Research on Personalized and Adaptive Learning Strategies in Engineering Course Design: a Case Study of BIM and Building Construction

Bin Wu[a], Chun Liu[b*], Jili Pu[c]

YunNan Economics Trade and Foreign Affairs College, Kunming, 651705, China

[a]Binwu8723@163.com, [b*]492353412@qq.com, [c]857770700@qq.com

Abstract. In vocational and technical education, this study examines how personalized and adaptive learning strategies can enhance student interest and teaching quality in engineering courses, particularly for students with poor academic performance. Examples include courses on "Basic Techniques for BIM Application and Building Information Modeling" and "Building Construction Principles." Through an analysis of teaching practices at Yunnan Economy and Trade Foreign Affairs Vocational College, this study proposes innovative methods such as integrating certificates with courses, integrating theory with practice, and using parametric modeling software to enhance course interactivity and student engagement, promoting personalized learning among low-performing students.

Keywords: Personalized Learning; Adaptive Learning; BIM Technology; Building Construction; Vocational Education

1 Introduction

Research Background

With the rapid development of higher education in China, vocational and technical education has emerged as a critical pathway for cultivating applied talents. In engineering disciplines, such as building engineering technology, students need a strong theoretical foundation and practical skills to meet industry demands. Building Information Modeling (BIM) has become essential in the architecture, engineering, and construction (AEC) industry, necessitating its inclusion in higher education curricula. This integration aims to prepare students for modern AEC practices, with the challenge of effectively teaching BIM concepts and skills, especially to students with poor academic performance. To address this, various teaching strategies have been explored, including Problem-Based Learning (PBL), Project-Based Learning, and Adaptive Learning, Figure 1. However, vo.ational and technical education faces challenges such as diverse student quality, limited resources, and traditional models that fail to meet personalized learning needs.

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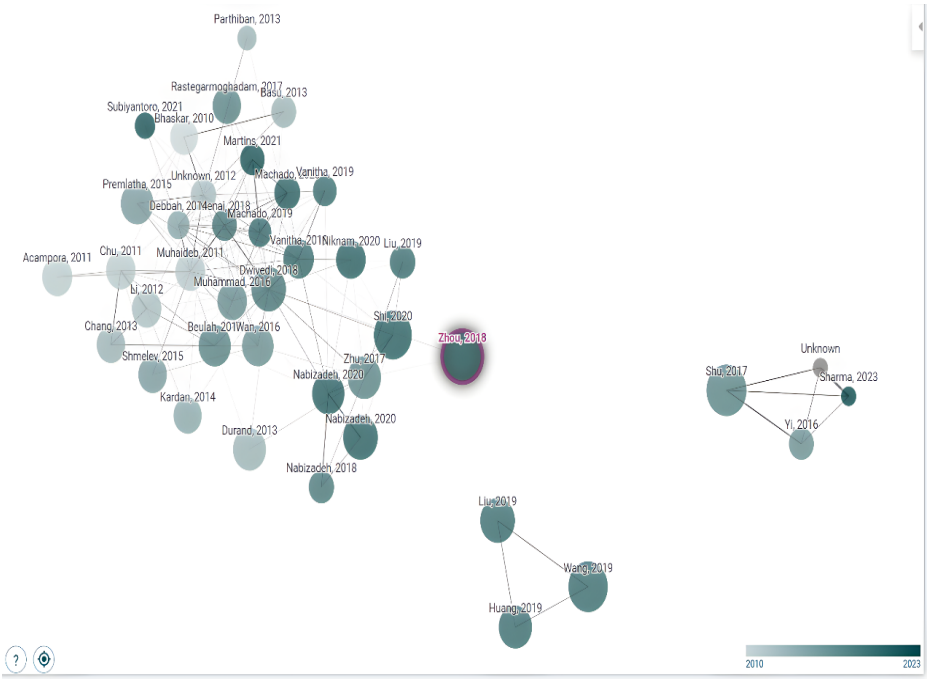

Fig. 1. Atlas of related research in recent years

In response, personalized and adaptive learning strategies have gained attention. Personalized learning tailors teaching content and methods to individual student characteristics, while adaptive learning uses technology to adjust learning paths and difficulty levels in real time. Combining these strategies offers new solutions for vocational and technical education.

2 Identifying Problems

Traditional teaching models in vocational and technical education, particularly in engineering courses like "Basic Techniques for BIM Application and Building Information Modeling" and "Building Construction Principles," have several issues affecting learning outcomes and teaching quality:Teacher-Centered Approach: Lecture-based methods lack interaction and fail to engage students actively.Theory-Practice Disconnect: Students struggle to apply theoretical knowledge to practical situations.Limited Resources: Classroom resources often cannot meet the personalized learning needs of all students.Low Interest and Participation: Some students lack interest in their subjects, reducing motivation and engagement.Lack of Interaction: Traditional lectures offer few opportunities for students to ask questions or participate.Insufficient Feedback: Students receive little timely feedback, making it hard to identify and correct issues.

3 The Practice and Effect Evaluation of Personalized Teaching Organization Among Students with low Academic Conditions and Higher Vocational Education

3.1 Design of Individualized Teaching Programs

Problem-based Learning (PBL) has been identified as an effective strategy to enhance students' understanding of BIM [1]. This is particularly important in higher vocational education, where designing personalized teaching schemes for students with lower academic performance is crucial. The core of personalized teaching lies in formulating differentiated teaching objectives and pathways based on students' learning foundation, learning styles, and interests, to meet the diverse learning needs of different students. The following are key points for designing personalized teaching schemes:

Analysis Based on Students' Academic Performance. Evaluate students' learning foundation and ability levels through multiple dimensions such as entrance tests, classroom performance, and homework completion to identify specific difficulties faced by students with lower academic performance. Additionally, use surveys and classroom observations to understand students' learning styles (e.g., visual, auditory, kinesthetic) to adopt suitable teaching methods. Adaptive learning strategies are increasingly being integrated into engineering education to create personalizedlearning experiences. These strategies utilize technology to tailor educational content to individual student needsthereby enhancing engagement and learning outcomes. For instance, an adaptive learning module implemented ira sophomore-level engineering technoloay course demonstrated that 81% of students achieved mastery across almodules, highlighting the effectiveness of personalized learning pathways[2].

Formulating Personalized Learning Pathways and Objectives. Based on students' learning foundation, divide teaching objectives into different levels, allowing students to improve step by step from different starting points. For example, for students with weaker foundations, the goals can be to master basic concepts and operational skills; for students with stronger foundations, the goals can be to deeply understand and apply complex models. Adaptive learning strategies have been implemented to tailor educational experiences to individual students' needs. This method includes adjusting teaching materials and grading standards based on students' performance and feedback to promote learning outcomes. Personalized learning environments have also been used to teach BIM, enabling students to quickly and effectively learn multiple applications, which is crucial for completing complex projects [3][4].

3.2 Implementation Process

The implementation process of personalized teaching requires collaboration among teachers, students, and technological means to ensure the effective implementation of the teaching scheme.

Small Class Teaching and Tiered Tutoring. Divide students into groups for teaching, with each group having similar foundations and abilities, to facilitate targeted tutoring

based on group needs. Small class teaching improves classroom interactivity and student participation.

Tiered Tutoring. Provide different levels of tutoring based on students' learning progress. For students with weaker foundations, teachers can provide additional tutoring time to help them understand difficult points; for students with stronger foundations, higher-level challenging tasks can be provided.

Utilizing Information Technology for Personalized Learning Support. Through online learning platforms (such as smart classrooms, MOOCs, etc.), students can independently choose learning content and resources based on their own learning progress and needs. The platform records students' learning trajectories, helping teachers understand students' learning situations.

3.3 Effectiveness Evaluation

Evaluating the effectiveness of personalized teaching is a critical component of instructional improvement. Through scientific evaluation methods, the actual effectiveness of personalized teaching can be objectively understood, providing a basis for subsequent instructional optimization.

End-of-Term Exams, Regular Assignments, and Project Outcomes. Analyze the impact of personalized teaching on students' learning outcomes using data from multiple aspects. Statistical methods can be used to compare grade changes before and after personalized teaching to assess its effectiveness.

Interviews and Questionnaire Surveys. Understand students' perceptions and evaluations of personalized teaching. Qualitative analysis can reveal changes in students' psychological states, improvements in learning motivation, and their mastery of course content.

4 Exploration of an Integrated Teaching Model for BIM and Building Construction Based on Synergy between Courses and Certifications

4.1 Background and Significance of Synergy between Courses and Certifications

Synergy between courses and certifications is an educational model that combines course teaching with vocational skill certification training. This model aims to enhance students' theoretical knowledge and practical skills through integrated teaching, thereby improving their professional competitiveness. In higher vocational BIM (Building Information Modeling) and building construction courses, the application of the synergy between courses and certifications model is highly significant.

Meeting Industry Needs. Increasing Skill Requirements: As the construction industry continues to develop, the demands for specialized talent are also increasing. Not only solid theoretical knowledge but also practical operational skills and project management abilities are required. Importance of Certificates: Vocational skill certificates

are critical standards for measuring professional skills. Graduates holding these certificates are more likely to secure employment opportunities and are more competitive in the workplace.

Improving Teaching Effectiveness. Combining Theory and Practice: By integrating course teaching with vocational skill certification training, the integration of theory and practice can be better achieved, improving students' learning outcomes and application abilities. Comprehensive Ability Development: The synergy between courses and certifications model can develop students' comprehensive abilities, including technical skills, project management, and teamwork.

4.2 Design of the Synergy between Courses and Certifications Teaching Model

To achieve synergy between courses and certifications, a comprehensive plan is needed in course design, teaching implementation, and evaluation methods.

Alignment of Course Content with Certification Standards. Course Content Design: Align the content of BIM and building construction courses with the standards of relevant vocational skill certifications to ensure that the teaching content covers all the knowledge points and skill requirements of the certification exams. Modular Teaching: Divide the course content into several modules, each corresponding to one or more vocational skill certification assessment contents, making it easier for students to learn and prepare for exams with clear goals.

Integration of Teaching Methods and Resources. Project-Based Teaching: Adopt a project-based teaching method, integrating real projects into course teaching, and cultivating students' practical operational and problem-solving abilities through project practice. Blended Learning: Combine online resources and offline teaching, using online platforms to provide rich learning resources and interactive tools, while conducting practical operations and project guidance through offline teaching. Blended learning, which combines online and face-to-face instruction, is another strategy used to personalizeengineering education. This approach leverages the strengths of both modalities to foster creative thinking andproblem-solving skills among engineering students. [5]

5 Conclusion

The rapid development of the construction industry has led to an increased demand for highly qualified and skilled professionals. Higher vocational colleges play a crucial role in cultivating applied technical talents and supplying high-quality professionals to the construction sector. Therefore, exploring and innovating teaching models to improve educational quality is of significant practical importance. This study focuses on Higher Vocational BIM (Building Information Modeling) and Architectural Construction courses, specifically examining adaptive learning environments, the integration of courses and certificates, and the application of parametric modeling software. The aim

is to enhance students' theoretical and practical skills and improve their professional competitiveness.

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