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Research on Instructional Design of Junior High School Three-View Drawings Based on TPACK Theory and VR Technology

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***Keywords*:** TPACK Theory; VR Technology; Junior High School Mathematics; Three-View Drawings; Instructional Design

***Abstract*:** This study constructs an instructional design for junior high school three-view drawings by integrating TPACK theory and VR technology. It aims to address the difficulties of students' poor spatial imagination and low learning motivation in traditional teaching. Through immersive VR scenarios, progressive question chains, and hierarchical practice, the design realizes the deep integration of subject content, teaching methods, and technology. It not only helps students master knowledge and develop spatial thinking but also provides a replicable paradigm for technology-integrated mathematics teaching, highlighting the value of TPACK in guiding instructional innovation.

1. Teaching Objectives

1.1 Teaching Purposes

This case has the following teaching uses:

Learn systematic instructional design thinking: This case fully presents the whole process from theoretical basis (TPACK), student situation analysis, goal setting, situation creation, activity design to evaluation and summary. It has extremely high learning value for master's degree students in education to understand "how to systematically design a lesson".

Understand the basis and purpose of technology selection: The case clearly points out why VR technology is chosen instead of other technologies (such as ordinary courseware). The purpose is to create immersive situations that cannot be realized in conventional classrooms to solve core teaching difficulties. This helps to cultivate the rational thinking of pre-service teachers to "select technologies according to needs" and avoid using technologies just for the sake of using them.

Serve as a core case for classroom teaching activities: This case can be used as a discussion topic for classroom teaching activities. The discussion directions can include: How effective is the integration of various elements of TPACK? Is VR technology irreplaceable in this lesson? How can the teaching link design be further optimized? These activities thus promote professional dialogue and shared growth among teachers.

Demonstrate the practical application of TPACK theory: This case provides a "textbook-style" example for teachers on how to apply the abstract TPACK theoretical framework to specific classroom teaching. It clearly shows how to organically integrate subject content (CK - concepts and drawing methods of three-view drawings), pedagogy (PK - situation creation, inquiry-based learning, intuitive teaching method) and technology (TK - VR technology), rather than simply superimposing them.

Provide innovative strategies to solve teaching difficulties: The teaching difficulty of "three-view drawings" lies in students' spatial imagination ability. Through the immersive experience of VR technology, this case dynamically and visually presents the abstract processes of "projection" and "rotation", providing teachers with a new and effective weapon to overcome this traditional difficulty[1].

Display instructional design of interdisciplinary integration: The case combines mathematics education with humanities and history (ancient Chinese architecture "Zhai"), providing teachers with specific ideas and practical paths on how to carry out interdisciplinary theme teaching and how to integrate excellent traditional Chinese culture education into mathematics classrooms.

1.2 Target Learners

This case is mainly developed for master's degree students in education. It is suitable for postgraduate students majoring in subject teaching (mathematics), and can also be used in related courses for master's degree students in education majoring in subject teaching (mathematics).

1.3 Applicable Courses

Research on Middle School Mathematics Curriculum and Textbooks, Research on Instructional Design and Implementation of Middle School Mathematics, Research on Mathematics Education Reform

2. Inspirational Thinking Questions

To promote in-depth understanding and transfer application of this case, the following thinking questions can be put forward:

This case takes VR technology as the core teaching tool. Teachers should analyze the following questions:

What irreplaceable or significantly superior values does VR technology provide in solving the teaching difficulty of "three-view drawings" (spatial imagination) compared with traditional models and animation demonstrations?

Is it possible that this technology integration replaces the necessary "abstract" thinking process of students with the "intuition" of technology? Will it exacerbate educational inequality due to equipment and cost issues?

If only low-cost physical models and Geometer's Sketchpad are used, how to design teaching to achieve similar teaching goals? How much is the "incremental benefit" of VR?

Take a specific teaching link in this case (for example, from VR observation to summarizing the rules of three-view drawings in "cooperative exploration") as an example for micro-analysis:

In this link, how do teachers' subject content knowledge (CK - principles of three-view drawings), pedagogical knowledge (PK - questioning, guiding inquiry) and technological knowledge (TK - VR operation) interweave and interact to support students' learning?

Is the success of this link key to the exquisite VR model or the carefully designed teaching dialogue and activity process? Which composite element in the TPACK framework (such as PCK, TPK) does this reflect the core role of?

If this link is to be improved, how to further strengthen students' dominant position in inquiry under the support of technology, rather than just "following observation"?

This case relies on specific VR resources. Teachers should think about the following questions:

Putting aside VR technology, what is the core teaching concept in this case that is most worth learning from? (For example, starting from real situations, embodied cognition, visualizing and decomposing cognitive difficulties, etc.) Teachers can choose another teaching difficulty (for example, the concept of "function" in junior high school mathematics, "dynamic geometry problems", or abstract concepts in other subjects) and try to use the core teaching concept extracted from this case to design a TPACK-integrated teaching plan that does not rely on high-end VR equipment. In the proposed plan, what alternative technologies (such as GeoGebra, APP, graphic calculator, etc.) will you choose to undertake the "cognitive scaffolding" function similar to VR?

3. Analysis Ideas

3.1 Starting Point: Accurately Diagnosed Core Teaching Problems (Top-level Core Problems)

The case starts from two traditional dilemmas in the teaching of junior high school "three-view drawings":

Problem 1 (Difficulty in spatial imagination): Three-view drawings involve frequent conversion between two-dimensional and three-dimensional spaces, which highly depends on students' spatial imagination ability. This is a cognitive difficulty for students' learning.

Problem 2 (Weak learning motivation): The concepts are abstract, and traditional teaching methods (looking at pictures, drawing models) easily make students feel bored[2]. This is a motivational and emotional difficulty.

3.2 Bridge: TPACK Theoretical Framework as the Core of the Solution

The innovation of the case lies in that instead of using technology scattered or improving teaching methods, it introduces the TPACK (Technological Pedagogical Content Knowledge) theory as the "brain" and "framework" of top-level design. The three core elements of TPACK exactly address the above two core problems:

Subject Content Knowledge (CK) - "What to teach?"

The core is "the concepts and drawing rules of three-view drawings". Its internal logic is to derive the necessity of three-view drawings from the limitations of single projection, and strictly follow the rules of "length alignment, height alignment, and width equality".

Pedagogical Knowledge (PK) - "How to teach?"

The case adopts "situation creation" and "inquiry-based learning". Through the VR scene of the ancient Chinese architecture "Zhai", it stimulates interest (solves the motivation problem); through carefully designed "question chains" (such as: "Is one view enough?" "What is the relationship between the three views?"), it guides students to actively construct knowledge instead of passively accepting it (solves the method problem).

Technological Knowledge (TK) - "What to use for teaching?"

The core is "VR immersive experience technology". Its value lies in its ability to dynamically and visually display the projection process and rotation and unfolding process, embodying the most abstract "spatial imagination" process and directly overcoming Problem 1 (difficulty in spatial imagination).

The key lies in integration: The success of the case does not lie in the simple superposition of these three elements, but in their deep integration (i.e., TPACK):

TCK (Technological Content Knowledge): Recognize that VR technology is particularly suitable for visualizing the geometric content of "projection".

TPK (Technological Pedagogical Knowledge): Use VR to support the teaching methods of "situation creation" and "inquiry-based discovery".

Final TPACK: Form a complete design scheme of "understanding the concepts of three-view drawings through problem inquiry in the ancient architecture situation created by VR".

3.3 Carrier: Development of Specific Teaching Strategies

Under the guidance of the TPACK theory, the case derives three interlocking teaching strategies, transforming theory into executable classroom activities:

Strategy 1: VR situation, turning abstraction into intuition (corresponding to the integration of TK, PK and CK)

Practice: Use VR technology to construct an immersive situation of "Zhai", placing abstract geometric concepts in a real cultural background.

Logical relationship: VR technology is not only a demonstration tool here, but also a cognitive tool and a motivation-stimulating tool. It presents CK (three-view drawings) in an unprecedentedly intuitive way, perfectly embodying the integration idea of TPACK.

Strategy 2: Guided by question chains, turning passivity into initiative (corresponding to the integration of PK and CK, i.e., PCK)

Practice: Design a progressive question chain from "single projection" to "three-view drawings", guiding students to think about the necessity and rules of three-view drawings.

Logical relationship: This is a deep understanding of subject content (CK) by pedagogy (PK). Even without VR, this is the key to understanding three-view drawings. The addition of VR technology (TK) provides a tool for exploring and verifying these questions, making inquiry possible.

Strategy 3: Hierarchical application, turning knowledge into literacy (corresponding to the deepening and transfer of CK)

Practice: The exercise design progresses step by step from simple cuboids, to combined solids, and then to complex cultural relic "planers".

Logical relationship: This reflects the grasp of the subject knowledge structure (CK). Through hierarchical application, students can practice and consolidate the initially established spatial concept (intuitive imagination) and drawing skills at different levels of complexity, and finally realize the internalization from knowledge to literacy.

3.4 End Point: Achievement of Teaching Objectives and Implementation of Literacy

Through the above logically rigorous design, the case finally effectively achieves its teaching objectives:

Students not only master the knowledge and skills of three-view drawings (knowledge objectives).

Moreover, in the VR-assisted inquiry process, they develop spatial imagination ability and problem-solving ability (ability objectives).

At the same time, in the cultural infiltration of ancient Chinese architecture, they stimulate learning interest and national pride (emotional objectives).

In summary, the analysis ideas of this case reveal the internal logic of an excellent technology-integrated instructional design: it starts from a profound insight into real teaching problems, succeeds in taking a solid educational theory (TPACK) as the overall framework, and finally lands on a series of teaching strategies that seamlessly connect technology, teaching methods and content. This is not only a lesson plan, but also a thinking model of "how to scientifically carry out instructional design"[3].

4. Case Analysis

This case is an excellent design with great foresight and depth under the guidance of TPACK theory.

It accurately realizes the in-depth value of technology: The application of VR technology directly points to teaching difficulties and realizes the "redefinition" of learning tasks in key links.

It demonstrates a deep integration model: In micro-teaching links, technology, teaching methods and content are integrated, jointly promoting the development of students' high-order thinking.

It has high transferability: Its core design concept can be extracted and applied to many other teaching topics, providing educators with a model of "how to think like a designer".

The most precious legacy of this case is not the VR technology itself, but the design paradigm behind it of "supporting inquiry in real situations through visualization technology to deepen conceptual understanding". Master's degree students in education should learn this ability of "extraction and transfer", transforming the advanced concepts in high-cost cases into implementable and creative instructional designs in their own teaching situations. This case strongly proves that for future-oriented mathematics education, the key lies in the maturity of teachers' Technological Pedagogical Content Knowledge (TPACK), which is more important than mastering any single technology or teaching skill.

5. Summary of Key Points

The success of this case stems from the collaborative application of various teaching strategies under the guidance of TPACK theory:

5.1 Immersive Situation Creation Strategy

Practice: Use VR technology to construct a virtual scene of "ancient Chinese garden - Zhai", transferring the learning environment from the classroom to the cultural site.

Function: Greatly stimulate learning interest, endow the learning of three-view drawings with real significance and cultural connotation, and solve the problem of "why to learn".

5.2 Visualized Cognitive Scaffold Strategy

Practice: Use VR to dynamically and accurately demonstrate invisible thinking processes such as "orthographic projection" and "rotation and unfolding of projection plane".

Function: Embody the most abstract and core cognitive difficulties, provide strong external support for students to construct spatial concepts, and effectively reduce cognitive load.

5.3 Inquiry Strategy Guided by Question Chains

Practice: Design progressive questions (such as: "Is one view enough?" "What is the relationship between the three views?") to guide students to observe, think and summarize in the VR environment.

Function: Ensure that students maintain a positive thinking state in the technical environment, avoid "just watching the fun", and promote them to abstract mathematical rules from intuitive experience to realize active construction of knowledge[4].

5.4 Hierarchical Application and Transfer Strategy

Practice: The exercise design progresses step by step from simple geometric solids (cuboids) to combined solids, and then to complex daily objects (planers).

Function: Consolidate knowledge, improve skills, and guide students to transfer and apply what they have learned to solve practical problems, completing the leap from knowledge to literacy.

This case provides profound enlightenment beyond itself for the practice of "technology empowering education":

The depth of technology integration lies in "cognitive support" rather than "sensory stimulation": This case enlightens us that the value of technology application should not be evaluated by whether it is novel and cool, but by whether it provides irreplaceable cognitive support at key nodes of learning. The core value of VR here is as a "cognitive amplifier" and "thinking scaffold", rather than a simple demonstration tool.

The TPACK framework is a "navigation map" for teachers' professional development: This case is a perfect implementation of TPACK theory. It tells us that when designing teaching, teachers should consciously look for innovation points at the intersection of subject content (CK), pedagogy (PK) and technology (TK). The professionalism of teachers is reflected in this complex and structured integrated knowledge.

The key to solving teaching difficulties lies in "turning abstraction into intuition": Many teaching difficulties (especially in the field of geometry) stem from their abstraction. The successful path of this case is: find the "breakpoint" in students' thinking → use technology to visualize the thinking process at the "breakpoint" → guide students to cross the breakpoint. This idea has universal transfer value.

Cultural infiltration is a "flavor enhancer" and "adhesive" in mathematics teaching: Integrating ancient Chinese architecture culture into mathematics classrooms not only enhances the humanistic atmosphere, but also provides a warm and meaningful "anchor" for abstract mathematical concepts, making knowledge more vivid and easier to remember and understand, realizing the unity of knowledge and humanism.

The upgrade from "giving someone a fish" to "teaching someone to fish" is the core of design: The ultimate goal of this case is not to let students learn to draw three-view drawings of a specific object, but to let students master how to think about the conversion problem from three-dimensional to two-dimensional through the technology-assisted inquiry process. This is a kind of ability transfer of "how to learn"[5].

All in all, the essence of this case is that it demonstrates an instructional design paradigm of "student-centered, technology-supported, literacy-oriented". It reminds educators that in today's rapid development of technology, we should pay more attention to how to use technology to deepen rather than superficialize the learning process, and how to cultivate lifelong learners with advanced thinking ability who can adapt to complex challenges in the future.

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