Research on Vocational Undergraduate Higher Mathematics Teaching Based on Mind Maps

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Abstract. In recent years, vocational undergraduate institutions have experienced rapid enrollment expansion, leading to increasingly diverse student backgrounds and significant disparities in academic preparedness. Most students in these programs have relatively weak foundations in mathematics. Moreover, the abstract and highly logical nature of higher mathematics presents additional challenges for effective teaching in vocational undergraduate education. This study investigates the application of mind maps in higher mathematics instruction at vocational undergraduate colleges, aiming to stimulate students' interest in learning, enhance learning autonomy, and cultivate innovative and cooperative abilities. By analyzing existing problems in current higher mathematics teaching practices, this research implements an experimental teaching approach based on mind maps. Teaching plans integrating mind maps were designed and applied in classroom practice. The effectiveness of this approach was evaluated through comparative experiments between experimental and control classes, classroom observations, and student feedback surveys. The results indicate that mind map–based instruction significantly improves students' academic performance and mathematical thinking abilities compared with traditional teaching methods, with particularly notable benefits for students of average academic level. These findings provide practical insights and references for the reform and optimization of higher mathematics teaching in vocational undergraduate programs.

Keywords: Vocational undergraduate education; Mind maps; Higher mathematics.

1 Introduction

The biggest difference between vocational undergraduate programs and regular universities is that the main goal of vocational undergraduate colleges is to cultivate students' professional skills and practical abilities. It requires students to apply the theoretical knowledge they have learned to practice, providing a theoretical foundation for practical application. As a public fundamental discipline, the main training objective of advanced mathematics is to enable students to master necessary mathematical knowledge,

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cultivate their logical thinking and innovative abilities, and lay a theoretical and quality foundation for the subsequent study of professional courses. However, due to the weak mathematical foundation of students in vocational undergraduate colleges, coupled with the dull and uninteresting nature of higher mathematics content, most teachers use traditional teaching methods for lectures, and students can only passively accept them. Low interest in mathematics learning and high make-up exam rates have become common phenomena, which seriously hinder the cultivation of talents in vocational undergraduate colleges. Since 2016, an increasing number of scholars in China have begun to recognize and explore the instructional value of mind maps. While extensive research has been conducted on the application of mind maps in primary and secondary education, studies focusing on their use in vocational undergraduate education remain scarce. In response to the challenges identified in vocational undergraduate mathematics teaching, this study proposes the integration of mind mapping into higher mathematics instruction in vocational undergraduate programs. By using knowledge review as an entry point, this approach seeks to transform traditional teaching methods and leverage mathematics learning as a means to foster students' learning autonomy and innovative cooperative abilities, thereby enhancing their core competitiveness [1–4].

2 Problems in Higher Mathematics Teaching for Vocational Undergraduate Students

2.1 Poor Foundation, Not Very Interested in Learning Advanced Mathematics

In higher mathematics teaching, from definitions to theorems and formulas, emphasis is placed on the rigor of logical deduction, with little discussion on the process of discovering concepts or theorems, and little on the subject's ideas and practical background. At the same time, many students have a poor foundation in high school mathematics and believe that advanced mathematics is difficult, abstract, and difficult to learn. Therefore, they have no interest in learning advanced mathematics and develop a fear of difficulty. This lack of interest leads to a lack of research and effort in learning advanced mathematics, resulting in a cycle of giving up on advanced mathematics. Mind maps adapt to students' cognitive characteristics and reduce the difficulty of learning advanced mathematics. It has been found that most vocational undergraduate students have low interest in learning abstract theories, but strong hands-on and intuitive cognitive abilities. Mind maps can transform abstract mathematical concepts, theorems, and formulas into intuitive graphics, lines, and keywords, visualizing and organizing complex logical relationships. For example, when studying the topic of "limits", a mind map can be used to present the definition, properties, applications, and other aspects of limits in a hierarchical manner, allowing students to quickly grasp the knowledge framework and effectively reduce the difficulty of understanding abstract knowledge, which is in line with the cognitive habits of vocational undergraduate students.

2.2 Students' Learning Initiative Is Weak and Their Ability to Learn Independently Is Lacking

In the teaching practice of vocational undergraduate higher mathematics, students are generally in a passive state of receiving knowledge. In the classroom, they mainly listen to lectures and take notes, lacking active thinking and deep exploration awareness of knowledge, making it difficult to achieve substantive understanding and absorption of knowledge. At the same time, there are significant differences in the knowledge system, logical structure, and learning objectives between higher mathematics and high school mathematics, which puts higher demands on students' self-learning ability. However, most students still use the learning methods of mechanical memory and problem sea training in high school, which cannot adapt to the learning rules of higher mathematics, resulting in scattered knowledge mastery and weak ability to flexibly apply knowledge. The process of students drawing mind maps is essentially a cognitive process in which they actively organize knowledge, internalize and understand the connotation of knowledge. During the drawing process, students need to independently select core knowledge points, clarify the internal connections between knowledge, and design presentation forms based on their own cognitive characteristics. This process can effectively activate learning initiative, fully mobilize learning enthusiasm and creativity, and promote students to transform from passive knowledge receivers to active knowledge explorers, gradually cultivating their self-learning ability and logical thinking ability.

2.3 Unable to Connect with Professional Course Requirements and Enhance Knowledge Application Abilities

The core goal of vocational undergraduate higher mathematics teaching is to meet professional needs, serve practical applications, break down the barriers between mathematical knowledge and professional skills, and achieve a deep integration of "mathematical tools" and "professional scenarios". Mind maps can organically combine mathematical knowledge with professional scenarios, while sorting out mathematical knowledge, marking its application scenarios and examples in professional courses. Taking modern logistics management as an example, derivative knowledge can be closely integrated with logistics enterprise inventory optimization, transportation cost accounting and other scenarios through mind mapping, allowing students to clearly see the practical value of advanced mathematics and enhance their learning motivation. This teaching model can not only help students intuitively perceive the practical value of higher mathematics, solve the cognitive dilemma of "learning application disconnect", stimulate the intrinsic motivation of active learning, but also guide students to master interdisciplinary knowledge transfer methods, enhance their ability to use mathematical thinking to solve practical professional problems, and conform to the core positioning of vocational undergraduate education to cultivate applied talents.

3 Specific Application Strategies in Vocational Undergraduate Higher Mathematics Teaching

3.1 Teaching Principles

The training objective of higher mathematics is to enable students to acquire systematic and good learning methods, strategies, and thinking habits while mastering a solid and broad mathematical foundation theory and in-depth specialized knowledge. They should also possess excellent scientific literacy, rigorous academic attitude, and strong innovative spirit, and be able to actively accept new knowledge and explore new ideas. The value of knowledge lies not in itself, but in how it is applied. The fundamental purpose of mathematics classroom is to develop students' core literacy and cultivate their thinking ability. The traditional teaching mode of "teacher lectures, students listen" can no longer fully tap into students' classroom subjectivity, and it is difficult to guide students to achieve self-awareness, self-learning, and self satisfaction. Teachers should combine teaching content with students' existing knowledge patterns, carefully design teaching, create appropriate problem scenarios, guide students to discover and explore independently, and independently propose valuable "good questions" [5-7]. By adopting a problem-driven approach, students' intrinsic motivation for learning can be effectively stimulated, their learning autonomy enhanced, and their innovative abilities strengthened, thereby promoting the comprehensive development of their thinking skills. In teaching practice, the guiding role of teachers and the (subject) role of students should be fully integrated and mutually reinforced to ensure the effective advancement of teaching activities. Through this collaborative teaching model, both teachers and students can achieve mutual growth and continuous improvement throughout the instructional process.

3.2 Teaching Strategies

The application of mind maps in mathematics classrooms remains relatively limited, and many students are unfamiliar with this learning tool. Therefore, before formally integrating mind maps into classroom instruction, teachers should clearly demonstrate their unique advantages and practical value in mathematics teaching through diverse instructional approaches in order to stimulate students' learning interest. First, students can be briefly introduced to the concept of mind maps, their drawing procedures, and their application scenarios in educational contexts. Subsequently, students may be guided to use mind maps for chapter review. In the initial stage, teachers can provide a basic framework for the mind map, with students supplementing and refining the content. Gradually, instruction can shift to providing only a few core keywords, encouraging students to independently construct knowledge structures and develop a systematic understanding of the subject matter. By actively engaging in the process of drawing mind maps, students can directly experience the practicality and enjoyment of this learning tool [8–9]. Furthermore, during the explanation of example problems and the organization of problem-solving strategies, teachers can employ mind maps to visually

present the logical sequence of problem-solving steps, thereby enhancing students' interest in learning and fully activating their initiative and engagement in the learning process.

3.3 Basic Method

3.3.1 The Method of Using Mind Maps to Clarify Learning Tasks.

Learning tasks mainly include core elements such as learning content, learning objectives, and learning methods. When assigning learning tasks, teachers should systematically and targetedly design and assign them based on factors such as the key and difficult points of the textbook, students' cognitive patterns, and logical connections of knowledge, to ensure that students' learning activities are carried out in an orderly manner around the learning tasks. In mathematics classroom teaching based on mind maps, clear learning tasks can be achieved through the use of mind maps to clearly present the connections and differences between new and old knowledge in terms of learning content, learning objectives, and learning methods. In specific implementation, students can first independently set learning tasks, which can then be revised and improved by teachers to fully stimulate students' interest in learning and stimulate their learning enthusiasm and initiative. When studying the section on sequences, students have already learned about functions. Here is a mind map to guide students in understanding sequences using the idea of functions, in order to activate their thinking. This approach can not only help students build knowledge connections, activate logical thinking, achieve the integration of new and old knowledge, but also effectively improve classroom teaching efficiency and quality. Figure 1 is a mind map of advanced mathematical sequences.

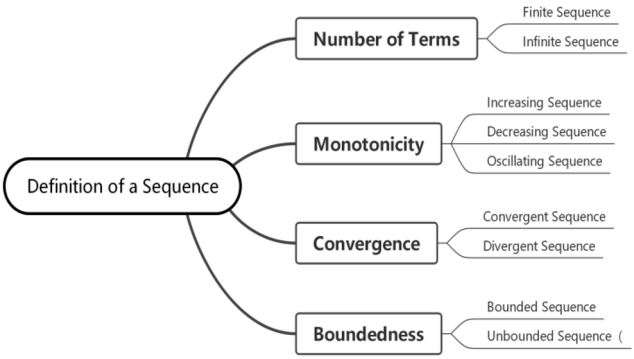

Fig. 1. Mind Map of Sequences in Advanced Mathematics

3.3.2 The Method of Constructing a Knowledge Framework Using Mind Maps.

The process of accumulating knowledge is a gradual process from point to line, to surface, and then to three-dimensional structure. As an efficient knowledge visualization tool, mind maps can vividly and intuitively display the thinking process of the

human brain, helping students remember, understand, and apply knowledge points, sort out and integrate the internal connections between knowledge, and form knowledge lines; By weaving knowledge threads into a knowledge network, a complete and stable knowledge structure is ultimately constructed, optimizing one's own cognitive system [10-12]. For example, during the "sequence" review class, the teacher can determine the core theme as "sequence" and require each student to independently extract keywords, draw mind maps, and construct their own knowledge system based on their own memory, understanding, and mastery of the knowledge point. Afterwards, the teacher helps students improve their mind maps and solidify their knowledge structure through explanations and comments. Figure 2 is a mind map of advanced mathematical limits.

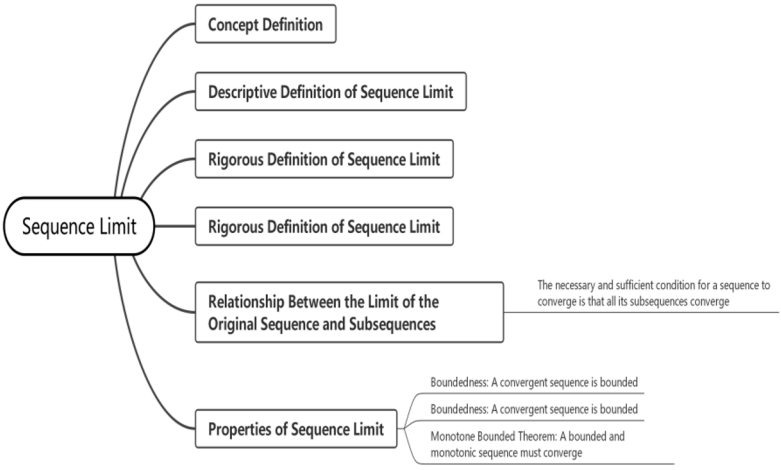

Fig. 2. Mind Map of Limit Concepts in Advanced Mathematics

3.3.3 The Method of Promoting Knowledge Application through Mind Mapping.

The core of the application of knowledge is the ability to flexibly apply learned knowledge and achieve extrapolation. In the process of learning new knowledge, using mind maps can keenly capture the correlation between new and old knowledge, and then transfer and apply existing knowledge to the understanding and mastery of new knowledge. Using mind maps during the problem-solving process can help accurately and quickly extract effective information from the problem, clarify the logical connections between known conditions and the problem to be solved, and efficiently mobilize the relevant knowledge and principles stored in the brain to organize and determine problem-solving strategies, ultimately enhancing problem-solving abilities. Drawing a mind map can enhance students' understanding of the inherent connections between knowledge, problems, and knowledge, help improve their knowledge system, enhance their ability to transfer knowledge, and ultimately achieve the learning goal of drawing analogies. The specific process of using mind maps to solve problems is shown in Figure 3.

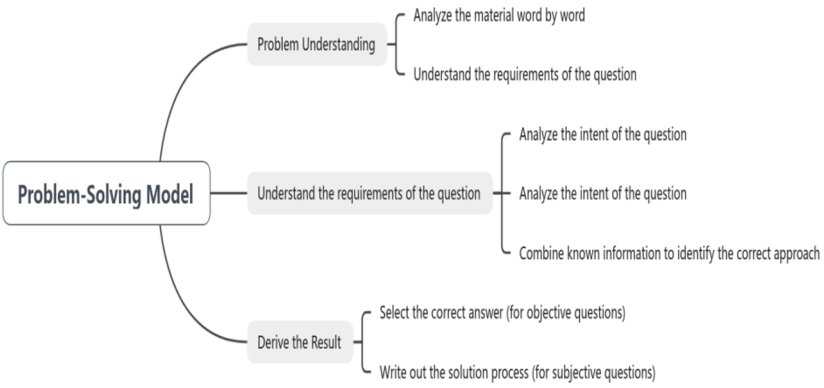

Fig. 3. Mind Map of the Problem-solving Model

4 Application Effect and Data Comparison

The purpose of this experimental study is to verify that introducing mind maps into vocational undergraduate higher mathematics classroom teaching can effectively promote students' memory and understanding of mathematical knowledge, strengthen their ability to apply knowledge points, and improve their problem-solving efficiency and quality. At the same time, validating mind maps as an efficient tool for organizing and summarizing knowledge points can help students build a complete knowledge system, deepen their deep understanding of knowledge points and textbook content, cultivate students' logical thinking ability, and ultimately achieve an improvement in students' mathematical learning performance. I am a higher mathematics teacher at a vocational university. This semester, I am responsible for teaching higher mathematics to two freshman classes, each with 50 students. Both classes are new to higher mathematics courses and the total semester hours are uniformly set at 48 hours. To explore the impact of different teaching modes on teaching effectiveness, this study adopts a controlled experimental design: Class A serves as the experimental class and adopts a mind map teaching mode. By constructing a systematic knowledge framework and sorting out the logical connections of knowledge points, it helps students understand and remember; Class B serves as the control group and follows the traditional teaching mode, with classroom lectures and example analysis as the main teaching methods. The experimental period is one semester, during which the teaching content, teaching staff, and assessment standards of the two classes are strictly ensured to be completely consistent, ensuring the singularity of the experimental variables. At the end of the semester, a unified formative assessment paper will be used for comprehensive evaluation, with a maximum score of 100 points. The specific score distribution is: 40 points for basic questions (focusing on core concepts and basic operations), 30 points for mid-range questions (focusing on knowledge transfer and method application), and 30 points for

comprehensive application questions (testing complex problem-solving and logical reasoning abilities). This assessment comprehensively tests students' mastery and practical application ability of advanced mathematics knowledge, providing empirical evidence for the optimization of teaching modes. The test data statistics are shown in Table 1 below.

Table 1. Comparison of Academic Performance Data

Classroom	Number of people	Average	Pass rate	Excellent rate
Experimental Class	49	77.2	88.6%	21.2%
Control class	48	65.5	75.8%	12.9%

The data shows that the overall performance of the experimental class is significantly better than that of the control class, with an average score 12.6 points higher. The pass rate and excellent rate have increased by 19.3 and 10.4 percentage points, respectively. This result confirms that mind maps can help students better grasp the intrinsic connections between knowledge and enhance their comprehensive application abilities. Applying mind maps to the teaching and review of advanced mathematics for first-year vocational undergraduate students presents two significant advantages compared to previous teaching models: firstly, students' enthusiasm for actively learning advanced mathematics is significantly improved. With the help of mind maps, students have developed a strong interest in learning advanced mathematics, and the number of people actively seeking advice from teachers has significantly increased. Their creative and divergent thinking has also been effectively stimulated. Secondly, students' higher mathematics grades have steadily improved. From the results of the formative assessment test, it can be seen that the student's performance in this assessment has made significant progress compared to the previous one. This is due to the fact that mind maps help students systematically sort out the basic knowledge of each chapter. During the sorting process, students' logical thinking and summarization abilities are also synchronously improved.

5 Conclusion

With their strong visual and structural features, mind maps are well aligned with the characteristics and instructional needs of higher mathematics teaching in vocational undergraduate programs. They play a significant role in reducing learning difficulty, constructing coherent knowledge systems, stimulating students' interest in learning, and enhancing practical application abilities. This study integrates the teaching principles, strategies, and methods of mind mapping and conducts a teaching experiment using two classes taught by the author, with one class designated as the experimental group and the other as the control group.

By comparing students' test scores before and after the experiment, several conclusions can be drawn. First, the use of mind maps effectively enhances students' memory and comprehension of mathematical knowledge. Through mind map–based instruction,

teachers can help students clearly understand the origin, development, and internal connections of mathematical concepts, enabling them to construct systematic knowledge frameworks and improve knowledge retention. Second, mind maps contribute to higher learning efficiency in mathematics. Their strong functions of summarization and integration allow students to grasp key knowledge points holistically, thereby significantly improving learning efficiency. Third, mind maps have a positive impact on students' academic performance in mathematics by increasing classroom participation, interaction, and sustained attention. Finally, mind maps promote the development of students' problem-solving abilities and mathematical thinking, enhance their overall competencies, and provide a solid theoretical and cognitive foundation for subsequent professional course learning.

It should be noted that the teaching practice in this study is limited to vocational undergraduate higher mathematics. Future research may extend the application of mind maps to other types of courses to further examine and validate their effectiveness and advantages in a broader educational context.

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