

# *Practical Exploration of the Construction of University Mathematics Curriculum Based on Project-Based Learning*

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**Keywords:** Project method, Course construction, Teaching reform

**Abstract:** Project based teaching method is a teaching mode that aims to enable students to understand or apply the central concepts, methods, and principles of a certain discipline, organize teaching activities through the joint implementation of a complete "project", integrate students into the process of completing meaningful tasks, and enable them to actively learn and independently construct knowledge. It aims to cultivate practical knowledge and abilities. The theoretical basis of project-based teaching method comes from modern cognitive theory. Modern cognitive psychology divides knowledge into two categories: declarative and procedural. Divide the process of knowledge learning into three stages: acquisition, consolidation and transformation, and transfer and application. For different types of knowledge, different methods should be adopted in different learning processes.

## 1. Introduction

The three courses of college mathematics (Advanced Mathematics, Linear Algebra, Probability & Statistics) are important basic courses for students in various majors of higher education institutions in China. College mathematics courses not only lay the foundation for students to learn and research subsequent courses, but also cultivate scientific literacy such as rigorous logic and clear expression. However, college mathematics has the characteristics of high abstraction, rigorous logic, and implicit wide applicability. Therefore, students often feel difficulties in the learning process, which easily leads to losing interest and motivation in learning, leading to poor academic performance in mathematics. Therefore, in the teaching process of university mathematics courses, it is necessary to fully utilize various teaching methods and information technology, adopt various teaching methods, effectively mobilize students' learning enthusiasm, and transform their passive acceptance of knowledge into active learning and participation in the teaching process. These measures have to some extent improved the monotonous and tedious traditional teaching model of "blackboard+chalk", and improved the learning effectiveness of students. College mathematics generally adopts teaching methods such as "case teaching" and "heuristic".

In recent years, the innovation and reform of learning methods have become a key focus of teaching reform research in various countries around the world. Many Western countries advocate for

"design learning" and "exploratory learning" to fully mobilize students' learning initiative. Japan leads "comprehensive learning" to improve students' learning abilities and efficiency. The Taiwan region of our country advocates "motivational active exploration" to improve the quality of students' learning. At present, China mainly implements the transformation of teachers' teaching methods and students' learning methods, shifting from requiring students to actively explore learning, constructing various educational and teaching methods, stimulating students' interest in learning, and improving teaching quality.

The project-based method originated from Harvard University in the United States and is popular in Germany and the United States, especially suitable for vocational and technical education. This teaching method is action oriented, with the goal of completing projects and starting from learning knowledge. Apply project based teaching methods to teaching courses such as financial marketing, nursing, enterprise management, college English, and microcontroller learning [1-19]. There are many mathematics courses in vocational, vocational, and vocational schools in China that adopt project-based teaching methods. However, there is very little research on the use of project-based teaching methods in the three courses of university mathematics in undergraduate colleges [9,14,16,18], all of which are in the initial stage. During the teaching process, the teacher decomposes the content to be learned into several specific projects, develops specific teaching plans, and implements the teaching of relevant courses. During the teaching process, students are required to develop relevant design plans for each project and conduct relevant discussions. During project implementation, teachers will provide explanations on project related knowledge points, and students will complete the project on their own. This teaching process not only imparts students' knowledge of relevant courses, but also cultivates their operational skills and exercises their abilities. Project based teaching has unique advantages in higher education, especially in the teaching of engineering related majors, which is conducive to the cultivation of students' comprehensive abilities.

School education should not only impart knowledge but also help students develop skills. The so-called knowledge refers to declarative knowledge, while skills refer to procedural knowledge. Narrative knowledge is the foundation of procedural knowledge, which is composed of concepts and rules, specifically manifested as a set of operational steps. From the perspective of the learning process, in the first stage, all the knowledge learned is basically in a declarative form. In the second stage, a portion of the new knowledge is declarative knowledge, and the scope of declarative knowledge has been expanded. The other part is transformed into procedural knowledge through operational practice. In the third stage, different types of knowledge are used to solve different problems. Narrative knowledge mainly solves the problem of 'what'. Procedural knowledge is mainly used to solve the problem of "how to do". In the second stage, obtaining procedural knowledge through operational exercises demonstrates that behavioral guided teaching methods such as operational exercises are important means for students to acquire procedural knowledge and cultivate their comprehensive abilities. The behavior guided teaching method emphasizes ability development, student autonomy, and achievement motivation. The commonly used behavioral guidance teaching methods currently include case teaching method, simulation teaching method, and project teaching method. The project-based teaching method has different effects from other methods, such as being close to real life, cultivating students' multiple abilities, unleashing teachers' creativity, and promoting teaching change. It is a very popular teaching method in the international education community today [18].

With the rapid development of intelligent technologies such as electronics and computers, some applications of university mathematics knowledge have become somewhat disconnected from the times. The teaching of traditional university mathematics courses mainly follows traditional methods for teaching related theories, resulting in a lack of interest in learning among students and poor teaching effectiveness. College mathematics, on the other hand, focuses relatively on theoretical

knowledge and lacks practical experience, making students feel that mathematics is useless and boring. Course teaching should be based on cultivating students' initial ability to solve complex problems and comprehensive application abilities. Develop specific teaching plans and implement them based on the teaching objectives of the course, forming a course structure to cultivate students' computing, application, and comprehensive abilities. Through the implementation of project-based teaching method, the basic knowledge of university mathematics is integrated into relevant projects, greatly enhancing students' learning interest, improving the quality of teaching, and better cultivating students' practical abilities [18].

## 2. The research value

Our school is committed to cultivating high-quality applied talents. In the report of the fourth Party Congress of the school, it was proposed that the school's goal for the next five years is to "lay a solid foundation for the cradle of engineers in the prime area of the new era, and preliminarily build a first-class, distinctive, and high-level applied university in Beijing. The quality of applied talent cultivation is higher, and it is more in line with the economic and social needs of the capital. The current reform of engineering education in the school aims to implement the fundamental task of cultivating morality and talents, fully understand and accurately grasp the new situation and requirements of building a high-level applied university, focus on high quality, and make every effort to create the cradle of engineers in the new era.

The three courses of college mathematics are important basic courses for engineering majors, which have the characteristics of rich teaching content, high knowledge density, long teaching time span, abstract principles, and high learning difficulty. In addition to providing essential basic mathematical knowledge for engineering students, university mathematics courses should also enable students to master certain scientific thinking and research methods, enhance their application ability, broaden their thinking, stimulate exploration and innovation spirit, improve their scientific literacy, and provide good support for the development of various majors and students' professional learning.

In the past three years, our university has enrolled 26 majors in undergraduate programs with an enrollment scale of over 1600 students. There are a large number of students and majors involved. Our first year undergraduate students complete two semesters of public compulsory courses such as Advanced Mathematics (I) and Advanced Mathematics (II). Some majors also need to complete Linear Algebra courses in the first year, while in the second year, they complete Linear Algebra courses and Probability and Statistics courses. The teaching of basic courses involves all science, engineering, economics, and humanities majors in our school.

Our university's undergraduate enrollment covers 26 provinces and cities across the country, and students have weak mathematical foundations. There are also significant differences in mathematical foundations among students from different regions of origin. Taking the national enrollment situation in 2022 as an example, out of 1542 new students, the average score in mathematics (out of 150) in the college entrance examination was only 93.49 points, with a standard deviation of 13.39. 35% of students scored below 90 points, and 75% scored below 103 points.

The three mathematics courses in universities are an important foundation for engineering students to learn professional courses. Some engineering students in our university have relatively poor mathematical foundations, and their college entrance examination scores reflect significant differences in their mathematical foundations, which is not conducive to the learning of subsequent professional courses. High quality talent cultivation and professional education require a solid foundation in basic course teaching, but our enrollment source has a relatively poor mathematical foundation. How to solve this dilemma and achieve good results? The teaching philosophy of student-centered and output oriented, based on the level of our school's students, teaching according to their

aptitude, and conducting relevant teaching research and practical work based on project research methods, aims to cultivate students' computing ability, application ability, and comprehensive problem-solving ability.

### 3. The main issues addressed

By designing a reasonable project to integrate some knowledge points, we can solve the problem of abstraction and generalization in mathematics courses, making the mathematical content concrete and detailed. For example, in the design of this project, "the physical condition of college students in our school (including height, weight, study time, entertainment time, internet time, sleep time, etc.)" is no longer a cold formula for random variables, population, samples, sampling theory, etc. It is the specific height, weight, study time, entertainment time, sleep time, etc. of the students themselves, which is the things around them. The students see the humanistic care of the teacher, Instead of serious mathematical reasoning, it is more in line with the structure and characteristics of current college students in our school.

By designing projects with strong applicability, we can solve the contradiction between the useful nature of university mathematics and the phenomenon of "useless". Teaching mathematics is very useful, but our college students are unable to integrate and differentiate in reality. Design simple projects in mathematics to show students the true usefulness of mathematics. Real projects provide students with ways and opportunities to experience and experience. Through dialogue, communication, and evaluation with classmates, it is beneficial for students to integrate knowledge and think from multiple perspectives and perspectives.

By incorporating mathematical modeling, mathematical experiments, and other forms of content into the project, practical functional issues in mathematics courses are addressed. Based on the characteristics of university mathematics curriculum content, design project content with practical problems as the background, gradually carry out mathematical assumptions, establish mathematical models, integrate mathematical experiments and other content, obtain more reasonable project solutions, and provide decision-making basis for practical problems.

### 4. The main content

In the teaching process of university mathematics courses, various teaching methods and information technologies are fully utilized, effectively mobilizing students' learning enthusiasm, transforming their passive acceptance of knowledge into active learning and participating in the teaching process. These measures have to some extent improved the monotonous and tedious traditional teaching model of "blackboard+chalk", and improved the learning effectiveness of students.

(1) Design a reasonable project to integrate some knowledge points, make mathematical content concrete and detailed, and solve the abstract and general problems of mathematical courses. For example, designing specific practical projects on the relationship between shoe length and height, searching for literature, summarizing mathematical knowledge and methods used (sampling theory, correlation coefficients, hypothesis testing, expanding knowledge linear regression, etc.), group activities (collecting data, designing implementation plans, group discussions, conclusions, validation), and project reports. Not only can we infer formulas to obtain mathematical conclusions, but we can also see how conclusions are used and clarify the specific meanings of conclusion formulas. Cultivating students' scientific thinking while subdividing complex problems into simple ones and finding corresponding solutions is more in line with the structure and characteristics of our university's current college students.

(2) Design projects with strong applicability to present the useful essence of university

mathematics and solve the "useless" phenomenon of university mathematics. Teaching mathematics is very useful, but our college students cannot solve the practical problems they encounter through integration and differentiation in reality. Design real application projects - Reconnaissance satellites are generally used for message detection and intelligence gathering, and their wide-angle high-resolution cameras can monitor every scene on the Earth's surface in their "line of sight" and take photos. The use of satellite search intelligence can not only avoid disputes over aerial violations, but also avoid attacks due to its high operational altitude. It has the advantages of large reconnaissance area, fast speed, good results, long-term or continuous monitoring, and is not limited by national boundaries and geographical conditions. It is the "eye of a thousand miles" and "ear of the wind" in modern warfare. So what is the height from the ground of the synchronous reconnaissance satellite and what is the coverage area? What is the coverage of a satellite? How many satellites will it take to cover the surface of the Earth? This project involves knowledge of advanced double integrals, physics, etc. This type of project provides students with ways and opportunities to experience and experience, integrating interdisciplinary knowledge through online resources, information, dialogue, exchange, and evaluation with classmates, and thinking and solving problems from multiple perspectives and layers.

(3) The design project integrates mathematical modeling, mathematical experiments, and other forms of content to solve practical functional problems in mathematics courses. The real world is complex and ever-changing, and the content of university mathematics courses is basically fixed. Designing project content based on practical problems requires mathematical assumptions, mathematical simulations, establishing mathematical models, integrating mathematical experiments, and other content to obtain more scientific and reasonable project solutions and provide decision-making basis for practical problems.

(4) The design project integrates ideological and political elements of the curriculum, seamlessly integrating them into the entire process inside and outside the classroom. Stimulate students' teamwork spirit, cultivate their practical and innovative abilities, scientific thinking and logical reasoning abilities, and subtly guide and cultivate students' values, professional ethics, and social responsibility.

## 5. Innovation

(1) Centering on student outcomes and combining theory with practice, cultivate students' innovative awareness. In class, various teaching methods such as case teaching and heuristic teaching are used to cultivate students' scientific logic and mathematical modeling abilities. In class, simple written and experimental assignments are used to consolidate classroom knowledge. The project teaching method, which is relatively complex and closely related to the new engineering field, uses projects as the main research object after class, broadening students' cutting-edge perspectives and enabling them to truly experience the application of university mathematics in the new engineering field.

(2) Pay attention to the difficulty and depth of the project, reflecting the high-level and cutting-edge nature of the course. To effectively support the achievement of course objectives, emphasis is placed on the difficulty and depth of project content, the integration of university mathematics and multidisciplinary approaches, and the cultivation of students' comprehensive abilities and advanced thinking in solving complex engineering problems. For example, through the project "Research project on the physical condition of college students in our school (including height, weight, study time, entertainment time, online time, sleep time, etc.)", we guide students to view problems from various perspectives, solve problems with different methods, broaden their horizons, and actively track cutting-edge trends. In addition, in the era of big data, the utilization and analysis of massive

information cannot be separated from mathematical software such as MATLAB. Display abstract mathematical relationships through software, implement module calculations, and analyze big data.

(3) The project-based method is a new and challenging teaching model for both students and teachers. In the specific implementation process, this project attempts to find a teaching mode that best meets the practical teaching needs. According to teaching objectives, teachers design projects that are scientifically reasonable and suitable for the abilities of students in the school. They teach in class around difficult knowledge points, methods, mathematical ideas, etc. in the projects. After class, students organize and summarize knowledge, methods, etc., and carry out group activities (investigation, discussion, design plans, simulation, MATLAB experiments, project reports, PPT production, defense, etc.). This model is guided by teaching objectives, strengthens students' autonomous learning ability, and adapts to changes in the times, bringing challenges to both students and teachers.

## Acknowledgements

The authors gratefully acknowledge the financial support from the 2023 Higher Education Science Research Planning Project of the China Association of Higher Education - Practice and Research on University Mathematics Curriculum Based on Project-Based Learning (23SX0411).

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