Discussion on the construction of vocational undergraduate mathematics curriculum system

Bowen LI

Shenzhen Polytechnic University, Shenzhen 518055, China

Abstract: The country has established a pilot project for undergraduate vocational education, proposing new requirements for mathematics courses. Taking the curriculum system positioning and construction planning as the benchmark, this paper starts from the early stage of preparation, reconstructs the curriculum, and establishes a brand-new mathematics curriculum system. The final framework consists of a core curriculum of general education that strengthens the foundation and a disciplinary foundation platform curriculum that highlights the cultivation of applied abilities. Different courses are designed for different majors to adapt to the new challenges of vocational undergraduate education.

Key words: vocational undergraduate; mathematics; curriculum system

1 Introduction

On 24th January, 2019, the State Council issued the National Vocational Education Reform Implementation Plan, which explicitly stated that "vocational education and general education are two different types of education with equal importance." At the same time, it established the pilot project for undergraduate vocational education to achieve this goal. As a leading institution in domestic vocational education, the school has actively carried out reforms in vocational undergraduate education and restructured various courses. As a fundamental public course, mathematics holds a crucial position. However, in vocational undergraduate education, the content and design of mathematics courses differ from those in specialized fields. Therefore, teachers in the mathematics department are actively exploring how to construct the curriculum system for vocational undergraduate mathematics and how to design the course content.

2 Curriculum system positioning and construction planning

Before constructing the curriculum system, it is essential to first clarify the positioning of vocational undergraduate curriculum systems, ensuring the two major elements of vocational nature and undergraduate characteristics. The goal is to establish a benchmark against postgraduate entrance examinations, setting high standards for the construction of vocational undergraduate mathematics courses. The aim is to establish a first-class vocational education undergraduate curriculum system nationally, forming a distinctive and profound vocational paradigm [1].

3 Preliminary preparation

To establish a high-standard, first-class vocational undergraduate curriculum system in the country, the school leadership convened a seminar with the mathematics department teachers to discuss the construction of the mathematics curriculum system. The positioning and standards for curriculum system construction were established, and significant support was expressed. The mathematics department teachers organized a seminar to discuss how to implement the

construction of the curriculum system, focusing on the following aspects.

Firstly, reviewing curriculum resources involved arranging existing course materials such as curriculum standards, schedules, lesson plans, and online resources like videos and PowerPoint presentations.

Secondly, collecting curriculum standards from major undergraduate institutions and vocational undergraduate institutions offering mathematics courses. Teachers were assigned to gather curriculum standards from two to three schools each, providing a basis and reference for the construction of the curriculum system [2].

Thirdly, reviewing the postgraduate entrance examination syllabus to identify specific differences in the syllabus for Mathematical Analysis I, II, and III. These include differences in the corresponding majors, course content, and teaching materials.

After the review, the distinctions between the corresponding majors for Mathematical Analysis I, II, and III in the postgraduate entrance examination were clarified. Mathematical Analysis I mainly targets 20 engineering disciplines, Mathematical Analysis II focuses on five majors, including textiles, light industry, agriculture, forestry, and food, while Mathematical Analysis III is geared toward economics and management majors. Additionally, there are differences in the course percentages for Mathematical Analysis I, II, and III, as shown in Table 1.

Table 1. The proportion of postgraduate mathematics courses

Courses	Higher mathematics	Linear algebra	Probability theory and mathematical statistics
Mathematics I	56%	22%	22%
Mathematics II	80%	20%	/
Mathematics III	60%	20%	20%

Additionally, there is also a big difference in the content and requirements of Mathematics I, II and III. Specifically, compared with Mathematics I and III, Mathematics II does not include vector algebra and analytic geometry, as well as infinite series, while Mathematics I and Mathematics III may have detailed differences in certain chapters, reflecting the characteristics of their respective majors. The specific content differences and their distribution are shown in Table 2.

Table 2. Differences in the contents of postgraduate mathematics courses

Courses	Advanced Mathematics (upper)	Advanced Mathematics (Lower)	Linear algebra	Probability theory and mathematical statistics
Mathematics I	There are two more ordinary differential equations	Vector algebra and analytic geometry, multivariate differential learning, multivariate function integral learning (add triple integral, curve integral, surface integral, etc.), infinite series	In the vector, the substrate, orthogonal transformation, etc	Random events and probability, random variables and their distribution, multidimensional random variables and their distribution, numerical characteristics of random variables, and the theorem of large numbers and central limit theorem; basic concepts of mathematical statistics, parameter estimation and hypothesis testing
Mathematics II	Function, limit, continuous, unary function differential learning, unary function integral	Ordinary differential equations, the calculus of multivariate functions	Determinant, matrix, vectors, system of linear equations, matrix eigenvalues and eigenvectors, quadratic type	/

		learning		
Mathematics III	There are two more ordinary differential equations	Multivariate functional calculus, the infinite series	Same number 2	No hypothesis testing

4 Curriculum system framework

On the basis of the above preparatory work, the mathematics curriculum system framework was finally formed by strengthening the core curriculum of general education and the basic platform course of outstanding application ability, and the formulation of the corresponding curriculum standards was completed. As shown in Table 3.

Table 3. Framework of mathematics curriculum system

		Course title	Class hours
Strengthen the foundation	Core curriculum of general education	Advanced Mathematics I (upper)	80
		Advanced Mathematics I (lower)	80
		Advanced Mathematics II (upper)	48
		Advanced Mathematics II (lower)	48
		Advanced Mathematics III (upper)	64
		Advanced Mathematics III (lower)	64
		Mathematical Foundation (upper)	48
		Mathematical Foundation (lower)	48
Application ability training	Subject basic platform course	Linear algebra I	48
		Linear algebra II	32
		Probability theory and mathematical statistics I	64
		Probability theory and mathematical statistics II	48
		Complex change function and the integral transformation	48
		Operations research	48

5 General education core courses

As an essential component of strengthening foundational knowledge, the general education core courses should lay a solid foundation and construct core general education courses with high standards. First and foremost, it is crucial to clearly define the positioning of these courses as general education core courses, forming the basis for subsequent courses.

5.1 Course positioning of Advanced Mathematics

The Advanced Mathematics course is a mandatory foundational course offered to students majoring in science and engineering disciplines, particularly those preparing for the postgraduate entrance examination in the Mathematics I subject or those with higher requirements for advanced mathematics. This course, a sub-course of university mathematics, is not only indispensable for subsequent courses, but also an important means for cultivating rational thinking. In the teaching process, instructors should not only impart the mathematical knowledge listed in the syllabus, but also strive to reveal important thinking methods inherent in mathematical knowledge. Using knowledge (concepts, theories, applications, etc.) as a medium, instructors should vividly and concisely articulate the thinking methods inherent in the knowledge, allowing students to be immersed in rational thinking and appreciate its beauty, thus subtly enhancing their abilities and qualities.

5.2 Objectives of the Advanced Mathematics course

Knowledge objectives: Through the study of these courses, students should acquire fundamental concepts, theories, methods, and operational skills in single-variable calculus and its applications, multi-variable calculus and its applications, infinite series, ordinary differential equations and difference equations, vector algebra and spatial analytic geometry, linear algebra, probability theory, and mathematical statistics. This lays a necessary mathematical foundation for future study of various subsequent courses and the expansion of knowledge in continuous, discrete, and stochastic quantities [3].

Skills objectives: Alongside knowledge transmission, attention should be paid to cultivating students' ability for abstract thinking and logical reasoning, as well as the integrated application of learned knowledge to analyze and solve problems. The course aims to progressively foster students' spirit of exploration and innovation, along with strong self-learning capabilities.

Quality objectives: This course, as a sub-course of university mathematics, is not only indispensable for subsequent courses, but also a significant vehicle for cultivating rational thinking. In the teaching process, instructors should not only impart the mathematical knowledge listed in the syllabus, but also strive to reveal important thinking methods inherent in mathematical knowledge. Using knowledge (concepts, theories, applications, etc.) as a medium, instructors should vividly and concisely articulate the thinking methods inherent in the knowledge, allowing students to be immersed in rational thinking and appreciate the beauty, thus subtly enhancing their abilities and qualities.

6 Discipline foundation platform courses

As a distinctive feature of the curriculum system, discipline foundation platform courses emphasize the cultivation of skills and should be constructed with a focus on integration with professional disciplines, utilizing a modular format. The key objective is to foster students' analytical and processing capabilities for random phenomena and data, as well as their skills in modeling practical problems and analyzing and improving model errors.

Discipline foundation platform courses, such as Linear Algebra and Probability Theory and Mathematical Statistics, align with vocational undergraduate professional groups, highlighting the cultivation of mathematical application abilities in the context of new subject developments and technologies.

6.1 Positioning of the Linear Algebra course

Linear Algebra I is a discipline foundation platform course designed for science and engineering students. It serves as a foundational course for advanced mathematics and is a crucial branch of mathematical content with extensive applications in scientific research and engineering technology. The course aims to familiarize students with basic concepts and related theories of linear algebra, to master topics such as determinants, matrices, and linear systems of equations, and to cultivate fundamental computational abilities, logical reasoning skills, innovative awareness, and the ability to analyze and solve problems. This lays the groundwork for the subsequent study of courses and practical work. The main content of the course includes matrices and determinants, elementary transformations of linear systems of equations and matrices, vector sets and vector spaces, eigenvalues and eigenvectors of matrices, and quadratic forms.

6.2 Objectives of the Linear Algebra course

Knowledge objectives: Through the teaching of this course, students should systematically grasp the theory of matrices and linear systems of equations, N-dimensional vector spaces, matrix eigenvalues, eigenvectors, and quadratic form theories. They should be able to solve practical problems, cultivate a unique algebraic thinking mode and logical reasoning abilities, and establish a solid mathematical foundation for further study of subsequent courses and modern scientific technology.

Skills objectives: Through course study, students should develop good study habits, and enhance their self-learning abilities by utilizing various online platforms for acquiring mathematical knowledge. By learning about matrices, determinants, vectors, etc., students should acquire methods for quantitative representation, abstract generalization, logical reasoning, and rigorous calculation. They should integrate linear algebra knowledge to establish mathematical models and solve practical problems.

Quality objectives: Through the study and training related to this course, students should be able to identify the rationality and correctness of linear algebra applications in related fields, appreciate its logical, rigorous, and scientific nature, and further cultivate students' logical thinking, innovative thinking, and exploratory thinking.

6.3 Positioning of the Probability Theory and Mathematical Statistics course

Probability Theory and Mathematical Statistics is a discipline foundation platform course designed for science and engineering students. This course primarily investigates the statistical regularities of a large number of random phenomena in the natural world, human society, and technological engineering. It extends the knowledge of advanced mathematics and serves as an applied theoretical foundation for other interdisciplinary subjects. The course aims to cultivate students' abilities in logical reasoning, abstract thinking, handling random events, and processing data. It assists students in understanding the basic statistical laws and principles of random phenomena, equipping them with essential knowledge of probability and statistics, and enhancing their mathematical literacy in applying probability and statistical methods to analyze and solve real-world uncertainties.

7 Teaching implementation

7.1 Teaching team

The course leader is appointed from faculty members with profound academic accomplishments, rich teaching experience, distinctive teaching characteristics, and holding advanced professional and technical positions. A well-structured teaching team, combining full-time and part-time instructors based on qualifications such as academic titles, educational background, and age, has been established. The standard class size of 80 students is assigned to one course instructor. Instructors are required to have university teaching qualifications and hold a bachelor's degree or higher in mathematics or statistics.

Currently, the teaching team consists of 24 members, including 3 with senior professional titles, 15 with doctoral degrees or higher, 12 young teachers under the age of 40, 12 dual-qualified teachers, and 3 part-time teachers. Team members have previously led the development of one national-level quality course, one national-level quality resource-sharing course, received a first prize in teaching achievements from Guangdong Province, and served as chief editors for one national-level planned textbook and associate editors for another.

7.2 Teaching methods

The teaching methods integrate group discussion with individual learning, theoretical instruction with practical activities, traditional chalkboard explanation with modern multimedia teaching, and heuristic guidance with classroom discussions. Classroom exercises are combined with pre- and post-class assignments. Online and offline learning are integrated, fostering an interactive and engaging classroom atmosphere.

Teaching facilities: multimedia classrooms, mathematics laboratories, mathematics software (MATLAB or PYTHON, etc.).

Teaching resources: textbooks, online resources, etc. Basic teaching resources include lesson plans, course standards, practical training guides, and more. Enriched digital teaching resources include online courses, high-quality resource-sharing courses, new format textbooks, micro-videos, virtual simulations, interactive animations, audio, graphics,

courseware, etc. The online learning environment is well-supported with a comprehensive online learning support system.

8 Assessment methods

To implement a comprehensive, all-round, and developmental assessment model to evaluate students' overall mathematical abilities and qualities. The assessment is entirely formative, with a final closed-book examination. Formative assessments for this course are based on regular performance assessments, including stage theory exams (mid-term exams or three or more stage assignments, conducted online or offline), regular assignments (which may include software experiment reports), regular attendance, and in-class question practice. The final comprehensive test includes five types of questions in an open-book format.

The score distribution for the five types is as follows: Formative Assessment Score = Assignment Score (10%) + Regular Attendance Score (5%) + In-class Question Practice Performance Score (5%) + Stage Theory (online or offline) Exam Score (50%) + Final Closed-book Exam Score (50%).

Final Grade (50%) = Final Comprehensive Open-book Exam Score (50%); Regular Grade (50%) = Assignment Score (10%) + Regular Attendance Score (5%) + In-class Question Practice Performance Score (5%) + Stage Theory (online or offline) Exam Score (50%).

9 Conclusion

Undergraduate vocational education imposes not only requirements on the curriculum but also places greater demands on teachers. Curriculum reform and teacher learning are both urgent. Through the analysis and reconstruction of the curriculum system, a distinctive vocational undergraduate framework has been established. This framework aligns with postgraduate standards, aiming for high standards and consists of a core general education course that strengthens fundamentals and a discipline-based foundational platform course that emphasizes applied skills development.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Yang DH. 2019. Exploration on the construction of basic courses and teaching reform of vocational undergraduate mathematics. *Think-tank Era*, 38:2.

[2] Li BW. 2018. Research on teaching reform of economic information management and mathematics in higher vocational education. *Science and Education Guide (China Ten Journal)*, 20:40-41.

[3] Li BW, Peng Y. 2021. Teaching reform of economics and management mathematics under the background of artificial intelligence - discussion on project driven teaching mode. *Advances in Higher Education*, 5(5):58-60.