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Development and Implementation of a Four-Dimensional Dynamic Stratified Teaching Model in Vocational Undergraduate Mathematics Education

Shi Wang[*]

Hainan Vocational University of Science and Technology, Haikou, 571126, China
[*]*Corresponding Author*

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Abstract: In response to significant disparities in students' foundational knowledge, and insufficient alignment between mathematics courses and professional requirements in vocational undergraduate education, this study proposes a four-dimensional, dynamic, stratified teaching model centred on knowledge foundation, learning ability, learning styles and professional requirements. Based on these multidimensional learning profiles, student characteristics can be accurately identified in order to formulate stratified teaching objectives, differentiated instructional content, diverse teaching methods and a dynamic evaluation and adjustment mechanism. The model has been fully implemented in the Advanced Mathematics course. A quasi-experimental design was adopted to compare teaching effectiveness between an experimental group and a control group. The results suggest that the four-dimensional, dynamic, stratified model can effectively enhance students' mathematical performance and engagement in the classroom, strengthen the integration of mathematics teaching and professional learning, and promote students' personalized development. This study provides a practical, scalable approach to reforming mathematics teaching in vocational undergraduate education.

1. Introduction

Vocational undergraduate education is a vital component of the modern vocational education system, responsible for cultivating highly skilled technical talent. As industries continue to evolve, the development of talent has shifted from a focus on individual skills to a focus on comprehensive competencies, placing greater demands on the teaching of foundational subjects. Mathematics, as a core foundational subject, provides theoretical tools for professional learning and plays a crucial role in developing logical thinking and problem-solving abilities[1-5].

In practice, however, students on vocational undergraduate education come from diverse backgrounds and exhibit significant differences in their knowledge foundation, learning habits and learning abilities. A uniform teaching model with a fixed pace and requirements is insufficient to meet the requirements of all students; those with weaker foundations struggle to keep up, while those with stronger backgrounds lack opportunities for further advancement. This results in suboptimal overall teaching outcomes. Existing stratified teaching approaches often base classification solely on examination scores, failing to incorporate learning processes and multidimensional factors. Furthermore, mathematics courses are not sufficiently aligned with professional requirements, and their application orientation remains unclear[6-10].

To address these limitations, this study moves beyond traditional single-dimension, static stratification by integrating four key dimensions: knowledge foundation, learning ability, learning styles, and professional requirements, to construct a four-dimensional dynamic stratified teaching model. The study clarifies the model's conceptual framework, operational mechanisms, and implementation pathways, and validates its effectiveness through empirical research. It aims to resolve issues of insufficient differentiation and weak professional alignment in vocational undergraduate mathematics teaching, thereby providing both theoretical insights and a practical paradigm for the reform of foundational courses in vocational undergraduate education.

2. Construction of the Four-Dimensional Dynamic Stratified Model

2.1. Knowledge Foundation Dimension

The knowledge foundation dimension serves as the starting point and prerequisite for stratified teaching. It primarily assesses students' existing mathematical knowledge base, mastery of prerequisite courses, and the integrity of their knowledge structure, constituting an objective factor that determines their learning starting point. Students in vocational undergraduate education come from diverse backgrounds, and some exhibit weaknesses such as insufficient mathematical foundations, fragmented knowledge, and limited computational skills. Therefore, systematic diagnostic assessment is required to achieve precise stratification.

Specific evaluation methods include diagnostic placement tests upon entry, mathematics performance during senior secondary education, assessments of prerequisite courses, and targeted diagnostics of foundational knowledge. The assessment content focuses on key prerequisite topics for advanced mathematics, such as functions, limits, algebraic operations, and fundamental geometry, in order to comprehensively identify students' areas of weakness and strength.

This dimension is not static; rather, it is continuously updated as teaching progresses. It should be dynamically adjusted based on unit tests and periodic assessments to ensure that stratification outcomes remain aligned with students' current levels of knowledge.

2.2. Learning Ability Dimension

The learning ability dimension constitutes the core basis for stratified teaching. It focuses on assessing students' abilities in understanding, transferring, applying, and innovating with mathematical knowledge, reflecting their level of cognitive processing and developmental potential. This dimension differs from the knowledge foundation dimension, which emphasizes knowledge accumulation. In vocational undergraduate mathematics learning, learning ability is primarily manifested in students' capacity to comprehend abstract concepts, analyze problem structures, select and apply appropriate mathematical methods, and construct models to solve problems in specific contexts.

In terms of evaluation, process-oriented assessment should be emphasized. This can be implemented by designing learning tasks with varying levels of difficulty and observing and recording students' performance. For instance, for the same knowledge point, tasks may include basic computations, integrated applications, and contextualized problems, with comprehensive evaluation based on classroom interaction, group discussions, and the quality of assignments.

Moreover, this dimension is inherently developmental. During the teaching process, students' abilities should be enhanced through stratified task design and targeted guidance, and their levels should be dynamically adjusted based on their stage-specific performance to avoid rigid or fixed stratification.

2.3. Learning Style Dimension

The learning style dimension primarily reflects students' preferences in the processes of information reception and knowledge processing, which have a significant impact on learning effectiveness. In vocational undergraduate mathematics teaching, students often rely on different approaches to understand the same content; therefore, it is necessary to incorporate learning styles into the basis for stratification. Based on instructional practice, learning styles can be broadly categorized into visual, auditory, and kinesthetic types. Visual learners tend to understand knowledge more effectively through diagrams, charts, and other visual representations; auditory learners rely more on verbal explanations and communication; while kinesthetic learners prefer to acquire knowledge through hands-on activities and practical applications.

In terms of identification, a combination of learning style questionnaires and classroom observation can be employed. By analyzing students' patterns of attention in class, the forms in which they present assignments, and their tendencies in participating in learning activities, their learning styles can be preliminarily identified.

In stratified teaching, the purpose of introducing the learning style dimension is not to simply classify students, but to provide a basis for adjusting instructional approaches. By adopting diversified modes of content presentation, students with different learning styles can all obtain more suitable learning experiences, thereby enhancing overall learning effectiveness.

2.4. Professional Requirements Dimension

The professional requirementds dimension reflects the orientation of vocational undergraduate education and serves as a key feature that distinguishes the four-dimensional dynamic stratified model from traditional stratification approaches. Differences in knowledge structures and competency requirements across disciplines directly influence the teaching focus and application orientation of mathematics courses.

In practice, this dimension should be operationalized by analyzing talent cultivation programs, curriculum structures, and job competency requirements of different majors, thereby clarifying the supporting role of mathematics within each discipline. For instance, engineering-related majors emphasize computational and modeling abilities; economics and management majors focus more on data analysis and the application of functions; while information-related majors place greater importance on logical structures and algorithmic foundations.

In the design of teaching content, discipline-specific contexts can be incorporated to situate mathematical concepts, enabling students to understand their practical value while learning. Meanwhile, during the stratification process, learning tasks can be appropriately adjusted according to differences in professional requirements, ensuring that, on the basis of mastering fundamental knowledge, students from different majors are also exposed to content relevant to their individual academic and professional development.

3. Operational Mechanism of the Four-Dimensional Dynamic Stratified Teaching Model

To ensure the effective implementation of stratified teaching, a closed-loop operational mechanism of 'diagnosis - stratification - implementation - feedback - adjustment' is established, enabling dynamic management throughout the entire process. First, students' data on knowledge foundation and learning styles are collected through placement tests and questionnaires to complete the initial stratification. Second, dynamic adjustments are made during the teaching process based on learning performance and results from periodic assessments. Third, precise instruction is implemented through stratified objectives and differentiated tasks. Finally, the effectiveness of stratification is evaluated and optimized through multi-dimensional assessment results, thereby forming a continuous improvement loop.

Accurate diagnosis constitutes the foundational stage of stratified teaching, with its core lying in the comprehensive collection of multidimensional data reflecting students’ learning characteristics. Unlike traditional approaches that rely on a single performance indicator, this study collects information on knowledge foundation, learning ability, learning style, and professional requirements during the diagnostic phase.

Following the construction of student learning profiles, initial stratification is conducted. To avoid bias arising from single indicators, a multidimensional integration approach is adopted for comprehensive evaluation. Specifically, knowledge foundation and learning ability serve as the primary criteria for stratification, while learning style and professional requirements function as auxiliary reference factors. On this basis, students are classified into three levels: foundational level (Level C), application level (Level B), and extension level (Level A).

Once stratification is completed, instructional implementation should be aligned with the characteristics of students at different levels. While maintaining consistency in overall course objectives, targeted teaching is achieved through stratified objectives, differentiated content, and tiered task design. In classroom teaching, a combination of unified instruction and stratified tasks can be employed: unified instruction ensures the systematic delivery of core concepts and fundamental methods, while stratified tasks address the diverse learning needs of students. Additionally, instructional flexibility can be enhanced through group collaboration, tiered assignments, and individualized guidance. Teachers should adjust the pace of instruction and task difficulty in a timely manner based on student feedback to improve instructional alignment.

Evaluation and feedback serve as a crucial link between instructional implementation and dynamic adjustment. Within the four-dimensional dynamic stratified model, a diversified evaluation system should be established, emphasizing formative assessment while supplementing it with summative assessment. Formative assessment includes classroom participation, assignment quality, group task performance, and periodic quiz results, reflecting students’ continuous learning processes. Summative assessment, primarily through midterm and final examinations, evaluates students’ overall mastery of knowledge. Feedback methods include both quantitative data analysis and qualitative information collection, such as student questionnaires and interviews. By obtaining feedback through multiple channels, teaching effectiveness can be assessed from different perspectives.

Dynamic adjustment is a defining feature that distinguishes this model from traditional stratified teaching. To prevent rigid stratification, students’ levels should be periodically adjusted based on their learning progress. In practice, stage-based evaluations can be conducted every three to four weeks, and adjustments can be made according to changes in knowledge mastery, learning performance, and task completion. Students who demonstrate significant improvement may be promoted to higher levels and provided with more challenging tasks, while those experiencing learning difficulties may receive reduced task difficulty and enhanced guidance to support gradual progress. At the same time, a degree of stability should be maintained to avoid disruptions caused by frequent changes. Therefore, baseline conditions and adjustment thresholds should be established to ensure that stratification remains both flexible and relatively stable.

4. Implementation Pathways of the Four-Dimensional Dynamic Stratified Teaching Model

4.1. Design of Stratified Teaching Objectives

The implementation of stratified teaching is first reflected in the differentiated design of teaching objectives. While ensuring consistency in overall course objectives, a stratified objective system should be constructed according to the characteristics of students at different levels, enabling all students to develop based on their existing foundation. Specifically, teaching objectives can be divided into three levels: foundational (Level C), application (Level B), and extension (Level A). The foundational level emphasizes the understanding and mastery of basic concepts and methods; the application level focuses on the use of knowledge in standard problem-solving contexts; and the extension level targets the enhancement of comprehensive analytical and knowledge transfer abilities.

Taking the topic 'Applications of Derivatives' in Advanced Mathematics as an example, students at the foundational level are required to master basic derivative computation methods and understand the criteria for monotonicity and extrema of functions; students at the application level should be able to use derivatives to solve optimization problems and conduct simple contextual analysis; students at the extension level are expected to construct models and solve problems in more complex situations. In formulating objectives, descriptions should be as specific as possible to avoid ambiguity, allowing students to clearly understand learning requirements. Moreover, objectives across different levels should be progressive, providing pathways for students to advance to higher levels.

4.2. Organization of Stratified Teaching Content

In terms of content organization, differentiated design should be achieved within a unified curriculum framework to avoid fragmentation caused by stratification. A 'unified foundation-stratified extension-professional integration' structure can be adopted. The unified foundation component targets all students, focusing on core concepts and fundamental methods to ensure the integrity of the knowledge system. On this basis, differentiated learning content is designed according to students' levels: the foundational level emphasizes basic exercises and consolidation of fundamental methods; the application level incorporates training on typical problems; and the extension level introduces more comprehensive and complex tasks.

Instructional content can be organized through a 'same knowledge point, multiple task levels' approach. For instance, in teaching function extrema, problems of varying difficulty can be designed for students at different levels to choose from, thereby enabling differentiated learning within the same classroom. At the same time, attention should be paid to the coherence between content at different levels, ensuring transitional space that facilitates students' movement between levels.

4.3. Diversified Implementation of Teaching Methods

Considering differences in learning styles, a single lecture-based approach should be avoided in favor of a combination of multiple instructional methods to enhance adaptability. For students who prefer visual learning, graphical demonstrations and dynamic visualizations can help in understanding abstract concepts; for those who rely on auditory input, explanation, questioning, and discussion can strengthen comprehension; and for students inclined toward experiential learning, case analysis and task-driven approaches can promote the application of knowledge.

In terms of classroom organization, a cyclical structure of 'explanation - practice - discussion -

feedback' can be adopted. Teachers first explain key content, followed by stratified exercises, then facilitate problem-solving through group discussions or individualized guidance, and finally provide collective feedback. In addition, project-based learning tasks can be appropriately introduced to integrate multiple knowledge points into real-world problems, enabling students to gradually develop an understanding of knowledge structures through task completion.

4.4. Integration of Profession-Oriented Content

Professional integration is a key feature of vocational undergraduate mathematics teaching. During implementation, professional requirements should be embedded throughout teaching content and task design to enhance the practical value of the course. In the preparation stage, connections between mathematical knowledge and professional courses should be identified based on talent cultivation programs, clarifying key application directions. During instruction, discipline-related problem contexts can be introduced to help students understand the practical significance of mathematical knowledge.

In the design of assignments and exercises, profession-related elements should also be incorporated, enabling students to engage with problems relevant to their fields of study and thereby improving the relevance of learning. It should be noted, however, that professional integration must serve the objectives of mathematics teaching, and excessive inclusion of non-essential content should be avoided so as not to dilute instructional focus.

4.5. Stratified Evaluation and Dynamic Adjustment

Evaluation and adjustment are essential for the sustained operation of stratified teaching. An evaluation system aligned with stratified instruction should be established, covering both learning processes and learning outcomes. Formative assessment includes classroom participation, assignment quality, and learning attitudes, while summative assessment is primarily conducted through periodic tests and final examinations.

In terms of application, evaluation results should serve as a key basis for stratification adjustment. By analyzing students' stage-specific performance, their learning levels can be adjusted in a timely manner to reflect their most recent learning status. At the same time, feedback and improvement suggestions should be provided to students, enabling them to clearly understand their strengths and weaknesses and thereby fostering a continuous improvement-oriented learning process.

5. Empirical Study of Teaching

5.1. Research Subjects and Methods

Two parallel classes of first-year students from a vocational undergraduate institution were selected as the research subjects. The experimental group (50 students) adopted the four-dimensional dynamic stratified teaching model, while the control group (48 students) received traditional unified instruction. The teaching content was Advanced Mathematics, and the experiment lasted for one semester. The study employed a quasi-experimental design, along with statistical analysis and questionnaire surveys.

5.2. Results and Analysis

5.2.1. Comparison of Academic Performance

Pre-test and post-test scores of the two groups were statistically analyzed, as shown in Table 1.

Table 1 Comparison of Academic Performance

Group	Pre-test Mean	Post-test Mean	Improvement
Experimental Group	62.3	78.6	+16.3
Control Group	63.1	70.2	+7.1

As shown in Table 1, the pre-test scores of the two groups were comparable, indicating a similar baseline level. After one semester, the improvement in the experimental group was significantly greater than that in the control group. This result suggests that stratified teaching enhances instructional targeting to a certain extent, enabling students at different levels to achieve more effective progress based on their initial abilities. In particular, for students with weaker foundations, reducing task difficulty and increasing guidance help them gradually master basic content; for students with stronger foundations, providing more challenging tasks facilitates further development of their abilities.

5.2.2. Analysis of Learning Engagement

Regarding process-oriented learning data, assignment completion rates and classroom participation were analyzed for both groups. The results show that the assignment completion rate in the experimental group was approximately 92%, compared to about 78% in the control group. In terms of classroom questioning, group discussions, and voluntary help-seeking behaviors, the experimental group demonstrated significantly higher participation frequency than the control group.

These findings indicate that stratified teaching can effectively enhance student engagement. This improvement may be attributed to the better alignment between task difficulty and students' actual levels, allowing students to receive timely feedback during task completion and thereby increasing their motivation. In addition, the introduction of stratified tasks and group activities provides more opportunities for participation, helping to address the issue of insufficient engagement among some students in traditional classrooms.

5.2.3. Survey on Professional Relevance

A questionnaire survey was conducted among students in the experimental group. The results indicate that approximately 85% of students perceived a certain degree of alignment between course content and their respective majors, and were able to understand the application of mathematical knowledge within their disciplines. About 72% reported that they were able to apply mathematical methods to solve simple discipline-related problems during the learning process.

In terms of learning experience, most students believed that stratified teaching made learning tasks better aligned with their individual conditions, thereby facilitating their understanding of course content. However, some students reported difficulties in adapting to level adjustments, suggesting that further optimization of adjustment strategies is needed in the implementation process.

6. Conclusions

This study addresses key issues in vocational undergraduate mathematics teaching, including significant student heterogeneity, reliance on single-dimensional stratification, and weak alignment with professional requirements, by constructing and implementing a four-dimensional dynamic stratified teaching model. Empirical results demonstrate that this model can effectively accommodate individual differences among students, improve academic performance and learning engagement, strengthen the integration between mathematics and professional disciplines, and better meet the talent cultivation requirements of vocational undergraduate education.

In practice, the implementation of the four-dimensional dynamic stratified model places higher demands on teachers' instructional design capabilities, their ability to analyze learning conditions, and their competence in interdisciplinary integration. Future research may leverage information technologies such as artificial intelligence and big data to enable automated collection of learning data, intelligent generation of stratification results, and precise delivery of teaching resources. Such advancements could further optimize the stratified teaching process and promote the development of vocational undergraduate mathematics education toward greater intelligence, precision, and personalization, thereby providing stronger support for the cultivation of high-level technical and skilled talents.

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