ITM Web of Conferences **77**, 01002 (2025) https://doi.org/10.1051/itmconf/20257701002
EMIT 2025

Innovative teaching model: improving mathematical core literacy in architectural vocational schools

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Abstract. This paper focuses on mathematics teaching in architectural vocational schools and proposes an innovative teaching model aiming to enhance students' mathematical core literacy. It elaborates on the connotation and implementation steps of this model and analyzes it with specific teaching cases, providing a reference for the reform of mathematics education in architectural vocational schools.

1 Introduction

In architectural vocational education, mathematics, as an important basic subject, has a profound impact on students' professional learning and future career development. However, the traditional teaching model has deficiencies in cultivating students' mathematical core literacy and cannot fully meet the requirements of the architectural profession for students' mathematical abilities[1]. Therefore, exploring innovative teaching models is crucial for improving the quality of mathematics teaching in architectural vocational schools.

2 The connotation of mathematical core literacy in architectural vocational schools

The mathematical core literacy in architectural vocational schools includes spatial imagination ability, mathematical calculation ability, logical reasoning ability, and mathematical modeling ability[2]. Spatial imagination ability helps students understand architectural drawings and three - dimensional structures; mathematical calculation ability is indispensable in calculating the quantity of construction work; logical reasoning ability can assist students in analyzing the stability of architectural structures; and mathematical modeling ability can be used to solve optimization problems in architectural design[3].

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3 “Construction Situation Integration - Practical Inquiry - Mathematical Modeling - Feedback and Expansion (CFPM)” teaching model

3.1 Model connotation

3.1.1 Construction situation integration

Closely combine the content of mathematics teaching with architectural professional situations, and introduce mathematical problems from architectural examples to make students feel the practicality of mathematics in the field of architecture. For example, by presenting the roof structures of different architectural styles, the application of trigonometric functions in slope calculation is introduced.

3.1.2 Practical inquiry

Organize practical activities for students, such as on - site measurement of the size of building components and observation of spatial relationships in architecture. On the basis of practice, guide students to explore relevant mathematical problems and cultivate their independent learning and exploration abilities.

3.1.3 Mathematical modeling

Establish mathematical models based on architectural problems and transform actual architectural problems into mathematical problems for solution. For example, when studying the optimization problem of the amount of construction materials used, a function model is established to determine the optimal solution.

3.1.4 Feedback and expansion

Collect students' learning feedback through homework, classroom discussions, project evaluations, etc., and adjust teaching strategies in a timely manner. At the same time, expand the application of mathematical knowledge in the field of architecture to deepen students' understanding of the relationship between mathematics and architecture.

3.2 Implementation steps

3.2.1 Situation introduction and problem presentation

Teachers present architectural cases, such as the eaves structure of an ancient building, and raise mathematical problems related to angle measurement and geometric shape analysis to stimulate students' interest.

3.2.2 Organization of practical inquiry activities

Lead students to the architectural model room or on - site to observe similar structures, use measuring tools to collect data, and encourage students to discuss the involved mathematical knowledge.

3.2.3 Guidance of mathematical modeling

Guide students to establish mathematical models based on the measured data and architectural principles. For example, use the principle of similar triangles to calculate the length and angle relationship of the eaves. Teachers guide students to use appropriate mathematical methods to solve the models beside them.

3.2.4 Feedback and expansion teaching

Let students present the modeling results, and teachers evaluate and provide feedback. At the same time, introduce new architectural situations, such as the special - shaped structures of modern architecture, and expand the application of mathematics in them, such as the use of spatial vectors in the positioning of complex structures.

4 Specific Application Cases of the "Construction Situation Integration - Practical Inquiry - Mathematical Modeling - Feedback and Expansion (CFPM)" teaching model

4.1 Case 1: application of trigonometric functions in architectural sunlight analysis

4.1.1 Construction situation integration

Taking the planning and design of a residential community as the background, teachers show the differences in sunlight duration of buildings with different orientations and heights. Through the demonstration of sunlight simulation software, the mathematical relationship between sunlight angle, building height, and building spacing is introduced, making students understand the importance of sunlight analysis in architectural design, especially in ensuring the quality of residents' lives.

4.1.2 Practical inquiry

Organize students to select several buildings with different heights and orientations on campus as observation objects. At different time points (such as morning, noon, and afternoon), use an angle - measuring instrument to measure the angles between sunlight rays and the ground and the building walls, and record the length of the building's shadow. At the same time, measure the distance between buildings, and students think about how to use these data to analyze the sunlight conditions during the practice.

4.1.3 Mathematical modeling

Based on the measured data, students establish a trigonometric function model. Taking the angle between sunlight rays and the ground as the independent variable and the building height and shadow length as variables, a relational model is established using the tangent function. For example, if the solar altitude angle is α, the building height is h, and the shadow length is l, then $\tan\alpha = \frac{h}{l}$. Through this model, combined with the data of the change in solar altitude angle in different seasons, the sunlight duration of buildings under different building spacings can be calculated, thus providing a basis for the rational planning of the residential community.

4.1.4 Feedback and expansion

Students present their measurement data, modeling process, and calculation results in class, and the teacher guides other students to discuss and evaluate. The teacher focuses on providing feedback on the rationality of model establishment, the accuracy of data processing, and the understanding of the application of trigonometric functions. In the expansion part, the teacher introduces more complex topographic factors, such as sunlight analysis of mountainous buildings, and asks students to think about how to establish a model on sloping ground and how to consider the influence of surrounding mountains on sunlight occlusion.

4.2 Case 2: application of sequences in architectural stair design

4.2.1 Construction situation integration

Teachers display pictures of various styles of architectural stairs, including spiral stairs and straight - run stairs. They introduce that stair design should not only consider aesthetics but also meet ergonomics and safety standards, such as the reasonable setting of step height and width. This leads to the mathematical problem of determining the number and size of steps according to the floor height and stair traffic requirements, making students understand the key role of mathematics in the detailed design of architecture.

4.2.2 Practical inquiry

Students are grouped to conduct on - site measurements in teaching buildings or libraries with stairs on campus. They measure the total height of the stairs, step height, step width, and the horizontal projection length of the stairs. At the same time, they observe the comfort level and walking speed of people going up and down the stairs and think about the relationship between these factors and the design parameters of the stairs.

4.2.3 Mathematical modeling

Based on the measured data and ergonomic principles, students establish a sequence model. Taking the floor height H as the target value and the step height h as the term of the sequence, if the number of steps is n, then $H = nh$. Considering the safety and comfort standards, the step height h has a certain range of values. The appropriate values of n and h can be determined through the general term formula and the sum formula of the sequence. At the same time, combined with the relationship between step width and walking comfort, the stair design model is further optimized.

4.2.4 Feedback and expansion

Each group reports the measurement results and modeling ideas, and the teacher evaluates whether the model meets the actual architectural standards and ergonomic requirements.

The teacher provides feedback on the problems of students in the application of sequences and data processing. In the expansion part, the teacher introduces the stair design of special building types (such as barrier - free buildings) and asks students to consider how to add ramp design factors to the model and how to optimize the combination design of ramps and stairs through mathematical methods to meet the usage needs of different groups of people.

5 Conclusion

The "Construction Situation Integration - Practical Inquiry - Mathematical Modeling - Feedback and Expansion (CFPM)" teaching model effectively improves the mathematical core literacy of students in architectural vocational schools by closely combining mathematics teaching with architectural professional situations and practice. This innovative model helps students better apply mathematical knowledge to architectural professional learning and provides strong support for cultivating high - quality talents that meet the development needs of the construction industry. In future teaching practice, this teaching model can be further improved and promoted.

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