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Research on the Reform Strategy of Higher Vocational Mathematics Teaching for the Cultivation of Core Competencies in the Digital-Intelligent Era

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Abstract: The advent of the digital-intelligent era has put forward new requirements for higher vocational education. As a key link in cultivating students' logical thinking, scientific literacy, and innovative abilities, mathematics teaching urgently needs systematic reform. Based on the background of the development of digital-intelligent technology, this study focuses on the cultivation of core competencies in higher vocational mathematics.. By analyzing the current problems in higher vocational mathematics teaching, it explores the in-depth integration and application value of digital-intelligent technology in teaching, and proposes targeted reform strategies. The aim is to promote the transformation of higher vocational mathematics teaching from knowledge transmission to competency cultivation, and provide theoretical reference and practical paths for cultivating high-quality technical and skilled talents adapting to the needs of the digital-intelligent era.

Keywords: digital-intelligent era; core competencies; higher vocational mathematics; teaching reform

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1. Introduction

With the rapid development of digital-intelligent technologies such as big data and artificial intelligence, social production methods and occupational structures are undergoing profound changes, which poses new challenges to the talent training objectives and models of vocational education. As a public basic course, higher vocational mathematics not only undertakes the task of providing instrumental knowledge for students' professional learning but also shoulders the important mission of cultivating students' mathematical core competencies. However, traditional higher vocational mathematics teaching still has problems in concepts, content, methods, and evaluation, such as disconnection from the digital-intelligent era, inconsistency with students' actual needs, and weak connection with professional applications. These problems lead to students generally feeling that mathematics is "difficult to learn and useless", resulting in insufficient learning initiative and effectiveness[1]. Against this background, how to use digital-intelligent technology to empower the entire teaching process and promote the transformation of higher vocational mathematics teaching from focusing on knowledge indoctrination to focusing on core competency cultivation has become an urgent and important issue.

2. Problems existing in higher vocational mathematics teaching

2.1. Outdated teaching concepts and objectives, disconnected from talent needs in the digital-intelligent era

At present, the mathematics teaching concepts in many higher vocational colleges still remain in the knowledge-oriented stage. The main teaching objective is positioned at imparting mathematical concepts, theorems, and computational skills to meet the instrumental requirements of subsequent professional courses[2]. This view fails to recognize that in the digital-intelligent era, the core competencies of technical and skilled talents has evolved from a single computational ability to comprehensive competencies such as data thinking, modeling ability, algorithm understanding, and the ability to solve complex problems. The formulation of teaching objectives is often vague and broad, such as “mastering basic knowledge” and “cultivating computational ability”, without clearly defining and hierarchically requiring for specific high-order core competencies such as mathematical abstraction, logical reasoning, mathematical modeling, and mathematical technology. In the selection of teaching content, excessive emphasis is placed on the rigor of the mathematical discipline’s own system, lacking connections with emerging digital-intelligent fields such as big data analysis, artificial intelligence basics, and machine learning algorithms. This prevents students from realizing the importance of mathematics for contemporary cutting-edge technologies. Due to the late understanding of new educational concepts, mathematical teaching reform lacks the guidance of top-level planning and cannot timely adapt to the needs of industrial transformation and digital development.

2.2. Outdated teaching content disconnected from majors, insufficient applicability and era characteristics

The content of higher vocational mathematics textbooks generally tends to be a “compressed version of undergraduate textbooks”, still taking the classic theoretical system of calculus, linear algebra, and probability and statistics as the main line, with numerous knowledge points, abstract theoretical derivations, and slow updates. Although some textbooks attempt to add some application cases, they often remain superficial. The cases are either too simple and idealized or have little connection with the real scenarios and work tasks in the professional fields of higher vocational students[3]. For example, Fourier transform and Laplace transform, which engineering majors may need to focus on in signal processing applications, or optimization theory models in logistics scheduling, are often glossed over or completely absent in general mathematics textbooks; content urgently needed by finance and economics majors, such as basic data mining and the application of statistical inference in business decision-making, is rarely involved. This disconnect in content prevents students from establishing a direct link between mathematical knowledge and future vocational skills, generally leading to the perception that “learning mathematics is useless”, which seriously undermines learning motivation.

2.3. Single teaching model and methods, lack of student subjectivity and practicality

Current higher vocational mathematics classrooms are still dominated by the “indoctrination” model where teachers lecture and students passively listen, supplemented by a large number of exercise drills. Although this model is conducive to efficiently transmitting systematic knowledge, it severely suppresses students’ initiative to explore and creative thinking. The teaching process is centered on “teacher-textbook-blackboard (or PPT courseware)”, lacking interaction, inquiry, and collaboration. Students rarely have the opportunity to experience the discovery process of mathematical knowledge, participate in the mathematical modeling and solution of real problems, or use mathematical tools to complete project tasks in team cooperation. In many cases, the application of digital-intelligent technology in teaching only stays at the shallow stage of replacing blackboards with PPT and replacing part of the explanation with video playback, and fails to make full use of online platforms, simulation software, intelligent tools and other means to realize student-centered in-depth teaching modes such as blended learning, flipped classroom and project-based learning. The single teaching method leads to a dull classroom atmosphere and low student participation, making it difficult to effectively cultivate core competencies in problem-solving, cooperative communication, critical thinking, and other processes[4].

2.4. Rigid teaching evaluation system, neglect of process and competency development

The evaluation of higher vocational mathematics mainly relies on the final closed-book exam, and the exam content mostly focuses on memory-based knowledge points, fixed problem-solving steps, and calculation accuracy[5]. The summative evaluation method of "one exam determines everything" cannot comprehensively and objectively reflect the real development of students in various aspects of mathematical core competencies, especially for abilities that are difficult to test with standardized questions, such as mathematical modeling, data analysis, and mathematical abstraction. The evaluation subject is single, mainly completed by teachers, without the participation of students' self-evaluation, mutual evaluation, or enterprise or professional teachers[6]. It lacks attention to various aspects such as learning attitude, cooperative spirit, exploration process, and innovative thinking. Due to the deviation in evaluation orientation, students naturally focus their learning on memorizing formulas and practicing questions for exams, while ignoring the understanding of mathematical ideas, the mastery of mathematical methods, and the improvement of application abilities. This not only discourages some students who are good at practical operations but not good at exams but also misleads teaching, leading teachers to gradually shift their teaching focus to reviewing knowledge points, forming a situation where "exams replace teaching", which deviates from the direction of cultivating students' comprehensive quality.

3. Reform strategies of higher vocational mathematics teaching for the cultivation of core competencies in the digital-intelligent era

3.1. Reconstruct the curriculum content system and create an integrated curriculum structure

The top priority of the reform is to break the discipline-oriented curriculum content organization method and establish a dynamic curriculum content system led by core competencies, deeply integrated with professions, and reflecting the characteristics of the digital-intelligent era[7]. Specifically: (1) Strengthen the construction of a "basic platform": Streamline and optimize the content of classic courses such as calculus, linear algebra, and probability and statistics, retain the most important mathematical ideas, concepts, and methods, weaken the overly abstruse theoretical proof parts, highlight their value as general tools, and lay a solid foundation for all professional students. (2) Develop "professional modules": Collaborate with teaching teams of various majors to conduct in-depth research on the mathematical knowledge and abilities required by the professional post groups of each major, and jointly design a series of menu-based and optional professional application mathematics modules. For example, set up courses on mathematical methods in signal processing for electronic information majors, basic courses on geometric modeling and motion control mathematics for intelligent manufacturing majors, and courses on economic data analysis and forecasting for finance and business majors. The content of the modules should combine professional cases and use industry data and relevant professional software (such as Python, MATLAB, SPSS, etc.) for analysis. (3) Develop interdisciplinary "interdisciplinary projects": The design of "interdisciplinary projects" should be based on the principles of comprehensiveness and authenticity, and carry out the design of interdisciplinary mathematical application projects or topics, such as "Optimization Analysis of Store Location Based on Historical Sales Data" (combining mathematics, marketing, and management) and "Mathematical Models and Algorithm Implementation in Intelligent Car Path Planning" (combining mathematics, automation, and programming). Project-driven learning allows students to comprehensively apply mathematical knowledge and multi-disciplinary knowledge in solving complex and open-ended problems, deeply exercising core abilities such as mathematical modeling, mathematical technology, teamwork, and communication and expression. In addition, the curriculum content should set up a dynamic update mechanism to continuously introduce basic knowledge in fields such as big data and artificial intelligence, maintaining the novelty of the curriculum[8].

3.2. Innovate teaching models and methods and build a new smart teaching ecosystem of human-machine collaboration

Make good use of digital-intelligent technology to promote the transformation of the teaching model from "teacher-centered" to "student-centered", and change traditional one-way transmission into interactive learning inside and outside the classroom. Specifically: (1) Implement a blended online-offline teaching method[9]: Use smart teaching platforms (such as smart education of China, etc.) to pre-position content such as knowledge explanation and basic training online, allowing students to learn independently through micro-courses, interactive animations, online quizzes, etc.; focus on breaking through key and difficult points, group discussions, project exploration, and answering questions in offline classrooms to achieve knowledge internalization and ability improvement. (2) Promote project-based learning and case teaching based on real scenarios: Use the aforementioned "professional modules" and "interdisciplinary projects" as an important part of teaching. Teachers guide students to form project groups, and in work scenarios created by technologies such as virtual simulation and digital twins, or directly bring actual enterprise problems into the process of mathematical modeling and solution, completing them through a series of processes including problem proposal, information collection, model establishment, solution verification, and report writing[10]. During this process, students are encouraged to use mathematical software and data analysis tools for exploration and solution. (3) Explore personalized tutoring of human-machine collaboration: Introduce intelligent tutoring systems or adaptive learning platforms as an effective supplement to teachers' teaching. The system provides personalized learning path recommendations, intelligent question answering, and targeted exercises based on students' learning data, thereby realizing differentiated teaching. Teachers are freed from heavy repetitive labor and become more designers, guides, and facilitators of students' learning, guiding and promoting students' thinking development, emotional experience, and comprehensive ability formation. The reconstruction of the teaching model makes mathematics learning more active, inquiry-based, cooperative, and personalized, thus providing a normalized path for the implementation of core competencies[11].

3.3. Reform the teaching evaluation mechanism and establish a comprehensive competency evaluation system

Evaluation reform is a baton that should be consistent with the goals of core competency cultivation[12]. Specifically: (1) Diversification of evaluation content: Instead of only using a single assessment of knowledge and skills to evaluate students' abilities, design a multi-faceted ability test including the degree of understanding of mathematical knowledge, mathematical thinking abilities (abstraction, reasoning, modeling), mathematical application abilities (problem-solving, software use), and mathematical learning qualities (attitude, collaboration, reflection). (2) Diversification of evaluation methods: Adopt a variety of evaluation methods, including process evaluation (online learning data, classroom performance, group contribution), performance evaluation (project reports, modeling papers, oral defenses, experimental operations), technology-enabled evaluation (using AI to analyze the logic of problem-solving processes, tracking growth trajectories with learning analysis dashboards), and summative evaluation (reforming final exams by adding open-book, semi-open-book, case analysis, computer-based operation, and other question types). (3) Diversification of evaluation subjects: Build a multi-subject evaluation mechanism combining teacher evaluation, student self-evaluation and mutual evaluation, and enterprise mentors or professional teachers' evaluation, with special emphasis on peer evaluation and self-reflection in students' project learning. (4) Emphasize the developmental function of evaluation: Establish electronic portfolios of students' mathematical core competencies, continuously recording and displaying students' learning achievements and growth processes at various stages. In addition to being used for grade evaluation, the evaluation results should provide specific and timely information feedback to guide students' academic improvement and teachers' teaching quality improvement. The "evaluation-feedback- improvement" closed loop enables evaluation truly an important means to promote the development of students' competencies.

3.4. Empower teachers' professional development and improve teachers' digital-intelligent literacy

Teachers are the implementers of teaching reform, and their concepts, knowledge, and abilities will affect the effect of the reform. Therefore, higher vocational colleges should strengthen the improvement of teachers' "digital-intelligent literacy" and the cultivation of interdisciplinary teaching abilities[13]. Specifically: (1) Carry out special training and research studies: Organize teachers to participate in systematic training and workshops on the in-depth integration of digital-intelligent technology and education, core competency-oriented teaching design, mathematical modeling guidance, the application of relevant mathematical software (such as Python, MATLAB, WolframAlpha, etc.), and basic data analysis. (2) Establish a collaborative development platform[14]: Form interdisciplinary curriculum teaching and research teams, encourage mathematics teachers to take the initiative to enter professional departments to cooperate with professional course teachers in developing curriculum modules and project cases, and deeply understand professional needs. In addition, establish teacher exchange communities between schools and regions to share reform experiences and teaching resources. (3) Improve incentive and guarantee measures: Colleges should provide support in policies, funds, evaluation, etc., and incorporate teachers' achievements in teaching content reform, teaching method innovation, interdisciplinary curriculum development, and guiding students to participate in mathematical modeling competitions into the performance appraisal and professional title evaluation system, stimulating teachers' internal motivation to engage in teaching reform. (4) Continuous empowerment by digital-intelligent technology: Transforms teachers from knowledge transmitters into learning guides, curriculum designers, and technology integrators, and cultivate a high-quality "double-qualified" mathematics teacher team with profound mathematical foundation, solid technical background, and familiarity with professions, thereby ensuring the sustainable development of teaching reform[15].

4. Conclusion

The wave of the digital-intelligent era is profoundly reshaping the forms of society and education, endowing higher vocational mathematics education with new missions and connotations. The reform of higher vocational mathematics teaching oriented to core competency cultivation is a systematic project involving concepts, objectives, content, methods, evaluation, and teacher development. This study demonstrates the irreplaceable value of digital-intelligent technology in realizing personalized learning, deepening situational experience, and promoting precise evaluation for cultivating students' high-order competencies such as mathematical modeling and data analysis. At the same time, it directly addresses the prominent problems existing in current higher vocational mathematics teaching in concepts, content, models, and evaluation. On this basis, the proposed four-dimensional reform strategy centered on "integrated reconstruction of curriculum content, intelligent innovation of teaching models, comprehensive reform of evaluation systems, and professional empowerment of teacher teams" aims to build a new higher vocational mathematics teaching ecosystem that adapts to the requirements of the digital-intelligent era, centers on student development, and achieves in-depth integration of technology and education.

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