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Exploration and Practice on the Digital Transformation of "Food Physical and Chemical Inspection Technology" Course

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Abstract: *"Food Physical and Chemical Inspection Technology" as a core course in the Food Quality and Safety major faces three major challenges: limited access to large instrument operation, poor demonstration effects in experiments, and difficulties in evaluating ideological and political education. To address these issues, the teaching team has developed a "trinity" digital transformation solution. Through digital transformation, reforms have been implemented in three aspects: teaching resources, teaching environment, and teaching evaluation: (1) Virtual simulation software for large instruments has been developed to enhance students' practical training effectiveness; (2) A smart laboratory has been constructed to enable screen projection and live demonstrations of operation interfaces, optimizing the experimental teaching experience; (3) An evaluation mini-program for ideological and political education has been designed to quantify students' learning outcomes and achieve diversified evaluation. The digital transformation of the course has yielded significant results: (1) The quality of talent cultivation has markedly improved, with students consistently achieving excellence in national vocational skills competitions; (2) Teachers' teaching abilities have continuously strengthened, resulting in awards in teaching competency competitions; (3) The international influence has expanded, as the team completed the development of Tanzania's National Occupational Standard "Food Inspection Technician NTA-6" based on the course content. This study, aimed at precisely addressing teaching challenges, innovates the deep integration of digital technology and teaching, providing a replicable practical path for course reform in vocational colleges and contributing to high-quality educational development.*

Keywords: *Digital transformation, Food physical and chemical inspection technology; Teaching reform*

1. Introduction

Food is the paramount necessity of the people, and food safety is the top priority. Food safety has become a focal point of public concern and has been elevated to a national strategy [1]. The entire management of food "from farmland to table" relies on the support of professionals in food quality and safety. In particular, the continuous emergence of new technologies and business models in the food industry in recent years, such as online food third-party platforms and chain catering, has presented new challenges to the knowledge, skills, and competencies required of food quality and safety professionals [2-3]. "Food Physical and Chemical Inspection Technology" is a core course in the Food Quality and Safety program. The course adopts an integrated theory-practice approach and incorporates ideological and political elements such as "craftsmanship spirit, legal awareness, and professional ethics." It aims to cultivate students into guardians of food safety who "master inspection techniques, comply with laws and regulations, and uphold professional ethics," thereby supporting the national food safety strategy.

However, the course has faced numerous challenges in its long-term teaching practice. With the rapid advancement of food testing technologies and the ongoing reform of vocational education [4], traditional teaching models have proven inadequate for cultivating high-quality technical talent [5]. Through tracking teaching outcomes and gathering feedback from industries and enterprises, the teaching team has identified three critical issues that require urgent resolution: (1) Limited access to large-scale instruments: The course involves expensive analytical equipment such as liquid chromatographs and atomic absorption spectrometers, of which the school can only afford a limited number. Under the traditional practical training model, 4-6 students share one instrument, resulting in

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insufficient hands-on practice time per person, which severely hinders skill acquisition. Additionally, frequent instrument malfunctions occur due to students' lack of operational proficiency. (2) Ineffective experimental demonstrations: During experimental demonstrations, the limited space around the instruments allows only a few front-row students to clearly observe the teacher's operational details. Those in the back often end up "hearing about the experiment" rather than "seeing it." (3) Lack of evaluation methods for ideological education: As a provincial-level ideological education demonstration course, the program has developed a rich resource library for ideological and political content. However, it lacks effective evaluation mechanisms. Traditional survey methods are highly subjective and involve discontinuous data collection, making it difficult to objectively assess the improvement of students' professionalism [6,7].

In response to the aforementioned challenges, the course team has developed a "trinity" digital transformation solution (as shown in Figure 1), implementing systematic reforms across three dimensions: teaching resources, teaching environment, and teaching evaluation: (1) Digitalization of teaching resources: Developing virtual simulation software to overcome practical training resource constraints; (2) Intelligentization of the teaching environment: Establishing smart laboratories to enhance instructional demonstration effectiveness; (3) Data-driven teaching evaluation: Creating a mini-program for ideological education assessment to quantify educational outcomes. This solution adheres to the "student-centered" educational philosophy and reconstructs the course’s teaching implementation path and evaluation system through the deep integration of information technology and educational practices .

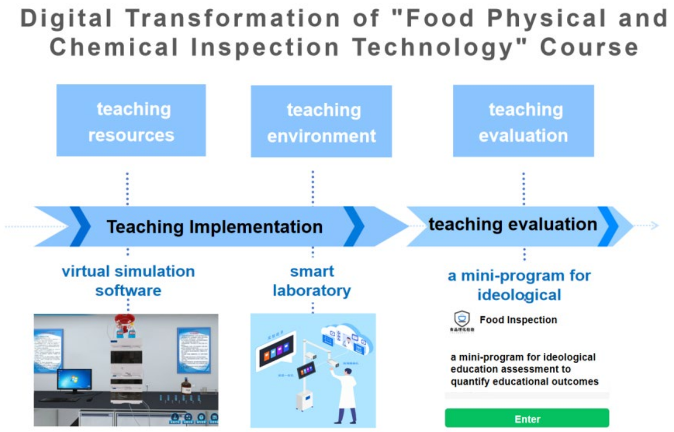

Figure 1 Design approach for the digital transformation of “Food Physical and Chemical Testing Technology” Course

2. Implementation Approach

2.1 Virtual Simulation Breaks Bottlenecks: Developing Instrument Simulation Software to Enhance Practical Training

To address the limited availability of large, expensive instruments in the course projects, virtual simulation software for major instruments (e.g. liquid chromatographs and atomic absorption spectrometers) was developed in collaboration with Ober Simulation Software Company. The development was based on course projects such as "Detection of Preservatives in Food" and "Detection of Heavy Metal Elements in Food", facilitating the smooth implementation of the course. During the course, each student repeatedly practices with the simulation software to familiarize themselves with the basic structure and operational procedures of the instruments in advance, laying a solid foundation for subsequent hands-on project implementation. Simultaneously, this approach integrates the theoretical knowledge students acquire with real-world workplace scenarios, ensuring the execution and implementation of a four-tier cognitive process: "intuitive perception → simulated practice → summary and improvement → real-world operation." This genuinely enhances students' practical skills and information technology application abilities.

Furthermore, the simulation software backend collects and records students' operational errors. By collaborating with AI and istudy platforms, it analyzes common mistakes, enabling teachers to better understand students' learning progress and provide more targeted explanations of relevant knowledge points in subsequent teaching processes.

2.2 Smart Training Drives Reform: Building a Multimodal Information-Based Teaching Environment

To address the issue of poor presentation during experimental demonstrations in course projects, a smart laboratory was established, integrating teaching software, hardware, and information-based teaching technologies. It supports the application of digital and modern teaching methods such as recording, live streaming, and screen mirroring, truly achieving enhanced teaching effectiveness through information-based approaches, as shown in Figure 2. During course projects, when teachers demonstrate the operation interface of instrument software, the smart training room system projects the instrument interface onto the teaching screen, allowing students to observe the operations more clearly and intuitively. When teachers explain the structure of instruments and demonstrate practical operations, the system enables live screen mirroring, presenting instrument structures and operational details more vividly to students. This addresses the issue in traditional training modes where students crowd around the teachers, unable to see details clearly. Meanwhile, students' operation screens can be simultaneously projected onto the large screen, enabling teachers to monitor multiple groups of students' training sessions in real time. This helps teachers identify and address common issues during training or provide timely personalized guidance. The development of the smart training room has pioneered a digital teaching model for the course, raised students' awareness of information-based learning, increased engagement, and further promoted the digital transformation of the "Food Physical and Chemical Inspection Technology" course.

Figure 2 The use of smart laboratory in the course

2.3 Digital Evaluation Aids Education: Innovating a Quantitative Assessment System for Ideological and Political Education Effectiveness

As a provincial-level exemplary course in ideological and political education, this course has developed extensive related resources. However, assessing the effectiveness of ideological and political education has always been challenging. To address this issue, a dedicated mini-program for evaluating ideological and political education was developed, utilizing digital means to assess its impact. This mini-program offers diverse teaching functions such as distributing questionnaires, pre-class previews, post-class tests, practical training report grading, recording class participation questions, and sign-ups for extracurricular activities. It tracks each student's performance in pre-class previews, post-class tests, and practical training reports, while also recording the number of questions asked during classes and participation in extracurricular activities. Additionally, the mini-program includes gamified challenges related to course content to enhance and monitor students' proactive learning motivation. Ultimately, it

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generates an individual growth chart for each student and a collective growth chart for the entire class. Using a devised weighted scoring method, it calculates an additional ideological and political education score for each student, quantifying the previously elusive effectiveness of such education. Furthermore, by integrating general AI platforms and tools like iStudy, the mini-program establishes a dynamic, multi-dimensional evaluation system that combines explicit and implicit indicators, collaboratively quantifying the outcomes of ideological and political learning and resolving the longstanding difficulty in evaluating its effectiveness.

3. Achievements of Digital Transformation

Firstly, through digital transformation, the course has significantly enhanced students' competencies and skills. Over the past three years, instructors have guided students to achieve outstanding results in various national and provincial skill competitions, including multiple first and second prizes in food nutrition and safety testing, food safety and quality inspection, and agricultural product quality and safety detection. Meanwhile, graduate employment rates and employer feedback have shown marked improvement. Secondly, the digital transformation has also improved the teaching proficiency of the faculty. Based on this course, teaching team members have received awards such as the President's Quality Award and a third prize in the Young Teachers' Teaching Competence Contest, laying a solid foundation for future teaching excellence. Furthermore, the transformation has facilitated international alignment of the course. The team successfully developed the "Food Testing Technician NTA-6" occupational standard as part of the second batch of Tanzania National Occupational Standards projects, marking a significant step toward integrating the course into global educational practices.

4. Conclusions

This work innovatively constructs a trinity digital transformation system comprising "teaching resources, teaching environment, and teaching evaluation." Addressing teaching challenges such as limited access to large-scale instrument training, suboptimal experimental demonstration effects, and difficulties in ideological and political evaluation, it has developed a series of digital solutions. Through the organic integration of digital tools such as virtual simulation systems, smart training platforms, and ideological evaluation mini-programs, the course has achieved: (1) Innovation in training models: constructing a closed-loop training system of "cognition-simulation-practice-evaluation"; (2) Reconstruction of teaching scenarios: creating a smart teaching environment that integrates virtual and real elements with multi-screen interactivity; (3) Innovation in evaluation systems: establishing a quantitative assessment mechanism for ideological education based on big data. This problem-oriented, technology-supported, and education-focused digital transformation path not only resolves specific teaching difficulties but also cultivates digital literacy among teachers and students, providing replicable and scalable practical experience for the digital reform of similar courses.

Furthermore, more efforts will be continuously made in the future for the digital transformation of the course in the following ways: (1) we plan to increase simulations of real-world scenarios, optimize the human-computer interaction experience, and establish a virtual-physical integrated evaluation mechanism to ensure that virtual training effectiveness can be effectively translated into practical operational skills. (2) we will continue to develop diverse functions of the smart training lab, explore digital teaching models, and improve equipment utilization efficiency. Simultaneously, we can collect and analyze usage data to continuously optimize functional configurations. (3) we will organize experts to review and refine evaluation metrics, increasing the proportion of formative assessment and develop data analysis models to enhance the scientific rigor of evaluation results. Furthermore, we can establish a feedback mechanism for evaluation outcomes to foster positive interaction between assessment and teaching. (4) we will develop a systematic plan to enhance teachers' digital teaching capabilities, promote experience sharing through workshops, teaching competitions, and other forms, and establish incentive mechanisms to encourage active participation in digital teaching reform.

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