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Research on the Construction of a Case Library to Enhance Mathematics Instructional Design Competence for Master of Education Students

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Abstract: This paper explores the necessity and methodology of constructing a case library to enhance the mathematics instructional design competency of Master of Education (M.Ed.) students. By analyzing current deficiencies in the cultivation of instructional design skills among M.Ed. students, the study identifies the core components of mathematics instructional design competency and elaborates on the principles for case library construction, content selection criteria, classification system, and evaluation mechanisms. The findings indicate that a high-quality mathematics teaching case library can effectively improve M. Ed. students' instructional design abilities, reflective thinking, and innovation skills. Additionally, the paper proposes specific implementation strategies and future development directions for the case library, offering valuable insights for mathematics teacher education.

1. Introduction

With the deepening reform of basic education, mathematics teachers face new challenges in professional development. As a crucial component of the future mathematics teaching workforce, the instructional design competency of M.Ed. students directly impacts the quality of mathematics education. However, current M.Ed. training programs suffer from a disconnect between theory and practice, a lack of high-quality teaching case resources, and inconsistent case quality, all of which hinder the development of instructional design skills.

Traditional teacher training models often emphasize theoretical knowledge while neglecting practical skills in real teaching scenarios. Although M.Ed. Students possess foundational subject knowledge, they struggle to translate theoretical knowledge into effective instructional design, leading to difficulties in handling complex classroom situations.

Case-based teaching is a vital component of graduate education reform [1]. To promote the reform of professional degree graduate education, China's Ministry of Education issued Guidelines on Strengthening Case-Based Teaching and Joint Training Base Construction for Professional Degree Graduate Students (2015), advocating for active case-based teaching, improved case library

construction, and shared case library mechanisms [2]. In August 2023, the National Steering Committee for Education Master's Degree Programs released the Revised Guiding Training Plan for Master of Education Programs, explicitly recommending case-based teaching and collaborative learning approaches. Therefore, constructing a systematic, high-quality mathematics instructional design case library has become an urgent task in mathematics teacher education. A well-designed case library can bridge the gap between theory and practice, foster professional growth, and enhance problem-solving abilities in real teaching contexts.

2. Core Components of Mathematics Instructional Design Competency

Teaching design is the presentation of mathematics teaching, good teaching design directly affects the mathematics classroom implementation effect. Mathematical teaching design is the process design of teachers projecting the mathematical knowledge points in the teaching material into the cognitive structure of students through the appropriate teaching method, so the Master of Mathematical Education needs to take into account the relationship between material analysis, emotional analysis and teaching method analysis when designing the teaching of specific knowledge points [4]. Therefore, as an important part of the professional literacy of mathematics teachers, the mathematics teaching design ability contains several interrelated core elements. First, the mathematics content knowledge is the foundation, teachers must have a deep understanding of the mathematical concepts, principles and methods taught, and grasp the intrinsic connection between the knowledge. Second, the teaching strategy knowledge is key, teachers need to master a variety of teaching methods and be able to choose the appropriate teaching strategy according to different teaching content and student characteristics. Together, they form a complete framework for mathematics teachers' teaching design capabilities, and are areas where case library construction needs to focus.

3. Principles for Constructing a High-Quality Case Library

Teaching design is the presentation of mathematics teaching, good teaching design directly affects the mathematics classroom implementation effect. Building a high-quality mathematics teaching case library requires following a number of scientific principles. First, the principle of authenticity, where cases should be derived from real teaching practices that reflect typical contexts and problems in the actual classroom. Real cases should provide a credible reference for the Master of Education to help them better understand the application of theory in practice. Second, the principle of authenticity, where cases should be representative and capable of reflecting common problems or successful experiences in mathematics teaching [5]. The case library should be a dynamically evolving system that can be continuously updated and refined as educational theory and practice develop. Finally, the principle of practicality, the case library should be designed to be easy for the educational master to retrieve and use, providing clear guidelines and supporting materials to ensure that the case can truly serve to enhance teaching design capabilities.

4. Case Library Content Structure and Classification System

4.1 Construction Logic of Multi-dimensional Classification Systems

The classification system construction of the mathematics teaching case library requires systematically balancing the dual dimensions of discipline knowledge logic and teaching practice needs. In the content architecture design, it is recommended to adopt a three-level progressive classification system:

The first-level classification (subject area layer) is divided into three core areas of algebra, geometry, statistics, and probability according to the standard of the mathematical curriculum. This top-level design maintains the knowledge of the mathematical discipline systematically, with a distinctive second-level classification under each area: the algebraic area can be divided into modules such as "numbers and formulas", "equations and functions", and "inequalities". The geometric area contains modules such as "plane geometry", "geometry", "analytical geometry", and "geometric transformation". The statistical and probability area is divided into modules such as "data collection and analysis", "probability calculation", and "statistical inference".

Secondary classification (knowledge module layer) focuses on the structured characteristics of knowledge. For example, the "equations and functions" module in the field of algebra can be further refined into three-level classification (teaching topic layer), including specific teaching topics such as "Strategy for Solving Uniform Secondary Equations", "Functional Image and Property Analysis", and "Modeling of Application Problems of Equations".

To strengthen the practice-oriented teaching, it is recommended to set up a multi-dimensional labeling system under each three-level classification. In addition to the conventional knowledge point labels, for example, in the field of geometry, it is possible to add a teaching ability label such as "Spatial Concept Cultivation" "Geometric Intuitive Development"" Deductive Reasoning Training" and "Mathematical Modeling Application". This composite classification method enables multi-path retrieval to help teachers accurately locate cases based on the dual needs of "Knowledge Content + Teaching Objectives", such as quickly finding "Realized Cases of Cultivation of Spatial Concepts in Stereo Geometry" or "Variable Training Cases of Proofs of Planar Geometry".

The classification system also reserves a dynamic expansion interface to support the addition of innovative teaching dimensions such as "interdisciplinary integration" and "project-based learning" according to the needs of teaching reform, ensuring that the case library can both meet the regular teaching needs and adapt to the development trend of teaching innovation.

4.2 Practice-oriented Design of Teaching Dimensions

In the field of education, scientific classification of teaching dimensions is crucial, it is a key factor in building an efficient teaching system and improving the quality of teaching. A reasonable method of classification of teaching dimensions can clearly demonstrate the systemic characteristics of the teaching process, providing strong support and guidance for teachers' teaching practice and teaching research. Based on this, it is recommended to adopt the "link-strategy" bi-axial classification method, this innovative classification method can analyze the teaching process from different angles in a comprehensive and detailed way.

From a vertical perspective, the teaching process can be precisely divided into five key stages according to the teaching link, each stage has its own unique teaching objectives and tasks, interrelated and progressive, together forming a complete teaching system.

Pre-class preparation: This is the starting point of the teaching process and the basis for the smooth conduct of subsequent teaching activities. During this stage, teachers need to carefully prepare lessons, study in-depth the curriculum and the content of teaching materials, and identify teaching goals and difficulties. Meanwhile, a thorough understanding of students' learning profiles—including their knowledge base, abilities, and interests—is crucial for designing targeted teaching plans. In addition, teachers need to prepare materials for teaching, such as teaching materials, teaching aids, multimedia materials, etc.

Context introduction phase: A good start is half of success, and the context introduction phase plays a crucial role in attracting students' attention and stimulating students' interest in learning. Teachers can quickly bring students into the learning state by creating vivid and interesting teaching

contexts, such as story introduction, question introduction, experiment introduction, etc. In this process, teachers must skillfully combine the teaching content with the reality of life, so that students feel the usefulness and fun of knowledge, thereby enhancing their learning motivation and initiative.

Knowledge construction phase: This is the core of teaching. The main task of teachers is to guide students to actively build knowledge systems. At this stage, teachers can adopt various teaching methods, such as teaching methods, discussion methods, inquiry methods, etc., to help students understand and master new knowledge. At the same time, teachers should focus on developing students' thinking and innovation abilities, guiding them to ask questions, analyze problems, and solve problems.

Application Migration Phase: The ultimate purpose of learning is to apply, and the application migration phase is an important part of testing whether students really master knowledge and are able to use it flexibly. Teachers can design various types of practice questions, case studies, project practices, etc. to allow students to apply the learned knowledge to real problems, improve their ability to apply knowledge and solve problems. At the same time, teachers can also guide students through the migration and expansion of knowledge, allowing them to move one-on-three, touch class bypass, develop students' innovative thinking and practical skills.

Evaluation Feedback Phase: Teaching evaluation is an integral part of the teaching process. It can provide timely feedback on students' learning situation and teachers' teaching results. In the evaluation feedback phase, teachers can use a variety of evaluation methods, such as exams, homework, classroom performance evaluation, student self-evaluation and mutual evaluation, etc., to comprehensively and objectively evaluate students' learning results.

From a horizontal perspective, teaching strategies can be divided into several types, each with unique advantages and specific applications. Teachers should flexibly select and apply these strategies based on instructional objectives, content, and students' actual needs.

Inquiry-based teaching: This teaching strategy emphasizes students' independent inquiry and discovery learning, encouraging students to acquire knowledge through independent thinking, experimental operations, and investigative research. For example, the "Mathematical Experimental Method" allows students to experience the formation of mathematical knowledge through practical operations and experiments, thereby deepening their understanding of mathematical concepts and principles.

Differentiated teaching: Each student is unique, and there are differences in their learning ability, learning speed, and interests. Differentiated teaching strategy is to pay attention to the individual differences of students, and to develop personalized teaching programs according to the different characteristics and needs of students. For example, "layered task design", teachers can divide teaching tasks into different levels, allowing students at different levels of learning to choose the appropriate task to study, so as to meet the learning needs of outstanding students, and allow students with weaker foundations to make progress within their capabilities, thus achieving common development of all students.

Technology Integrated Teaching: With the rapid development of information technology, the integration of technology into teaching has become an inevitable trend in the development of education. Technology Integrated Teaching Strategy is to make full use of modern information technology, such as multimedia teaching, online learning platforms, virtual reality technology, etc., to enrich teaching resources and teaching tools, improve the intuitiveness and fun of teaching. For example, "GeoGebra Dynamic Demonstration", teachers can use this software to present abstract mathematical knowledge in a dynamic form, so that students can understand mathematical concepts and principles more intuitively and improve the learning effect.

In the context of modern education informatization, the case library as an important teaching

resource, provides teachers with a wealth of teaching cases and reference materials. Through this classification method, users can query according to their own needs, while choosing a combination of different teaching links and teaching strategies, such as the combination query of "new teaching links + collaborative learning strategies". This way, teachers can quickly and accurately obtain case resources that fit a specific teaching context, providing useful lessons and references for their teaching practice, thereby constantly improving the teaching level and teaching quality.

4.3 Complete Presentation Framework for Case Elements

Each case in the case library should contain complete background information, teaching design, implementation process, student feedback and teacher reflection. Background information describes the teaching context and learning context analysis; teaching design presents a complete curriculum and resources; implementation process describes the actual classroom situation; student feedback provides evidence of learning effects; teacher reflection shows the thinking process of professional growth. This complete case structure can provide a comprehensive reference for the Master of Education. Specifically, each teaching case should contain five core dimensions:

Teaching Background Layer: This should include an analysis of the learning context (e.g., students' cognitive levels, common error types), a list of teaching resources (e.g., teaching tools, digital tools), and a description of the teaching environment (e.g., traditional classrooms or smart classrooms).

Design Program Layer: This should present complete teaching flowcharts, differentiated teaching strategies, and design documents such as formative assessment tools.

Implementation Record Layer: This should include procedural materials such as classroom video clips, excerpts of teacher-student interactions, and annotated textbook diagrams.

Evaluation Evidence Layer: This should provide both quantitative data (e.g., comparative test scores) and qualitative feedback (e.g., student learning logs, interview transcripts).

Reflection and Enhancement Layer: This should include the teacher's improvement plan, expert review suggestions, and future research directions for professional development.

5. Evaluation and Quality Assurance Mechanism of Case Library

Ensuring the quality of the case library requires the establishment of a systematic, standardized evaluation and guarantee mechanism, which is a dynamic process that requires multi-party participation and continuous optimization. Specifically, a complete case quality management system can be started from the following aspects:

First, the development of a scientifically sound case quality standard system is fundamental work. This standard system should adopt a multi-dimensional evaluation framework: in the content dimension, emphasize the authenticity, typicality and timeliness of the case material, to ensure that the case reflects the real teaching context; in the scientific dimension, require the case design to conform to the teaching laws of education and reflect advanced educational concepts; in the innovative dimension, encourage innovative breakthroughs in the teaching design, implementation methods or evaluation methods; in the practical dimension, assess the applicability and operability of the case in different teaching scenarios; and in the reflective dimension, require the case to include in-depth teaching analysis and suggestions for improvement.

Second, it is important to build a multi-stage and diversified review mechanism. It is recommended to implement a three-level review system: the junior review consists of 3-5 experts in the field of discipline, using a double-blind review method, focusing on the discipline accuracy, content integrity and teaching design rationality of the case; the intermediate review invites the front-line teachers with rich teaching experience to participate, through simulation teaching, group

discussions, etc., to assess the application of the case in the real classroom; the final review consists of educational experts, discipline experts and outstanding teacher representatives to form an evaluation committee, in the form of a reply review, to comprehensively examine the theoretical value, practical significance and innovation of the case. Each review stage must form a written review opinion and make specific modification recommendations.

It is also essential to establish a dynamic case update maintenance mechanism. It is necessary to establish a dedicated case quality monitoring team to conduct case use effectiveness assessment on a regular basis (e.g. every semester): collect use experience through teacher questionnaires, implement the effect through classroom observation records, and learn about learning results through student feedback.

Finally, it is recommended to establish an organizational guarantee system for case library quality management. Establish a Case Library Construction Steering Committee composed of school administrators, department heads, and teaching experts. Set up specialized working groups, including standards development teams, review expert panels, and operation maintenance teams. Develop institutional documents, such as "Case Library Construction and Management Guidelines," to clarify workflows and quality requirements for each stage. Enhance technical support by building an intelligent case management platform. This platform will enable digital management of the entire case lifecycle, including submission, review, application, and evaluation. Additionally, leverage big data analysis to assess case quality and provide insights for continuous improvement.

Through the quality assurance measures of the above system, we can build a complete closed loop covering standards development, review screening, use feedback, update maintenance, incentive promotion and other links, to ensure that the case library always maintains a high quality level, and truly becomes an important resource platform to support teachers' professional development and teaching reform.

6. Implementation Strategy and Application Effect of Case Library

The effective implementation of the case library requires accompanying strategic support. First of all, the training strategy is to provide specialized training for the Master of Education in case use methods, to help them master the basic methods of case analysis, such as context identification, problem analysis, program comparison, reflection enhancement, etc. Second, the integration strategy is to organically integrate the use of the case library into the various aspects of the Master of Education training, such as course teaching, micro-training, internship guidance, etc. Through enhanced analytical skills, one is now able to critically examine teaching practices through theoretical frameworks. This has significantly improved awareness of the necessity for professional development, leading to a commitment to continuous learning and improvement.

7. Conclusion

Mathematics Teaching Design Case Library has many important values for the Master of Education. Firstly, it provides rich practical references for the Master of Education to help him understand the core elements and innovative methods of mathematics teaching design through a selection of typical cases; secondly, the systematic construction of the case library (such as the "curriculum teaching, research, results transformation" integrated model proposed by Hefei Normal College) can significantly enhance the case analysis and application ability of the Master of Education to promote its transformation from theoretical learning to practice [3]; moreover, the dynamic update mechanism of the case library helps the Master of Education to master cutting-edge teaching concepts, such as how to integrate mindfulness education into the mathematics classroom or cultivate students' logical thinking through inquisitive teaching.

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