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Application of Mind Map-Based Fragmented Learning Model in Teaching "Principles of Concrete Structure Design"

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Abstract: Amid the digital transformation, fragmented learning has gradually become a mainstream learning method due to its flexibility. As a core course for civil engineering majors, "Principles of Concrete Structure Design" has a complex and abstract knowledge system, making it difficult for traditional teaching models to meet students' personalized learning needs. Focusing on this course, this paper explores the application of a fragmented learning model based on mind maps from multiple dimensions, including its value, principles, and implementation methods. This study aims to provide new ideas and methods for improving the effectiveness of teaching this course and helping students master the knowledge.

Keywords: Mind map; Fragmented learning; Principles of concrete structure design; Course instruction

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1. Introduction

"Principles of Concrete Structure Design" is a core course for civil engineering majors, playing a crucial role in laying a solid foundation for subsequent professional courses and engineering practice. The course covers various topics such as the material properties of concrete and steel, performance analysis of structural members under different stress states (e.g., bending, compression, tension, shear), and bearing capacity calculation. It is characterized by numerous concepts, strong logical connections, and abstract and challenging content. Most traditional classroom teaching adopts a traditional lecture format where teachers impart knowledge and students passively receive it. Due to the fragmented approach to presenting knowledge, students often struggle to develop a comprehensive understanding on their own, resulting in unsatisfactory learning outcomes [1]. With the widespread adoption of mobile internet, fragmented learning has gradually gained favor among learners due to its flexibility and convenience. As a visual thinking tool, mind maps can integrate disparate pieces of information into a coherent knowledge framework. Integrating mind maps into the fragmented learning approach for Principles of Concrete Structure Design is expected to overcome the challenges of traditional teaching and create new opportunities for curriculum reform.

2. Application of a mind map-based fragmented learning model in teaching "Principles of Concrete Structure Design"

2.1. Aligns with course knowledge characteristics and facilitates knowledge system construction

The knowledge system of "Principles of Concrete Structure Design" is characterized by a rigorous internal logic. The knowledge system progresses from the material level (properties of concrete and steel) to the member level (mechanical properties of components) and finally to practical engineering applications (design methods), with all parts being closely interconnected. For example, the calculation of a member's normal section flexural capacity not only requires an understanding of material properties such as the stress-strain relationship of concrete and steel, but also is based on basic assumptions (e.g., the plane section assumption) as prerequisites, while integrating the calculation principles of specific member cross-sectional forms such as singly reinforced rectangular sections. In a fragmented learning approach, students can use scattered time to learn individual knowledge points one by one. As a visual tool, mind maps can systematically integrate these fragmented knowledge points—such as material properties, basic assumptions, and component mechanical properties—through nodes and branches, clearly presenting the logical relationships between knowledge points. For instance, with "Flexural Performance of the Normal Section of Flexural Members" as the core, a mind map can extend branches including "Basic Assumptions," "Stress-Strain Relationship of Concrete and Steel," "Calculation Principles of Flexural Capacity of Singly Reinforced Rectangular Sections," and "Relative Height of the Boundary Compression Zone," with causal, progressive, and other connections reflected through lines and annotations between branches. By means of such mind maps, students can grasp the overall knowledge framework of the course, gradually construct a complete knowledge system of "Principles of Concrete Structure Design," and avoid a limited understanding caused by fragmented knowledge [2].

2.2. Adapts to students' personalized learning needs

There are significant differences in students' learning foundations, learning abilities, and learning rhythms. Some students can quickly grasp concepts related to the material properties of concrete but struggle to master the calculation of the shear capacity of members; others prefer to first study component design and application, and then revisit material and theoretical knowledge. The fragmented learning approach using mind maps gives students considerable autonomy, allowing them to choose learning content and sequences based on their individual needs. With the help of mind maps, students can quickly identify areas of weakness or topics of interest and engage in focused, bite-sized learning activities [3]. For example, students struggling with "Flexural Performance of the Normal Section of Flexural Members" can focus on the corresponding branches of the mind map, using spare moments between classes or during lunch breaks to delve into specific topics such as "Boundary Failure" and "Under-reinforced Failure." This approach accommodates their individual learning preferences and makes the learning process more efficient and focused.

2.3. Enhances students' independent learning and thinking abilities

In the traditional teaching model, students often rely on teachers' explanations to acquire knowledge, making it difficult to fully exercise their independent learning abilities. In contrast, the mind map-based fragmented learning model requires students to actively collect and organize relevant knowledge about "Principles of Concrete Structure Design" and integrate it into mind maps. In this process, students need to analyze, infer, and summarize knowledge, and reflect on the connections and differences between key concepts. For example, students compare the impact of parameter changes under different concrete strength grades on member bearing capacity, and analyze the similarities and differences in the mechanical failure characteristics of different components (e.g., flexural, compressive, and shear members). This process not only enhances students' independent learning abilities, transforming them from passive knowledge recipients to active knowledge constructors, but also cultivates their logical thinking, analytical skills, and synthesis abilities. It enables students to develop independent thinking during the learning process and deeply understand the fundamental principles and broader applications of course knowledge [4].

3. Principles of applying the mind map-based fragmented learning model in teaching "Principles of Concrete Structure Design"

3.1. Systematic principle

The content of the "Principles of Concrete Structure Design" course is highly systematic. From materials to components, and from theory to application, all elements are closely interconnected, forming a comprehensive knowledge framework. When implementing a mind map approach to fragmented learning, it is essential to maintain a systematic structure. The creation of mind maps should fully cover the main topics of the course: for example, the module on material properties includes the physical and mechanical properties of concrete and steel; the module on basic assumptions involves the plane section assumption, the assumption of neglecting concrete's tensile strength, etc.; the module on component behavior and design methods covers the mechanical analysis and design of various components such as members subject to bending, compression, tension, and shear. Additionally, the logical relationships between different concepts must be accurately represented to ensure a comprehensive understanding of the subject matter. For instance, when creating a mind map on the calculation of member bearing capacity, the connections between material properties, basic assumptions, and bearing capacity calculation principles should be clearly demonstrated. This allows students to grasp the broader context through the mind map, enabling fragmented learning to occur within a systematic framework while preventing fragmented or isolated understanding [5].

3.2. Simplicity and intuitiveness principle

A prominent feature of fragmented learning lies in its short duration and concise content; therefore, the design of mind maps must adhere to the principle of simplicity and intuitiveness. When presenting the knowledge of "Principles of Concrete Structure Design," it should be concise and clear, highlighting key points while avoiding excessive, cumbersome textual descriptions. Concise graphics, symbols, keywords, and other means can be used to intuitively display knowledge points. For example, different colors can be employed to distinguish between different knowledge modules, such as material properties and component mechanical performance; arrows can indicate causal, progressive, and other relationships between knowledge points; and simple schematic diagrams can illustrate component cross-sectional forms and failure modes. When demonstrating the normal section failure modes of flexural members, for instance, simple lines can sketch the cross-sectional stress distribution and crack development of under-reinforced failure, over-reinforced failure, and under-reinforced failure, enabling students to quickly understand and memorize knowledge points, improve the efficiency of fragmented learning, and acquire key information in a short period of time [6].

4. Applications of the mind map-based fragmented learning model in teaching "Principles of Concrete Structure Design"

4.1. Mind maps assisting course preview

During the course preview stage, teachers can provide students with a mind map framework for relevant chapters of "Principles of Concrete Structure Design." This framework should include the key concepts of the chapter and their logical relationships. Taking the chapter "Flexural Performance of the Normal Section of Flexural Members" as an example, the mind map framework can include main branches such as "Basic Assumptions," "Stress-Strain Relationship of Concrete and Steel," "Calculation Principles of Flexural Capacity of Singly Reinforced Rectangular Sections," and "Relative Boundary Compression Zone Height." During the preview, students can use spare moments to enhance the mind map based on this framework through textbooks and online resources.

In this process, students need to actively organize information, reflect on the meaning of each concept, and its connections with other concepts. For example, when learning "Basic Assumptions," students should understand that the plane section assumption means that the section remains plane after the member undergoes flexural deformation; the assumption of neglecting concrete's tensile strength is based on the fact that after the concrete in the tensile zone of the flexural member cracks, the tensile force is primarily carried by the steel reinforcement. Moreover, they need to comprehend the simplifying effect of these assumptions on the subsequent calculation of the member's load-bearing capacity—rationally simplifying complex actual stress conditions to facilitate the establishment of calculation models.

Through this preview process, students develop a general understanding of the upcoming content, enter the classroom with questions, can listen more effectively, follow the teacher's line of reasoning, and promptly identify key points and challenges, thus enhancing their learning efficiency in class.

4.2. Mind maps facilitating classroom learning and note-taking

Classroom teaching is the primary channel for students to acquire knowledge, but class time is limited, and knowledge density is high. The mind map-based fragmented learning model can effectively facilitate classroom learning and note-taking [7]. When delivering lectures, teachers can integrate mind maps to intuitively present abstract knowledge from "Principles of Concrete Structure Design," such as stress distribution and failure processes of members under bending or compression. During the lecture, students can simultaneously record key content and supplement details on their own mind maps. Thanks to the clear structure of mind maps, students do not need to take extensive notes; instead, they only need to capture keywords and core graphics. For example, when explaining the three stages of under-reinforced failure in flexural members, the teacher can use a mind map to demonstrate the stress changes and member deformation during the elastic stage, the cracked working stage, and the failure stage. Students only need to label keywords and simple graphics under the corresponding branches of the mind map, such as "Elastic stage: entire section active, linear stress distribution," "Cracked working stage: concrete cracking in tensile zone, increased steel stress," and "Failure stage: steel yielding, concrete crushing in compressive zone." This allows students to keep up with the teacher's pace while quickly organizing classroom notes. After class, students can use fragmented time—such as short periods before evening study sessions—to refine and reflect on their mind map notes, review classroom knowledge, and mark unclear parts to prepare for in-depth learning later, thereby deepening their understanding and memory of the knowledge in "Principles of Concrete Structure Design" [8].

4.3. Mind maps supporting post-class review and knowledge consolidation

Post-class review is a key component for strengthening knowledge retention and deepening understanding. The mind map-based fragmented learning model can effectively support post-class review and knowledge consolidation. Based on the mind maps compiled in class, students can review the course material in a fragmented manner in “Principles of Concrete Structure Design.” For instance, during spare moments such as breaks between classes or commutes to and from school, they can take out their mind maps and quickly review a specific branch of knowledge—such as “General Construction of Beams and Slabs”—to recall requirements for longitudinal reinforcement arrangement in beams, the functions and key configuration points of stirrups, and the roles of main reinforcement and distribution reinforcement in slabs. Concepts that are not well remembered or are difficult to understand can be marked for in-depth learning during dedicated time, such as extended periods of time on weekends. Meanwhile, students can try to draw their own mind maps to integrate knowledge from different perspectives. For example, with “Mechanical Failure Characteristics of Members” as the core, they can integrate knowledge about the failure modes, causes, and mechanical behaviors of flexural, compressive, shear, and other members. The process of reconstructing mind maps further consolidates their understanding of the course material, helping them form a more systematic and in-depth understanding [9].

4.4. Mind maps promoting knowledge application and expansion

“Principles of Concrete Structure Design” is a highly practical course, making the application and expansion of knowledge crucial. Mind maps can help students apply and expand their knowledge. After learning a specific topic, students can use mind maps to organize their thoughts for applying knowledge. For example, after studying “Calculation of Flexural Capacity of Singly Reinforced Rectangular Sections,” they can use a mind map to review the basic assumptions, material parameters, and calculation principles required for the calculation, then attempt to solve practical problems such as member design or bearing capacity verification. During this process, if problems arise—such as calculation results not meeting requirements or doubts about a certain calculation step—students can quickly use the mind map to find relevant knowledge and analyze the root cause: whether it is an error in material parameter selection or a misunderstanding of the calculation principle, allowing them to adjust their thinking and solve the problem promptly [10]. In addition, students can use mind maps to expand their learning to include related engineering cases and cutting-edge technologies. For example, they can research the application of different concrete structures in practical projects and understand the impact of new concrete materials on structural design, thereby broadening their knowledge base, improving their ability to apply knowledge and think innovatively, and accumulating more experience and ideas for future engineering practice.

5. Conclusion

The mind map-based fragmented learning model is highly consistent with the knowledge characteristics of “Principles of Concrete Structure Design” and students’ learning needs, and has undeniable application value. In the actual application process, by following the principles of systematicity, simplicity, and intuitiveness, and through paths such as assisting preview, facilitating classroom learning and note-taking, supporting post-class review and knowledge consolidation, and promoting knowledge application and expansion, the learning outcomes of the “Principles of Concrete Structure Design” course can be effectively improved. This model not only helps students better construct a knowledge framework but also significantly enhances their self-directed learning skills and critical thinking skills, laying a solid foundation for their subsequent professional course learning and engineering practice.

Although the mind map-based fragmented learning model has achieved positive results in the teaching of "Principles of Concrete Structure Design," it still faces several challenges in the implementation process. The primary issue is that creating mind maps requires teachers to invest a great deal of time, especially in the initial application stage. Secondly, some students lack sufficient self-directed learning skills and struggle to fully utilize mind maps to assist their learning. Furthermore, for theoretical content that requires in-depth understanding, mind maps alone may not fully replace traditional systematic lectures. Therefore, in teaching practice, strategies should be flexibly adjusted according to specific circumstances, and mind maps should be effectively integrated with other teaching methods to learn from each other's strengths and achieve the best learning outcomes.

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References

[1] Lin J, 2024, Research on Using Mind Maps to Promote the Construction of Students' Cognitive Structures in High School Geography Teaching. College Entrance Examination, (23): 87–90.

[2] Mao AL, 2024, Research on Improving Teaching Quality of Performance Management Course Based on Mind Map-style Blackboard Writing. Quality and Market, (07): 189–191.

[3] Zhai L, Wang JP, Wang PP, 2023, Influence of Mind Map-based Chain Quality Control Management on Drug Management Quality and Work Efficiency of Hospital Pharmacies. Tianjin Pharmacy, 37(07): 883–887.

[4] Wei HL, 2023, Optimizing Biology Teaching Effect with Mind Maps from a Structural Perspective. Parents, (19): 118–120.

[5] Li MT, 2024, Practical Research on Cultivating Junior High School Geography Comprehensive Thinking Literacy Based on Mind Maps. Taste · Classic, (10): 154–156 + 172.

[6] Wang N, Yang XM, Zhao HY, et al., 2023, Application of Mind Map Combined with PBL and CBL Teaching Methods in Emergency Nursing Teaching. China Continuing Medical Education, 17(09): 92–96.

[7] Chen LJ, 2024, Research on Teaching of Construction Project Management Course by Combining Flipped Classroom and Mind Maps. Sichuan Architecture, 44(02): 284–286.

[8] Wu GL, Long XB, Dai X, 2022, Optimizing Architectural Construction Drawing Teaching Design with Mind Maps. Journal of Kunming Metallurgy College, 38(02): 69–71 + 75.

[9] Yao WF, 2020, Research on Strategies for Constructing Efficient Classrooms of Building Materials Based on Mind Maps. Scientific Consult (Science & Technology · Management), (27): 120–121.

[10] Wang YL, Zhang M, Huang LL, 2020, Teaching Reform and Practice of "Building Construction" Course in Application-oriented Undergraduate Universities. Heilongjiang Education (Theory & Practice), (02): 78–79.