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Research on the Integration Pathway of Artificial Intelligence and Mathematics Teaching in Vocational Undergraduate Education

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Abstract: Artificial intelligence is profoundly reshaping educational structures and teaching models. As a foundational course in vocational undergraduate talent development systems, the quality of mathematics instruction directly impacts students' professional learning capabilities and career development potential. However, constrained by factors such as significant disparities in students' mathematical foundations, the high abstract nature of course content, and relatively monotonous teaching methods, mathematics instruction in vocational undergraduate programs often suffers from suboptimal teaching outcomes. Integrating artificial intelligence technology into vocational undergraduate mathematics instruction can drive a shift from experience-driven to data-driven teaching models, enabling precision, personalization, and intelligence in the teaching process. This study analyses the practical significance of AI-empowered mathematics teaching in vocational undergraduate education, identifies key challenges in current pedagogy, and explores integration pathway across four dimensions—teaching objectives, content, process, and assessment—to provide theoretical references and practical insights for reforming mathematics instruction in vocational undergraduate programs.

1. Introduction

With the rapid evolution of information technologies such as artificial intelligence, big data, and cloud computing, the education sector is accelerating its transition from traditional informatization toward a new intelligent phase characterized by data-driven approaches and intelligent decision-making. Policy documents including the “Education Informatization 2.0 Action Plan” and the “Overall Plan for Building a Digital China” explicitly advocate for the integration and innovation of information technology with teaching and learning, providing clear directional guidance for curriculum reform in higher education [1-3]. Against this backdrop, the application and implementation of artificial intelligence technology in higher education course instruction have become a significant topic in interdisciplinary research between pedagogy and information technology.

Vocational undergraduate education is oriented toward serving regional economic development and industrial needs, with its core objective being the cultivation of high-end skilled professionals equipped with solid practical and applied capabilities. As the foundational core of vocational undergraduate students' specialized studies, mathematics courses play an irreplaceable fundamental role in developing students' logical thinking abilities, quantitative analysis skills, and problem-modelling awareness [4-6]. However, in actual teaching practice, some vocational undergraduate mathematics courses still follow teaching models from general undergraduate or higher vocational education stages. Discrepancies exist between course objectives, teaching content, and instructional methods and the talent cultivation positioning of vocational undergraduate education, resulting in suboptimal teaching outcomes.

Artificial intelligence technology offers advantages in learning behaviour analysis, dynamic support for learning processes, and optimization of teaching evaluations, providing new technical pathway to address the challenges in vocational undergraduate mathematics teaching. The pressing issue in current vocational undergraduate mathematics teaching reform is how to reasonably integrate AI technology while adhering to educational principles, thereby optimizing teaching objectives, instructional processes, and evaluation systems. Based on this, this study explores pathway for integrating AI technology with mathematics course instruction in the context of vocational undergraduate education, aiming to provide insights for relevant curriculum reforms.

2. The Practical Significance of AI-Empowered Teaching in Vocational Undergraduate Mathematics Curriculum

2.1 Promoting the Shift in Teaching Philosophy from Teacher-Centred to Student-Centred

Traditional vocational undergraduate mathematics classrooms centre on teacher-led instruction, with pacing and content arrangements relying heavily on the instructor's teaching experience. This approach struggles to adequately accommodate individual differences in student foundations. Given the wide variation in mathematical backgrounds among vocational undergraduate students, a uniform teaching model often results in “students with weaker foundations falling behind, while those with stronger foundations find the content insufficiently challenging.” This disparity diminishes classroom engagement and learning motivation.

Artificial intelligence technology can continuously collect and quantitatively analyse student learning behaviours, homework quality, classroom interaction performance, and periodic assessment results. This generates personalized learning profiles that clearly reveal students' knowledge mastery levels, skill gaps, and learning difficulties. This provides precise data support for teachers' classroom design and instructional decisions, enabling more targeted teaching arrangements. Teachers can implement tiered and grouped instruction based on AI system analyses, providing foundational students with practice examples and step-by-step explanations while assigning application-based extension tasks to advanced learners. Practice demonstrates that this data-driven teaching model effectively boosts students' motivation for active learning, optimizes knowledge internalization, and drives classroom teaching from teacher-cantered to student-cantered transformation.

2.2 Enhancing the Accuracy and Adaptability of Mathematics Teaching

Students on vocational undergraduate programmes exhibit significant disparities in mathematical foundations. Traditional teaching models, characterised by uniform pacing and standardised requirements, struggle to accommodate individualised learning needs. This approach typically yields satisfactory outcomes for students of average ability, while those at either end of the spectrum experience suboptimal results. Artificial intelligence technology, integrated into intelligent learning systems, enables real-time diagnosis and dynamic analysis of students' knowledge acquisition. This facilitates the precise delivery of personalised learning resources. Taking the teaching of probability and statistics modules as an example: while advanced learners could be offered extension tasks such as data modelling and real-world case studies. Furthermore, AI enables real-time classroom feedback, allowing teachers to monitor student progress through system data and dynamically adjust explanation depth, exercise difficulty, and activity design. This data-driven precision teaching model not only enhances the alignment of content with students' actual abilities, alleviating learning pressures stemming from disparate foundations, but also optimises classroom time allocation, thereby improving overall teaching efficiency.

2.3 Facilitating the Effective Alignment between Mathematics Curriculum and Vocational requirements

The core value of mathematics curriculum lies not only in imparting theoretical knowledge but also in providing foundational support for professional studies and career practice. Traditional mathematics instruction often lacks sufficient application scenarios, making it difficult for students to grasp how mathematical concepts translate to real-world work contexts and thereby diminishing their interest in learning. Artificial intelligence technology can bridge theory and practice by integrating authentic occupational scenarios, industry data cases, and practical work tasks into the classroom. For instance, linear algebra instruction can incorporate matrix analysis through engineering project resource allocation problems; Probability and statistics instruction can leverage production quality control cases to guide students in applying statistical methods for data processing and decision-making. Contextualized teaching enables students to grasp the practical value of mathematical methods through “integration of learning and application.” Furthermore, AI platforms can flexibly adjust course modules based on different disciplinary talent development needs, reinforcing knowledge points closely tied to professional studies and job skills. This enhances the career orientation and practical focus of mathematics curricula.

3. Major Issues in the Teaching of Mathematics Curriculum for Vocational Undergraduates

3.1 Lack of Clarity in Course Objective Positioning

Course objectives serve as the core basis for guiding teaching implementation. Currently, some vocational undergraduate mathematics courses still set their objectives primarily based on the traditional mathematics discipline system, emphasizing the systematic nature of knowledge structures and the completeness of theoretical derivations. This approach pays insufficient attention to the cultivation of applied and practical skills, which are emphasized in vocational undergraduate education. In teaching practice, this objective orientation manifests as a curriculum content that leans heavily toward theoretical exposition, with teaching priorities focused on formula derivation and problem-type drills, while the application of mathematical knowledge in professional fields and real-world problems receives limited coverage. The misalignment between course objectives and the talent development goals of vocational undergraduate education prevents mathematics courses from fully fulfilling their foundational support role.

3.2 Lack of Close Connection between Teaching Content and the Major

In terms of curriculum design, vocational undergraduate mathematics courses predominantly employ standardized or adapted textbooks, featuring relatively rigid content structures with limited relevance to specific professional disciplines. Mathematics courses and specialised courses are typically taught independently by different instructors, lacking interdisciplinary collaborative teaching design and systematic communication. This results in disconnects between the two courses in terms of knowledge continuity and the integration of application scenarios. Consequently, students struggle to establish connections between mathematical knowledge and professional problems during their studies. Their understanding of the subject remains abstract, leading some to develop the perception that ‘mathematics is irrelevant to their specialisation.’ This, in turn, reduces their commitment to learning and diminishes the effectiveness of mathematics courses in supporting professional studies.

3.3 Limited Effectiveness of Teaching Methods in Accommodating Student Diversity

Vocational undergraduate students exhibit individual variations in their foundational mathematical knowledge, learning abilities, and study habits upon enrolment, presenting a common challenge in teaching practice. However, constrained by limited teaching hours and traditional instructional organisation, mathematics courses predominantly adhere to uniform teaching schedules and requirements. Within restricted classroom time, teachers must fulfil prescribed teaching objectives while accommodating students of varying ability levels. This makes it challenging to provide sustained, systematic personalised support for students with weaker foundations, nor can it offer sufficiently advanced learning content for those with strong foundations. This one-size-fits-all approach fails to adequately meet the learning needs of students across different ability levels, resulting in uneven teaching outcomes.

3.4 Limited Diversity in Teaching Evaluation Method

The current evaluation of mathematics courses in vocational undergraduate programmes remains centred on end-of-term examinations, constituting a typical summative assessment model. This approach primarily evaluates students' knowledge acquisition and problem-solving abilities, while relatively neglecting dimensions such as classroom participation, assignment quality, and knowledge application skills during the learning process. This singular assessment method struggles to comprehensively reflect students' learning journey and genuine learning outcomes, and also hinders teachers from obtaining timely instructional feedback to refine teaching strategies. Furthermore, summative assessment tends to steer students towards exam-focused learning objectives, neglecting the cultivation of deeper mathematical understanding and application skills. This approach runs counter to the application-oriented teaching objectives of vocational undergraduate mathematics courses.

4. Pathway for the Integration of Artificial Intelligence into Mathematics Curriculum

4.1 Constructing an AI-Based Hierarchical Teaching Objective System

Given the significant disparities in mathematical foundations among vocational undergraduate students, it is imperative to establish a tiered and progressive teaching objectives framework leveraging artificial intelligence technology. During the initial course phase, AI-powered learning diagnostics and data analytics will conduct comprehensive assessments of students' mathematical foundations, cognitive levels, and disciplinary backgrounds, providing precise data support for objective stratification. Building upon this foundation, teaching objectives are categorised into three tiers: Foundation-level objectives target all students, focusing on mastery of core mathematical concepts, fundamental computational methods, and essential skills to ensure students possess the basic mathematical literacy required for subsequent professional studies; Enhancement-level objectives target students of intermediate ability, prioritising the development of their understanding of mathematical methodologies and their capacity to apply these to straightforward problems, guiding them towards the correct use of mathematical tools in complex scenarios; The advanced tier integrates subject-specific requirements, emphasising mathematical modelling, data analysis, and interdisciplinary application capabilities to provide scope for enhancing students' comprehensive competencies. Defining tiered teaching objectives not only assists educators in rationally allocating instructional priorities but also guides students in formulating personalised learning plans. This approach effectively addresses the learning pressures and motivation deficits arising from a one-size-fits-all approach.

4.2 Implementing AI-Based Modularization and Contextual Reconstruction of Teaching Content

Optimising teaching content requires enhancing structural clarity and application orientation while retaining core theoretical foundations. Leveraging artificial intelligence technology, mathematics curricula can be decomposed into distinct, hierarchically organised knowledge modules, each designed around explicit learning objectives and practical application scenarios. Building upon this modular framework, teaching content undergoes contextualised reconstruction by integrating industry case studies, professional scenarios, and real-world problems via AI platforms, tailored to students' disciplinary specialisations. AI teaching platforms can deliver tailored application cases and practical tasks based on students' specialisations and learning progress. This enables students to grasp the professional relevance of theoretical knowledge while mitigating the disconnect between theory and practice. Furthermore, modular and contextualised design provides content support for differentiated instruction and personalised learning, allowing flexible content combinations to enhance teaching relevance according to individual learning needs.

4.3 Establishing an AI-Based Full-Process Teaching Support System

Artificial intelligence technology can be integrated throughout the entire teaching process—before, during, and after lessons—to establish a closed-loop teaching support system. Prior to lessons, diagnostic assessments conducted via AI evaluation tools precisely gauge students' prior knowledge and preparatory work, informing classroom instructional design. During lessons, intelligent teaching systems collect real-time student interaction data and immediate exercise results, dynamically analysing learning progress to assist teachers in adjusting teaching pace, explanation depth, and activity formats. This prevents teaching content from diverging from students' actual proficiency levels. Post-class, an intelligent homework system delivers differentiated learning resources: targeted consolidation exercises and supplementary explanations for students requiring reinforcement, alongside enrichment tasks for those progressing at a faster pace. Through coordinated support across these three phases, a closed-loop teaching model of ‘diagnosis-instruction-feedback-improvement’ is progressively established, enhancing overall teaching effectiveness.

4.4 Establishing an AI-Based Diversified Teaching Evaluation System

Breaking free from the limitations of traditional summative assessment, a diversified teaching evaluation system has been established, centred on formative assessment with summative assessment serving as a supplement. Artificial intelligence technology provides crucial support for the implementation of this system. Leveraging intelligent teaching platforms, formative data—including student classroom participation metrics, assignment quality, online learning behaviours, and periodic assessment outcomes—is continuously collected. Through algorithmic models, this data undergoes comprehensive analysis to generate holistic, objective evaluation reports that accurately reflect students' learning processes and achievements. AI-generated assessment outcomes serve solely as reference tools for teachers' instructional decision-making and reflection, and cannot replace their professional judgement. This diversified assessment approach guides students to focus on learning processes and competency development, thereby advancing the implementation of application-oriented teaching objectives in vocational undergraduate mathematics courses.

5. Conclusions

This study looks at how artificial intelligence technology can be used in mathematics courses. It is based on the goals of vocational undergraduate education. It analyses the main challenges currently facing mathematics teaching in vocational undergraduate programmes and proposes an AI-driven integration pathway across four areas: instructional objectives, content delivery, teaching processes and assessment methodologies. The study concludes that the core value of artificial intelligence in vocational undergraduate mathematics education is not simply to replace teachers or add technical tools, but to provide new ways of addressing traditional teaching challenges, such as significant student disparities, inadequate teaching targeting and delayed feedback on assessments, through data analysis and intelligent support. The role of mathematics courses in supporting professional learning and cultivating vocational competencies can be significantly enhanced by establishing tiered teaching objectives, restructuring modular and contextualised content, building comprehensive teaching support systems and optimizing diversified evaluation mechanisms. This will strengthen students' recognition of the value of mathematical education. Future research should focus on practical exploration within specific majors and courses, continuously tracking the implementation outcomes of AI-supported teaching models. This will provide more targeted references for reforming mathematics course instruction in vocational undergraduate education by accumulating practical experience and research data.

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