Schedule optimization	Matrix operations and graph theory	Critical path analysis of engineering network planning	Systematic project management ability

4.2.2. Analysis of typical teaching cases

Case 1: Cost dynamic optimization of commercial complex

Project scenario: The total cost of a project is $C(x,y)=1.2x^2+0.8y+50$ (x is the construction rate, y is the amount of materials), and the revenue function is $R(x)=100x-0.5x^2$.

Mathematical tasks:

1) The build profit function is $P(x,y)=R(x)-C(x,y)$.

2) A system of equations $\frac{\partial P}{\partial x}=0,\frac{\partial P}{\partial y}=0$ is established by solving partial derivatives.

3) Matlab was used to draw 3D profit surface and locate extreme value points.

Extension of teaching: The effect of premium of environmental materials on the optimal solution is discussed, and the Lagrange multiplier method is introduced.

Case 2: Construction risk assessment based on Monte Carlo simulation

Engineering scenario: Predict the cost of construction delays due to extreme weather.

Mathematical modeling:

1) Collect ten years of meteorological data and establish the normal distribution model of daily rainfall as $X\sim N(\mu,\sigma^2)$.

2) Define the delay cost function as $L(x)=\begin{cases}0 & x<30mm\\ 5000(x-30) & x>30mm\end{cases}$.

3) Generate 10000 random rainfall events through Python and calculate the expected loss $E(L)$.

Teaching results: Output risk probability distribution map, formulate rainy season construction emergency plan.

4.3. Teaching staff construction

Interdisciplinary teaching requires teachers to have both high mathematical theoretical knowledge and practical insights in engineering management, and be able to accurately refine the knowledge coupling points of the two (such as the mapping relationship between key path algorithms and matrix operations). Teacher construction requires three measures: First, organize interdisciplinary training, invite engineering management experts to analyze mathematical application scenarios in BIM technology, and improve teachers' curriculum design capabilities; second, build a collaborative platform for industry, academia and research, encourage teachers to participate in practical projects such as smart construction sites, and accumulate practical experience in transforming engineering problems into mathematical models; third, form a "mathematics + engineering" mixed teaching and research team to jointly develop a modular case library.

4.4. Innovation in teaching evaluation system

Building a diversified evaluation system is the key support for the reform of advanced mathematics teaching in engineering management majors. It is necessary to break through the traditional "one-test determination" model and establish a composite framework of "process observation + ability assessment": process evaluation covers classroom participation, homework innovation, and collaborative performance in mathematical modeling projects (such as algorithm design ability when analyzing engineering data using Matlab); performance evaluation focuses on real engineering tasks, such as the accuracy of matrix operations in the construction period optimization plan based on the critical path method, the rationality of differential equation models and other core abilities; introduces a mechanism for mutual evaluation of students' self-evaluation scales and groups to strengthen metacognition and critical thinking. The evaluation results need to be transformed into teaching improvement strategies in a timely manner, such as adjusting the focus of calculus teaching through homework error cluster analysis, forming a closed loop of "evaluation-diagnosis-optimization", and truly realizing the virtuous cycle of "using evaluation to promote learning and using evaluation to promote teaching".

5. Conclusion

This study constructs the teaching reform paradigm of "three-dimensional integration" in higher mathematics of engineering management. In terms of teaching concept, the use of multiple teaching to stimulate deep learning; In the content system, the mapping model is built to accurately match the professional needs; In terms of implementation guarantee, the "double teacher" team, case base and multi-dimensional evaluation system are created to provide a replicable scheme for intelligent construction and training of composite talents. In the future, the advanced mathematics teaching of engineering management major has a broad prospect, and deepening interdisciplinary integration is a trend, and comprehensive courses will be developed by integrating with multiple disciplines. At the same time, artificial intelligence technology will be used to achieve personalized teaching and evaluation based on student learning data to help teachers and students.

References

[1] Tan, X.Y., Zhang, Y.F., Zhang, H. and Li, T.X. (2024) Exploration of Hybrid Teaching of Higher Mathematics Based on Artificial Intelligence. Open Access Library Journal,11, 1.

[2] Zhu, Y.H. and Chen, S.H. (2022) On the Teaching Reform of Applied Mathematics in Colleges and Universities and the Cultivation of Students' Applied Mathematics Consciousness. Open Access Library Journal,9, 1-5.

[3] Meng, X. and Zheng, S. (2022) Research on the Integrated Teaching Mode of Online and Offline in College Mathematics Teaching. Creative Education,13, 2903-2912.
[4] da Silva, V., da Silva, J. and de Castro, R. (2015) Interdisciplinary Formation and Social Integration in Present-Day. Creative Education,6, 1825-1831.
[5] Jin, X.C. and Tang, J.L. (2025) Research on the Interdisciplinary Integration and Development of Dance under the "New Liberal Arts". Open Access Library Journal,12, 1-5.
[6] Er Saw P, Jiang S. The significance of interdisciplinary integration in academic research and application[J]. Bio Integration, 2020, 1(1): 2.
[7] Andrade-Arechiga, M., Lopez, G. and Pulido, J. (2013) Mathematics Education and Information Technologies in Emerging Economies. Creative Education,4, 40-47.
[8] Liu X .The application of information technology in the teaching of Chinese language and literature[J].Basic & clinical pharmacology & toxicology. 2019(S1):124.