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International Journal of Earthquake Engineering
Anno XLIII - Num. 1 - 2026

The use of real-world case studies in mathematical modeling courses to help students develop a sense of application

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SUMMARY: *Cultivating application-oriented talents with innovative ideas and strong comprehensive ability is the key to the current reform of mathematics teaching in colleges and universities. Based on the simulation and practicality of the case teaching method, this paper introduces it into the teaching of mathematical modeling courses. In order to investigate the role of case teaching method on the establishment of students' application consciousness, two classes with basically close starting levels are selected to carry out teaching experiments, and the teaching effect of mathematical modeling course based on case teaching method is evaluated by means of course tests and questionnaires. After the teaching practice, the test scores of the experimental students were improved by 7.34% compared with those before the experiment, and 3.40% compared with the control students, and 31.23%~47.93% in the cultivation of mathematical application consciousness was obtained, which confirms the role of the case-based teaching method in helping the students' academic performance and mathematical application consciousness. The application of actual case teaching method in mathematical modeling course is beneficial to cultivate students' mathematical thinking and innovation ability, and is a kind of teaching method that effectively improves the teaching effect of mathematical modeling.*

KEYWORDS: *mathematical modeling; teaching experiment; statistical analysis; teaching effect; case teaching method*

1 Introduction

As early as the 1960s, mathematical modeling emerged in some European and American countries, and was introduced into schools as a mathematical teaching activity. 1985, the first college student mathematical modeling competition held by the United States set off a worldwide craze, stimulating students' interest in learning mathematics and highlighting the value of mathematical modeling. From an international perspective, the Fifth International Congress on Mathematical Education (ICME) held in 1984, even more “mathematical modeling and applications” is included in one of the main topics [1]. At the same time, “Modeling and Applications in Mathematics Education” is also an important part of the research series of the International Council for Mathematics Education (ICMI), which emphasizes the connection between mathematical applications and mathematical modeling in the real world [2].

With the deepening of global education reform, the focus of mathematics education has shifted from the mere transfer of knowledge to the in-depth cultivation of core literacy [3]. As

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https://doi.org/10.65102/is2026282 Published: 30 April, 2026

a bridge connecting theory and practice, mathematical modeling has demonstrated its unique educational value in cultivating students' logical reasoning, abstract thinking and comprehensive application ability, and has become a key link in the modern education system [4]. Dutch mathematicians represented by Freudenthal put forward the theory of realistic mathematics education, advocating the connection between the real world within mathematics and the connection between mathematics and other disciplines from the context, mathematization, student initiative, learning activities and interweaving of disciplines [5-8]. In other words, in Freudenthal's view, “mathematics should be viewed as a human activity”, which has to be adapted to real situations, take into account various factors such as students' interests, and is not only dedicated to social problem solving, but is a process of activity that organizes the knowledge of the discipline from the real situation and the mathematical category itself [9, 10]. With the development of Freudenthal's theory of realistic mathematics education, in the 21st century, the goal of mathematics education is to allow students to experience the entire mathematical process of the problem situation, it is important to pay attention to the situation that students experience must be a real sense of what students experience is authentic learning [11-13]. For this reason, the United States took the lead in the implementation of “mathematical modeling”, focusing on the authenticity of mathematical problems, students' learning interests and needs, and the abstraction of real problems into mathematical problems, which promotes mathematics to reality.

Mathematical modeling has developed from its emergence to the present day without any uniformity in its connotations. The prevailing view in academia is that mathematical modeling refers to a dynamic problem-solving process. The term mathematical modeling emerged from abroad, and the view of Arseven, A (2015) that mathematical modeling refers to mathematical knowledge to explain and describe real-life events, test various ideas, and make estimates, this view emphasizes the multiple functions and importance of mathematical modeling in practical applications, which is not only the process of transforming a real problem into a mathematical expression, but also a systematic thinking and analyzing tool [14]. Subsequently, Azizi, T et al. (2021) further defined mathematical modeling as an abstract model constructed using a mathematical language that is often used to describe the behavior and evolution of a system, which is widely used in the fields of science and engineering, and has a variety of forms including problem discovery, data interpretation, and description of physical phenomena [15]. In addition, the view of Taite, G and DiNapoli, J (2025) suggests that mathematical modeling is a cyclical process that uses mathematical forms to describe and understand real-world situations, a process that includes setting assumptions, definitions, model applications, interpretations, and revisions in real-world situations [16].

In today's society, the rapid development of science and technology has given rise to the flourishing rise of big data, artificial intelligence, Internet of Things and other cutting-edge technologies, and the digital transformation and intelligent process has penetrated into all walks of life in an all-round way. Complex and changing social problems need to be analyzed and effectively solved with the help of scientific mathematical modeling methods [17]. Mathematical modeling has broken through the category of pure academic research tools, and has become an indispensable technical means in social practice, and its importance has become more and more prominent. Therefore, mathematical modeling education has also become a global educational consensus [18]. The study by Kertil, M and Gurel, C (2016) aims to provide insights into the relationship between mathematical modeling and integrated STEM (Science, Technology, Engineering and Mathematics) education, and the core objective of the study is to understand the role of mathematical modeling in STEM education and its impact on students' learning outcomes, and to provide a theoretical foundation and practical guidance for the educational practice of mathematical modeling [19]. Ferri, R (2018)

proposed a systematic approach to teaching mathematical modeling which includes theoretical and practical phases, cognitive activation, reflection, and summative assessment, which also uses video clips, written answers, and group interactions to simulate the process of real-world problem solving, aiming to enhance the teachers' competence in teaching mathematical modeling from the dimensions of theory, task-based instruction, and diagnosis [20]. Krutikhina, M et al. (2018) analyzed the structure of the process of teaching mathematical modeling and developed a system of tasks aimed at the formation of a series of training activities corresponding to the identified elements aimed at the formation of the elements of the teaching of mathematical modeling in relation to the stages of formalization and interpretation [21]. Sturgill, R (2019) conducted a study of 62 in-service teachers and 18 teacher educators in the Midwestern United States and found that the majority of in-service teachers and teacher educators were taught methods that did not support effective mathematical modeling instructional practices [22]. Lyon, J and Magana, A (2020) reviewed approaches to teaching mathematical modeling in engineering education and found that contemporary research on mathematical modeling education focuses on a number of topics such as instructional strategies, instructional delivery, and instructional evaluation, in addition to focusing on factors regarding the evaluation of mathematical modeling instruction [23]. In teaching mathematical modeling, the supportive role of the teacher is crucial, and for this reason the three features of scaffolding theory (flexibility, gradual weakening, and transfer of responsibility) proposed by Gürel, Z (2023) can effectively explain the supportive strategies and mechanisms of the teacher's role in the teaching and learning process [24]. Mu, S (2024) presented the application of traditional and modern teaching methods (problem-based, project-based, and computer-assisted teaching methods, etc.) in mathematical modeling, aiming to promote the innovation and optimization of mathematical modeling education by analyzing the effectiveness, technical support, and application of different teaching methods [25].

The serious lack of students' competence in mathematical modeling is the main reason for their lack of awareness of the applicability of mathematics and consequently their lack of interest in learning mathematics [26]. In practice, there is a close connection between the process of applying mathematics and mathematical modeling due to the existence of a close connection between the process of applying mathematics and mathematical modeling [27]. If there is a lack of mathematical modeling ability, the use of mathematics can not be experienced, and then can not feel the application of mathematics, the students' interest in learning mathematics will be low. The advantages of the practical case teaching method, on the other hand, lie in the purposefulness, simulation and revelation [28]. The case teaching method can effectively provide modeling exercises, and the models provided usually have practical applications, and can provide scientific and reasonable solutions for special practical problems [29-31]. The mathematical models given by case-based teaching are more structural, which is in line with the constructivist theory of education that puts forward the view of knowledge institutional education [32]. In addition, constructivist teaching theory believes that the educated person is the center of teaching and learning [33], and case-based teaching effectively demonstrates students' enthusiasm, initiative, and innovation through context, communication, collaboration, and other factors of the learning environment to satisfy the students' construction of the currently learned knowledge and to fully embody its significance. However, it is regrettable that the current research on the application of case teaching method in mathematical modeling courses remains only at the theoretical level. Although the case teaching method has been widely used in other disciplines and has achieved remarkable teaching results, the specific practice in mathematical modeling courses is still relatively small, and the related research mostly focuses on the theoretical discussion and model design,

and lacks systematic empirical research and the summary of practical experience.

The study discusses the application of case teaching method in mathematical modeling courses and points out the five steps of case teaching in mathematical modeling courses. Two parallel classes in the second year of a university are selected to carry out the experimental study, design the research plan, and construct the content of mathematical modeling course based on the case study method, collect the students' performance data and the effect of establishing the application awareness through the course tests and questionnaires, test the experimental hypotheses through the comparative analysis of the pre-test and post-test data, and explore the role of the use of the case study method of teaching in the mathematical modeling course in the establishment of the application awareness of the students. This study integrates the mathematical modeling course with the case teaching method, and provides evidence and ways for the teaching of mathematical modeling and the cultivation of students' application awareness through the discussion, research and practice of the teaching strategy of the case teaching method.

2 The use of case teaching method in mathematical modeling courses

Adhering to the principle of case-based teaching to carry out mathematical modeling course teaching can not only enhance students' interest and enthusiasm in learning mathematics, but also improve students' cognitive outlook on learning mathematics and application awareness, further improve and sublimate the educational quality of mathematical modeling course teaching, so as to enhance the educational role of mathematics.

2.1 Case Study Approach

The so-called case teaching method is a teaching method designed to develop and improve the intellectual capacity of learners. It is a method of teaching to develop and improve learners' knowledge and competence, in which real-life scenarios in actual practice are typified for the purpose of a certain professional background, and cases (usually in written form) are formed for students to think, analyze and decide, and to solve problems by means of independent research and mutual discussion. In detail, it is a teaching method that uses cases as teaching materials, combines them with the teaching theme, and through the teaching process of teacher-student interaction, such as discussion and questions and answers, allows learners to understand concepts or theories related to the teaching theme and develops their high-level abilities.

2.2 Steps of Case Study Teaching

In the mathematical modeling course, the steps of using the case method are shown in Figure 1, which can be divided into five stages:

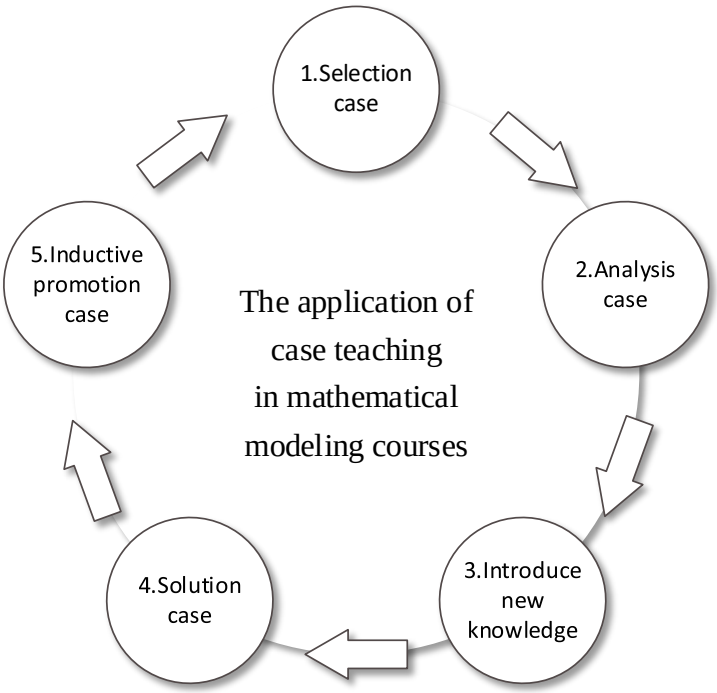

Figure 1: The application of case teaching in mathematical modeling courses

(1) Selection of cases. Teachers should carefully select cases related to the theoretical knowledge of the class before the lesson, and consider the purpose, interest, representativeness, authenticity and practicality when selecting cases, and lead to problems by the cases.

(2) Analyze the case. On the basis of guiding students to understand the case, the teacher puts forward some targeted unknown problems, triggering students to think.

(3) Case introduction of new knowledge teaching. Case problems to be solved need to use new mathematical modeling concepts and methods, which in turn introduces the concept of mathematical modeling in this lesson, new theoretical knowledge to explain the link.

(4) Solve the case. Discuss and summarize the ideas and methods to solve the problem, and then build a mathematical model and solve it to get the answer of the case.

(5) Summarize and generalize the case. List some similar cases, analyze the ideas and methods of solving the cases, find the commonality through comparison, generalize and exercise students to use the learned mathematical modeling concepts and methods to solve other related similar cases.

The teaching of mathematical modeling course should let students know more about the application of mathematics in their professional courses and practical problems. What is important in the teaching process of mathematical modeling course is to choose good cases, and the teaching cases should be combined with reality and close to the profession. For example: the theory and method of calculus through the establishment of models, the language of mathematics to explain the causes of some daily phenomena of practical cases are: why the chair can be put stable, why the shadow is so long, why the cans for the shape of a cylinder, the market price of goods is how to fluctuate. Gives the solution to some practical problems of practical examples: the total value of the uniform monetary flow and the calculation of the payback period, how to rinse the clothes the most clean, credit consumption in the determination of the amount of monthly repayments and so on. In order to cultivate students' hands-on ability and practical application ability, mathematical modeling ideas should be infiltrated in the teaching of mathematics, some practical application examples in

the classroom lectures, and introduce the solution of the problem used in this lesson which knowledge points. This not only improves students' interest in learning, but also makes students understand the importance of learning higher mathematics and its application in real life, and better stimulates the potential of students to use mathematical ideas and principles to solve practical problems.

3 Design of the research program

3.1 Experimental design

3.1.1 Purpose of the experiment

Based on the analysis of the use of case teaching method in mathematical modeling courses, through the experiment to change the traditional teaching concepts, reform the obsolete teaching methods, and test the role of the use of actual case teaching method in mathematical modeling courses on the cultivation of students' application consciousness.

3.1.2 Experimental hypotheses

Constructivist teaching theory holds that the educated are the center of teaching. Case teaching effectively demonstrates students' enthusiasm, initiative and innovative spirit through learning environment factors such as context, communication and collaboration. As a case teaching method that combines "application" and "personal experience", it can greatly promote mathematical modeling teaching and help students create and derive new "mathematical realities". Therefore, this paper proposes the hypothesis that the teaching strategy of implementing the case teaching method can enhance students' awareness of applying mathematics and their academic performance.

3.1.3 Research variables

(1) Dependent variable - case teaching method: the case teaching method is implemented in the mathematical modeling course in the experimental class, where students analyze and discuss the cases and investigate and study the related topics, so that the students' knowledge and experience and the actual problems can be effectively integrated through the combination and collision with each other, and the traditional teaching methods are used in the comparison class.

(2) Dependent variable - students' sense of mathematical application: tests were conducted before and after the experiment to analyze the weighting of the number of correct answers to each question and the number of correct answers to a number of questions. Students' sense of mathematical application and academic performance.

3.1.4 Experimental control

(1) The subjects are two parallel classes in a school's mathematical modeling course, tested simultaneously.

(2) The two classes were taught with the same textbook by two separate teachers.

(3) The experimental and control classes had the same amount of student work and the same number of teaching hours.

(4) The post-test was conducted simultaneously after one semester of the experiment.

(5) The same standard statistics were used for both tests.

3.1.5 Experimental methods

Two sophomore year classes of a mathematical modeling course at a university with a total of 90 students were selected for the experiment. The students were full-time undergraduate students and belonged to parallel classes, both of which numbered 45 and had basically the same ratio of males to females (25 and 27 females, respectively). In the final exam of the first semester of the sophomore year, the mathematics scores of the two classes were very close to each other, and the Mathematical Modeling 1 class was used as an experimental class and the Mathematical Modeling 2 class was used as a control class.

A course test was conducted before and after the experiment, and the analysis of the experimental class students' awareness of mathematical application was conducted by means of a questionnaire, which was compiled from 2 aspects, namely, students' understanding of the knowledge of mathematical modeling and their awareness of its application.

The questionnaire is divided into 2 parts, the first part is a survey on the understanding of the basics of mathematical modeling, the 1st-3rd questions are related to the investigation of students' understanding and mastery of the basics of mathematical modeling, which is a single-choice question, with the correct choice scored 3 points, and the error scored 1 point. The second part of the survey is the survey on the mastery of application awareness of mathematical modeling, questions 4-6 are to investigate the students' understanding and mastery of the application awareness of mathematical modeling, using a five-point Likert scale, in order to correspond to the degree of mathematical modeling instruction received by the students, the options of the questions selected by the students were scored as 1 to 5 points in accordance with the degree of conformity, very much not in conformity with the scores of 1 points, not in conformity with the scores of 2 points, and so on.

The reliability and validity of the six non-essential information questions in the 90 questionnaires collected before and after the experiment were tested. The total reliability of all the questions constituting the questionnaire in the pre-test and post-test was 0.753 and 0.768 respectively in order to consider this questionnaire as having good reliability and capable of further analysis.

3.2 Mathematical modeling course content construction

For the experimental students who apply the practical case teaching method, they first learn MATLAB software, an important tool for mathematical modeling, followed by the basics of mathematical modeling, and the total credit hours of the course are 28. The teaching content of the mathematical modeling course introduces some routine operations of MATLAB, which is divided into the part of software introduction and the part of case study, and the following are the teaching content, teaching requirements and credit hour allocation of the two parts.

3.2.1 Software introduction section

Selected part of a representative, relatively simple case to explain, through these cases to allow students to understand some simple mathematical modeling methods software introduction part of the main, the following is the specific arrangement:

(1) MALAB window environment and command form. (2) Basic mathematical operations. (3) MALAB solution of calculus problems, which includes operations on functions and limits, calculation of algebraic equations, calculation of differential quotients and integrals, calculation of extreme values, function graphing, etc.. (4) MATLAB solutions of linear algebra problems, including matrices and their operations, elementary transformations of matrices and systems of linear equations. This part of the content requires students to be familiar with the simple operation of MAT-LAB, can initially use MATLAB to solve some

simple mathematical computation problems, the allocation of class time is 8 hours.

3.2.2 Case study section

The case study part is designed for students to understand some simple modeling methods, mainly to develop students' thinking and improve their ability to apply mathematical knowledge to solve practical problems. The teaching content is divided into six parts:

(1) Introduction to mathematical modeling and mathematical modeling competition. (2) Several simple mathematical methods, such as geometric simulation method and parity check method. (3) Elementary mathematical models, such as the problem of a merchant crossing a river and the problem of fair seat allocation. (4) Modeling using calculus, e.g., renting an airliner or buying an airliner, modeling snow removal by a snowplow, etc. (5) Ordinary differential equation modeling, through examples of the establishment of ordinary differential equation models and some simple ordinary differential equation models, such as cooling models, mathematical models of weight loss. (6) Simple linear programming models. When teaching, students are required to be able to learn by example, from this one problem to solving this kind of problem, and some problems also require students to be able to express the problem solving process in the form of a thesis. This part of the class is allocated 20 hours.

4 Experimental results and analysis

4.1 Pre-laboratory measurements

4.1.1 Pre-test learning achievement

The quiz took one class period, was strictly supervised, and was completed independently to ensure the authenticity and reliability of the test results. The number of people who answered each question correctly and the number of people who answered a number of questions correctly in the test results were analyzed, and the statistical results of the pre-test students' answers are shown in Table 1, and the number of people who answered a number of questions correctly is shown in Figure 2.

From the test material, students were tested on their ability to apply their mathematical knowledge to solve various practical problems. The first and second questions tested students' ability to recognize diagrams and simple arithmetic. The third question mainly tests reasoning ability and does not require complex calculations. Questions four and five are decision-making application questions. The level of mathematical application in this test is not high, but the correct rate of students is not high, the percentage of the number of correct people in questions 3 to 5 are all below 60%, the number of questions that students answered correctly is mostly from 1 to 3, and the percentage of students who answered all 5 questions correctly is below 9%, which shows that the students' awareness of the application and their ability of application need to be strengthened.

From the data, it can be seen that students do not know how to or cannot reasonably model is the main reason for solving the problem is blocked, the number of people who answered questions 4 and 5 correctly accounted for less than 50%, and the crux of the problem is that the plot structure of the problem can not be accurately understood, which leads to unreasonable to get rid of the constraints of the plot structure, effective transition to the structure of the quantitative relationship, constructing mathematical models. The two classes are at a comparable level for solving mathematical application problems, the percentage of the number of people who got the questions correct and the percentage of the

number of people who answered a number of questions correctly are not very different, and the total scores are 75.70 and 75.03, which can be regarded as an equal group.

Table 1: The student answers question statistics results in the previous test

		Class 1		Class 2	
		Number	Weight/%	Number	Weight/%
First question		38	84.44%	39	86.67%
Second question	Q2.1	35	77.78%	36	80.00%
	Q2.2	31	68.89%	30	66.67%
	Q2.3	26	57.78%	27	60.00%
	Q2.4	25	55.56%	25	55.56%
	Q2.5	23	51.11%	24	53.33%
	Q2.6	24	53.33%	22	48.89%
Third question		26	57.78%	25	55.56%
Fourth question		20	44.44%	21	46.67%
Fifth question		18	40.00%	17	37.78%
Total score		75.70		75.03	

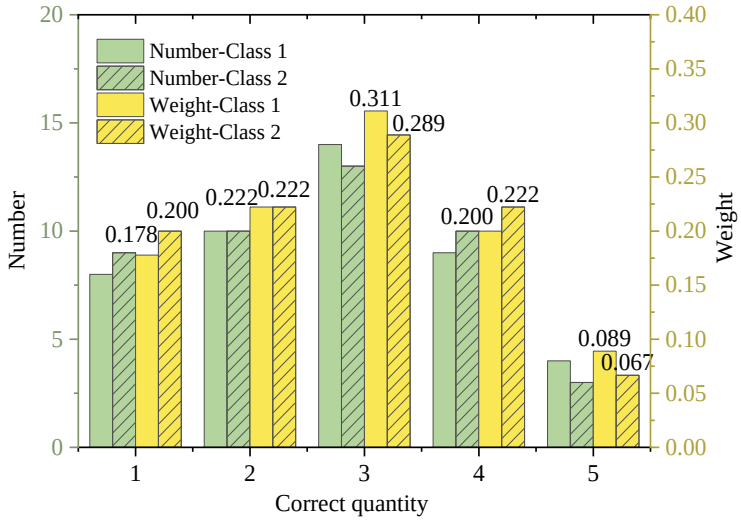

Figure 2: The student number of correct answer and proportion in the previous test

4.1.2 Applied Awareness Acquisition

(1) Basic knowledge understanding of mathematical modeling

Questions 1 to 3 in the questionnaire were to investigate the aspect of students' mathematical modeling knowledge understanding. The basic knowledge understanding of mathematical modeling of Class 1 students before the experiment is shown in Table 2. Question 1 was a single choice question "What do you understand about mathematical modeling?" This result shows that nearly half of the students understand the concept of mathematical modeling, but more than half of the students do not know much about it.

The second question is "What do you think are the steps of mathematical modeling?", 20 students answered correctly, accounting for 44.44% of the total number of students, and the remaining 55.56% of the students could not correctly choose the steps of mathematical modeling, indicating that Class 1 students lacked the teaching and learning of the basics of mathematical modeling before the experiment.

The 3rd question is “What competencies do you think are needed for mathematical modeling?” , only 16 students chose this question correctly, accounting for about 35.56% of the total number of students, and the rest of the students, about 64.44%, did not know what competencies are needed for mathematical modeling.

Table 2: Understanding of mathematical modeling basic knowledge in the previous test

Question	Score	Number	Percentage/%	Effective percentage/%	Cumulative percentage/%
Question 1	0	24	53.33%	53.33%	53.33%
	3	21	46.67%	46.67%	100.00%
	Total	45	100	100	
Question 2	0	25	55.56%	55.56%	55.56%
	3	20	44.44%	44.44%	100.00%
	Total	45	100	100	
Question 3	0	29	64.44%	64.44%	64.44%
	3	16	35.56%	35.56%	100.00%
	Total	45	100	100	

(2) Awareness of the application of mathematical modeling

Questions 4 to 6 in the questionnaire are for the investigation of students' awareness in the application of mathematical modeling. The preexperimental Class 1 students' mastery of mathematical modeling application awareness is shown in Figure 3, and the results of the descriptive statistics analysis are shown in Table 3.The mean values of the three questions are between 2 and 3, respectively 2.69, 2.53 and 2.42, which are in the middle of the state of non-conformity and indeterminacy, which suggests that the students' overall understanding and learning of mathematical modeling application awareness are still at a less mature level This indicates that students' overall understanding and learning of the application of mathematical modeling is still at a less mature level, and their knowledge of the application of mathematical modeling is still not very good.

The fourth question is “I know what problems can be solved with the mathematical knowledge I have learned”, the fifth question is “I know how to use mathematical knowledge to solve real-world problems”, and the sixth question is “I know which problems are solved using mathematical modeling”. These three questions provide a three-pronged approach to understanding students' self-perception of their awareness of the application of mathematical modeling. Most of the students chose the options of not meeting (for a score of 2) or not sure (for a score of 3) for these three questions, which means that most of the students did not know about the application of mathematical modeling, and they lacked both the basic knowledge of mathematical modeling and a deeper understanding of the nature of mathematical modeling.

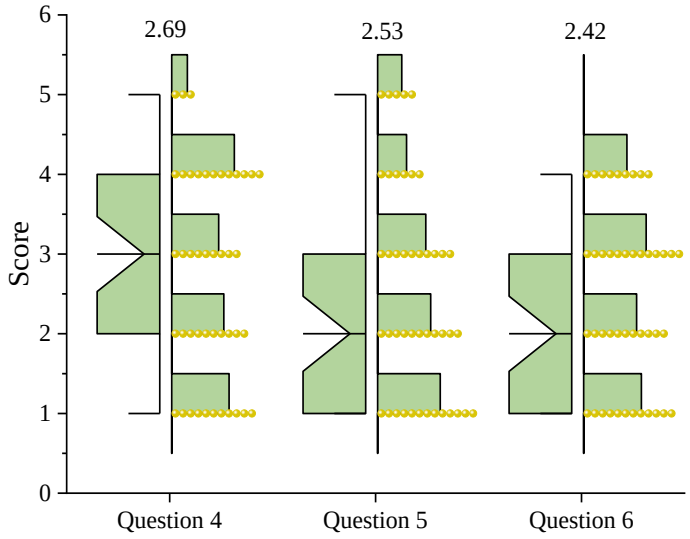

Figure 3: Knowledge of mathematical modeling application consciousness in the previous test

Table 3: Describe the statistical analysis results in the previous test

	Question 4	Question 5	Question 6
Mean	2.69	2.53	2.42
Number	45	45	45
Standard deviation	1.294	1.342	1.097
Mode number	4	1	3
Min	1	1	1
Max	5	5	4

4.2 Post-experimental tests

4.2.1 Post-test learning achievement

In this determination, students are assigned to use the time outside the classroom to go to the society to capture the background of the problem, collect data and information, and discover mathematical problems. After returning to school, they processed and organized them into application problems under the guidance of teachers. The test method was the same as the pre-test, and the number of people who answered each question correctly and the number of people who answered a number of questions correctly in the post-test were analyzed. The statistics of students' answers in the post-test are shown in Table 4, and the number of people who answered a number of questions correctly in the post-test is shown in Figure 4. The material content of Test 2 is slightly more difficult than that of Test 1. The first to third questions do not involve much calculation; the second question still tests students' ability to read and write diagrams; the third question still examines reasoning ability; and the fourth and fifth questions are about decision-making applications in a market economy, which are more comprehensive.

Looking at the overall results of the test, comparing vertically, the number of students answering each question correctly was higher than the pre-test scores for both Class 1 and Class 2. The total test score for Class 1 increased by 7.34% from 75.70 to 81.26, and the total test score for Class 2 increased by 4.74% from 75.03 to 78.59, with students answering questions correctly centered on the range of 3 to 5 questions. After the teaching experiment, students' awareness of mathematical application and their ability to apply it have improved.

This shows that the accumulation of mathematical knowledge and the improvement of mathematical ability have a certain relationship to the improvement of mathematical application ability.

In terms of side-by-side comparisons, the test scores of Class 1 and Class 2 ranged from a comparable number of correct answers to each question at the beginning to a difference in the number of correct answers to each question. For simpler issues such as graph literacy, the difference between the two classes was small, but for deeper and more difficult issues, there was a large gap between the ability to analyze and solve problems and modeling, with Class 1 being better than Class 2. On the one hand, the percentage of the number of correct answers to questions 3 to 5 in Class 1 was 51.11% to 71.11%, which were all above 50%, significantly higher than the pre-test, and higher than the 42.22% to 60.00% in Class 2, and the test scores were also 3.40% higher than those of Class 2. On the other hand, the percentages of answering 4 questions correctly and 5 questions correctly were 26.7% and 22.2% for Class 1, and 20% and 13.3% for Class 2. In the course of the experiment, the test scores of Class 1 moved towards a balanced direction, and polarization was weakened, while Class 2 showed less change. Therefore, the academic performance and modeling ability of Class 1 students were greatly improved after teaching the mathematical modeling course using the real case teaching method.

Table 4: The student answers question statistics results in the after test

		Class 1		Class 2	
		Number	Weight/%	Number	Weight/%
First question		41	91.11%	39	86.67%
Second question	Q2.1	43	95.56%	40	88.89%
	Q2.2	35	77.78%	35	77.78%
	Q2.3	37	82.22%	31	68.89%
Third question		32	71.11%	27	60.00%
Fourth question		29	64.44%	25	55.56%
Fifth question		23	51.11%	19	42.22%
Total score		81.26		78.59	

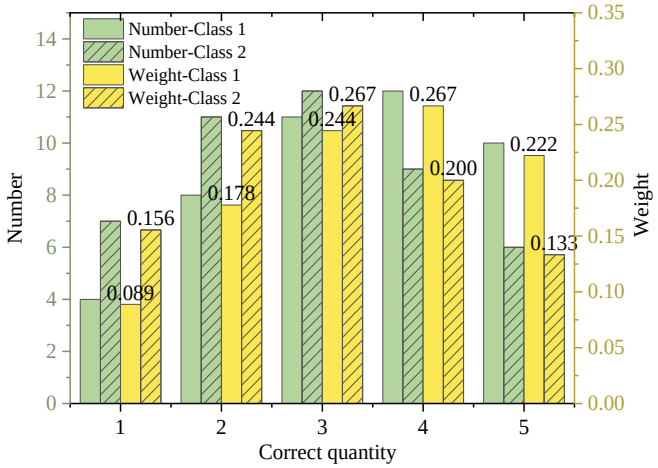

Figure 4: The student number of correct answer and proportion in the after test

4.2.2 Application awareness building

(1) Understanding of the basics of mathematical modeling

After the experiment, students' understanding of the basics of mathematical modeling is shown in Table 5. The percentage of experimental students who chose correctly on the understanding of the basics of mathematical modeling are 80% and above, most students understand the conceptual steps and other basic knowledge of mathematical modeling after carrying out the study, while the correct choices of experimental students on the three questions before the experiment are always below 50%, indicating that the students' understanding of the basics of mathematical modeling has been substantially improved after learning mathematical modeling by the case teaching method.

Table 5: Understanding of mathematical modeling basic knowledge in the after test

Question	Score	Number	Percentage/%	Effective percentage/%	Cumulative percentage/%
Question 1	0	7	15.56%	15.56%	15.56%
	3	38	84.44%	84.44%	100.00%
	Total	45	100	100	
Question 2	0	8	17.78%	17.78%	17.78%
	3	37	82.22%	82.22%	100.00%
	Total	45	100	100	
Question 3	0	9	20.00%	20.00%	20.00%
	3	36	80.00%	80.00%	100.00%
	Total	45	100	100	

(2) Establishment of Mathematical Modeling Application Awareness

The establishment of Class 1 students' awareness of mathematical modeling application after the experiment is shown in Figure 5, and the corresponding descriptive statistical analysis results are shown in Table 6. The scores of the three topics increased from 2.69, 2.53 and 2.42 before the experiment to 3.53, 3.56 and 3.58, which were 31.23%, 40.71% and 47.93% respectively, and the standard deviation was lower than that before the experiment, and the gap of the students' awareness of mathematical application was reduced, which indicated that the learning of mathematical modeling course based on the case-based teaching method could improve the students' mathematical application Awareness.

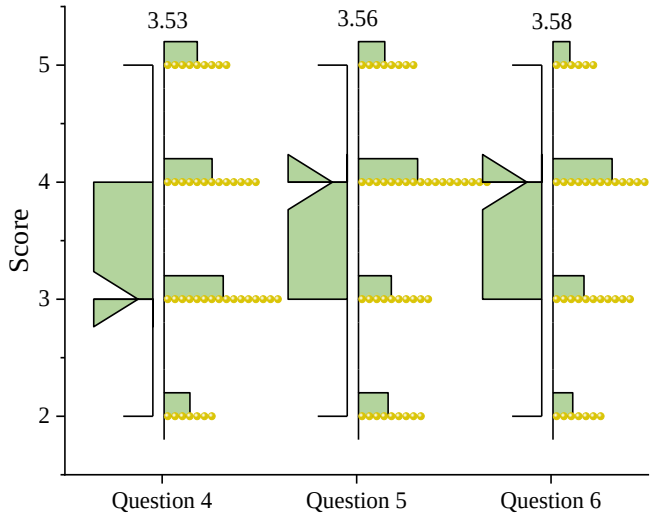

Figure 5: Knowledge of mathematical modeling application consciousness in the after test

Table 6: Describe the statistical analysis results in the after test

	Question 4	Question 5	Question 6
Mean	3.53	3.56	3.58
Number	45	45	45
Standard deviation	0.991	1.013	0.917
Mode number	3	4	4
Min	2	2	2
Max	5	5	5

5 Conclusion

In the teaching of mathematical modeling courses, case teaching effectively provides modeling exercises, and the models provided are usually of practical applicability, which can provide scientific and reasonable solutions for special practical problems. In this paper, the case teaching method is applied to mathematical modeling courses, taking two classes in a school as an example, designing an experimental scheme and conducting teaching experiments to explore the effect of implementing the case teaching method in mathematical modeling courses on the enhancement of students' application awareness. The results of the study show that the use of practical case teaching method can improve students' academic performance and application awareness. The specifics are as follows:

(1) In terms of academic performance, the posttest scores of the two classes improved by 7.34% and 4.74% respectively compared with the pre-test, and after a period of time, the students' mathematical modeling knowledge and ability were developed. However, the experimental students' performance improvement was significantly higher than that of the control students, and the posttest scores of the experimental students were 3.40% higher than those of the control students. Meanwhile, 48.9% of the experimental students answered more than 4 questions correctly compared to 33.3% of the control students. This indicates that the experimental students' course grades are effectively improved after the implementation of the case teaching method.

(2) In terms of application awareness, most of the experimental students mastered the basics of mathematical modeling after the teaching, with the correct selection rate of more than 80%, and the students' application awareness cultivation was improved by 31.23% to 47.93% after the experiment, which verified the enhancement of students' application awareness by the case teaching method.

The simulation, purpose, diversity and revelation of the case teaching method can cultivate and develop students' active learning ability, independent knowledge learning ability, communication ability and problem solving ability, enhance the teaching effect and teaching quality of mathematical modeling, and further achieve the purpose of improving students' application awareness and comprehensive ability.

Funding

This work was supported by the Sichuan Provincial Key Research Base of Philosophy and Social Sciences - Sichuan Provincial Education Development Research Center of China West Normal University (Project No. CJF24052, Host: Lin Lin) and the Chengdu Vocational and Technical College Education Association's 2024 Chengdu Vocational Education Teaching and Research Planning Project (Project No. GZZZ2024-23, Host: Lin Lin).

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