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APPLICATION EFFECTIVENESS OF HIGH-LEVEL PERSPECTIVE IN HIGH SCHOOL TEACHING UNIT DESIGN

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Abstract

High-level perspectives in high-school mathematics focus on exploring the generation significance of mathematical knowledge from the viewpoint of the knowledge system. Teaching unit design under this perspective provides important references for educational practice. This paper establishes a teaching unit design model guided by objectives and driven by evaluation, proposing a basic implementation pathway that includes: "content reconstruction — element analysis — goal setting — evaluation design — activity design — practice and reflection." Using the example of conic sections in high school mathematics, the study evaluates the effectiveness of this design model. The results demonstrate that this teaching design approach helps to open new pathways for enhancing the efficiency of unit teaching.

Keywords: *High-level perspective; Teaching unit-design; Mathematics teaching;*

Introduction

In current high-school teaching, a new wave of curriculum reform guided by core competencies is steadily progressing, making the development of students' core competencies an essential topic for educational researchers. However, in mathematics teaching, there remains a common phenomenon where teachers directly transmit mathematical knowledge as ready-made conclusions to students. This practice is not conducive to cultivating students' core competencies in mathematics.

Generally speaking, perspectives shape behavior, and teachers' understanding and views of the mathematical knowledge they teach directly influence their teaching behavior. One key reason for this phenomenon is that teachers' own perspectives on mathematical knowledge have certain shortcomings. Therefore, under the current context of curriculum reform and based on the requirements of the Curriculum Standards, teachers should adopt a high-level perspective, guided by a rational view of mathematical knowledge, to fully understand the nature and educational value of high school mathematics knowledge. This involves revealing the "generative" meaning of mathematical knowledge so that students can be guided to construct and generate mathematical knowledge in generative mathematics teaching. Through this, the cultivation of students' core competencies in mathematics can truly be implemented in teaching practice.

In the study of high-school mathematics from a high-level perspective, Pang et.al were one of the earliest to point out the possibility, practicality, and educational significance of using a high-level perspective to guide elementary mathematics teaching (Pang et.al. 1995). Chen proposed that secondary school mathematics should be understood with a unified and modern high-level perspective, highlighting the connections between elementary mathematics and higher mathematics, as well as between various areas of mathematical knowledge (Chen et.al. 1995). Zheng emphasized that high-level perspective guidance in secondary school mathematics teaching should not be simply understood as "transferring" higher-level content to lower levels; rather, it should be about

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"inspiring students with profound ideas" and going beyond specific knowledge and skills to delve into cognitive thinking, thereby achieving "deep mathematics teaching"(Zheng 2021). Li believed that teachers need to have a "high-level perspective" in mathematics, which refers to an overarching understanding of the nature of mathematical knowledge (Li 2021). Mastering a high-level perspective can help teachers grasp the main content of mathematics and establish connections between different topics. Zhoui and Zhang proposed strategies for using high-level perspectives to guide secondary school mathematics teaching, such as reorganizing secondary school mathematics content with advanced mathematical ideas as the main thread, reexamining secondary school mathematics problems, and analyzing elementary mathematics teaching from the perspective of advanced mathematics (Zhoui and Zhang 2014). Gao proposed methods to enhance the efficiency of mathematics classrooms through high-level perspectives, including changing mathematics teaching concepts, creating special classroom scenarios, deeply understanding textbooks, stratifying classroom training, seizing cognitive patterns, and utilizing modern technology (Gao 2022).

Some studies have conducted specific teaching designs from a high-level perspective. For example, Sun implemented a teaching design for a review lesson on "linear equations in one variable" that constructed mathematical models with a high-level perspective (Sun 2021). Wang et.al. discussed the differences and connections between elementary and advanced algebraic proof methods and designed a teaching lesson on "algebraic proof" from a high-level perspective (Wang et.al. 2020). These studies demonstrate that high-level perspective-based mathematics problem-solving primarily involves using advanced mathematical knowledge, ideas, and methods to explore solution techniques and strategies for secondary school mathematics exam problems. This not only makes the solution process simpler but also reveals the essence of the problem.

This study adopts a high-level perspective and takes high school mathematics conic sections as an example to examine its teaching effects. The research employs interviews to investigate the current situation and problems of unit teaching design ("interview study on the current situation and problems of unit teaching design"). Based on this foundation, unit teaching design is further reformed by constructing a unit teaching design model and conducting practical tests on the designed unit teaching cases.

Research Methodology

Research objects

A total of 88 students from Class 5 and Class 8 of the second year at a high school in Zhuzhou City participated in the study.

Study tool

The independent variable of this study was the unit teaching design model, while the dependent variable was the teaching effectiveness of the course. Unrelated variables such as the students' region, school, and grade were controlled. To better quantify the teaching effectiveness, the study developed a self-evaluation questionnaire for students and a test paper. These tools were used to compare the results with the implementation effects of unit teaching under traditional models.

The self-evaluation questionnaire included five dimensions: knowledge goals, ability goals, competency goals, emotional goals, and learning attitude. The first four dimensions corresponded to the teaching goals. Since deep learning often involves challenging content, students with insufficient confidence may struggle to achieve a high level of deep learning. Therefore, the questionnaire also included the dimension of learning attitude to better evaluate the students' learning experience. The questionnaire consisted of 15 questions, with three questions for each dimension, rated on a five-point Likert scale ranging from "completely disagree" to "completely agree."

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The test paper, based on the specific teaching objectives of conic sections (ellipse, hyperbola, and parabola), included five test questions (see Table 1). Scoring criteria were as follows: full marks for correct formulas and answers; half marks for correct formulas but incorrect answers; no marks for incorrect formulas and answers.

Table 1

Problem distributions of conic sections

Instruction Goal	Ability test	Number	Scores
Ellipse Focus and Fixed Value Calculation	Ability to accurately calculate the coordinates of the foci and solve related fixed value problems based on the definition	A1 (1), (2)	10
		A1 (3), (4)	20
Engineering Physics	Ability to accurately calculate the eccentricity and the area and trajectory formed by related moving points based on the definition	A2	20
		A3	10
Foreign Language Journalism	Ability to accurately calculate the chord length passing through a specific point on the parabola and the slope of the line tangent to the parabola at a given point.	A4	10
		A5	20

Results Analysis and Discussion

Teaching Design and Procedure

From a high-level perspective, and based on the framework and requirements of "unit-lesson teaching design," the study constructed a reverse unit teaching design model using the understanding by design theory. This model followed the implementation pathway of "content reconstruction — element analysis — goal setting — evaluation design — activity design — practice and reflection."

During the goal setting stage, clear objectives were determined through curriculum standards analysis, textbook analysis, content reconstruction, and student learning situation analysis, avoiding unclear, unfocused, or arbitrary teaching goals. In the evaluation design stage, evaluation content was closely aligned with the objectives, and appropriate methods and tools were selected to form feedback that assessed whether the objectives were achieved, addressing issues of lack of specificity and scientific rigor in traditional evaluation.

Steps in Unit Teaching Design

- Content Reconstruction: Identify the unit, organize it around the theme of problem-solving processes, and design key questions to form the unit's content system.
- Element Analysis: Analyze curriculum standards, students' cognitive foundations, and their levels of thinking development. Identify relationships within and across topics, embedded mathematical ideas, key teaching points, and differences in how various textbook versions introduce concepts, create scenarios, and arrange exercises.
- Goal Setting: Define expected outcomes. From a high-level perspective, unit goals were examined through a broader lens, emphasizing the integration of core competencies and key

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abilities.

- Evaluation Design: Determine suitable evidence. Teaching objectives were categorized into four dimensions (knowledge, ability, competency, emotional goals), with evaluations conducted through classroom observations, student exchanges, and process and summative assessments.

Questionnaire Distribution and Data Collection

After the lesson, students were given paper questionnaires, including the self-evaluation questionnaire and the test paper, to complete within a specified time under teacher supervision to ensure data validity. A total of 88 questionnaires were distributed, all of which were returned. After excluding invalid questionnaires (e.g., those with the same score for all questions), 79 valid responses remained.

Self-Evaluation Questionnaire Analysis

Reliability and Validity: The questionnaire's reliability coefficient was 0.884 (Cronbach's Alpha), exceeding the threshold of 0.7, indicating high reliability. For validity, the Kaiser-Meyer-Olkin (KMO) value was 0.811, also above 0.7, demonstrating good structural validity.

The questionnaire covered five dimensions: knowledge goals, ability goals, competency goals, emotional goals, and learning attitude. Average scores for these dimensions are shown in Table 8. The survey revealed that knowledge goals and ability goals achieved the highest scores (around 4 on average), followed by competency and emotional goals (around 3.5 on average), indicating a good overall understanding of the content on conic sections.

For the learning attitude dimension, question 13 was a reverse-scored item, with higher scores indicating more proactive learning attitudes and lower scores indicating passivity. The average scores for questions 13 to 15 were around 2.6, suggesting that students' learning attitudes require improvement.

Table 2

Average scores of five dimensions

Dimensions	No.	Content	Aver. Scores
Knowledge Objectives	1	Able to provide the basic definition of conic sections	4.011
	2	Understand the foci and eccentricities of various conic sections	4.251
	3	Understand the relationship between points on the curve and their coordinates	4.001
Ability Objectives	4	Able to calculate the area and trajectory formed by related moving points	3.892
	5	Able to solve fixed value problems related to conic sections	4.120
	6	Able to calculate related chord lengths and the slope of lines passing through tangent points	3.881
	7	Recognize the necessity of combining numerical and graphical methods	3.745

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Competency Objectives	8	Able to reasonably select different coordinate systems for calculations in specific contexts	3.625
	9	Appreciate the hierarchical abstraction of mathematics and the rigor of logical reasoning	3.947
Emotional Objectives	10	Appreciate the beauty of combining numerical and graphical methods and the elegance of simplicity in mathematics	3.562
	11	Recognize the convenience brought by different coordinate systems when studying problems	3.638
	12	Appreciate the thinking spirit and rich achievements of past great mathematicians	3.548
Learning Attitude	13	Rarely plan self-directed learning without tasks assigned by the math teacher	2.414
	14	Often actively participate in discussions during math class	2.985
	15	Often proactively express their opinions during math class	2.765

First, the raw scores from the test questions were calculated and converted into a 5-point scale. This was done to compare students' self-assessment scores based on the preset objectives for each test question with the actual results reflected by the tests.

From the test results, students showed a strong grasp of ellipse-related calculations, but their understanding of parabolas remains at a superficial level. Whether students truly comprehend, can apply, and analyze these concepts requires further testing. A comparison of the test results with the students' self-assessments showed general alignment, indicating that the teaching objectives were largely achieved.

The practice revealed that most students could memorize, understand, and apply new concepts and formulas but struggled with flexible application and drawing inferences. Students demonstrated weak post-class self-reflection and self-correction abilities. Since self-reflection is foundational for deep learning and self-correction reflects its outcomes, the lack of these skills hinders the achievement of deep learning. Without a positive learning attitude and strong motivation, deep learning remains unattainable. This underscores the need for teachers to intentionally cultivate students' reflective and self-correcting abilities

Results & Discussions

In this study, through classroom teaching based on unit teaching design, students showed good mastery of knowledge related to conic sections and a clear understanding of the relationship between numerical and graphical approaches, as well as conic sections in different coordinate systems. However, their comprehension of conic section calculations was not thorough. One reason could be the abstract nature and computational intensity of conic section concepts in high school mathematics. For this area of teaching, teachers need to go beyond basic concepts to incorporate related ideas like numerical-graphical integration to strengthen students' grasp of key concepts. This includes fostering a deeper understanding of the concepts' essence and increasing computational training.

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Learning from a high-perspective viewpoint achieves meaningful developmental value only when it moves toward deep teaching. The research and practice findings show that conducting educational activities based on "core competencies—curriculum standards—unit design—learning evaluation" fosters students' holistic and structured learning, transforming fragmented knowledge points into a networked structure. Therefore, building a "unit teaching design" model supports the realization of meaningful, high-level learning.

Main Conclusions

Currently, several issues persist in unit teaching design. Teachers lack clear goal-setting for mathematics, particularly in systematically addressing ability, competency, and emotional objectives. Teaching design struggles to pinpoint key and challenging points accurately. Significant differences exist between novice and experienced teachers in textbook analysis, with novices demonstrating a less thorough understanding of the material. Analysis of student learning situations is insufficient. Core elements of teaching, learning, and evaluation are disconnected. These issues highlight the gap between the current state of teaching design and its theoretical and practical potential.

The explorations and practices in this study, based on unit teaching design within a high-perspective framework, effectively promoted both student and teacher development.

For students, the teaching practices facilitated the cultivation of core mathematical competencies, improving the teaching of conic sections in high school and addressing issues like unclear objectives, unscientific activity and scenario design, superficial learning, and disconnection between teaching, learning, and evaluation. This improved the quality of mathematics teaching and fostered the development of students' mathematical thinking.

For teachers, the study encouraged them to adopt a high-perspective mindset, gaining a deeper understanding of the nature and educational value of high school mathematics. It also provided practical teaching approaches and pathways for frontline teachers, inspiring them to develop more teaching cases through a high-perspective framework for generative mathematics teaching design. This enhanced teachers' teaching design abilities, broadened their teaching perspectives, and improved teaching efficiency, demonstrating significant values.

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