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Research on the Digital Transformation of Basic Computer Education Driven by New Quality Productive Forces

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ABSTRACT

The emergence of "New Quality Productive Forces," characterized by high technology, high efficiency, and high quality, driven by innovation and centered on technologies such as artificial intelligence, big data, the Internet of Things, and cloud computing, is not only bringing profound transformations to human production, lifestyles, and modes of thinking but also imposing unprecedented higher demands on talents' digital literacy, computational thinking, and innovative capabilities. As the core component of higher education for disseminating digital competencies and foundational computational thinking, basic computer education faces severe challenges, as its traditional teaching models, content systems, and assessment methods are increasingly misaligned with the needs of the development of new quality productive forces. This paper aims to explore the new requirements for talent competency structures raised by new quality productive forces. By analyzing the key issues and challenges in current basic computer education regarding goal orientation, content systems, teaching models, and evaluation mechanisms, it delves into the practical pathways for the digital transformation of basic computer education driven by new quality productive forces. This transformation aims to facilitate the entire process of basic computer course teaching in universities towards becoming fully digital, online, interactive, personalized, and intelligent, thereby enhancing students' digital literacy and their awareness and capacity for lifelong learning. The study hopes to provide theoretical reference and practical guidance for the teaching reform and high-quality development of basic computer courses in China.

KEYWORDS

New quality productive forces; Digital transformation; Basic Computer education; Computational thinking; Artificial intelligence

1 Introduction

The term "new quality productivity" was first proposed in 2023, which is driven by technological innovation, supported by high-level innovative talents, and carried by strategic emerging industries and future industries. They have the mutual driven internal logic with educational development: on the one hand, new quality productive forces trigger systematic changes in educational concepts, goals, content, methods, systems, and governance; on the other hand, education is a key element and a positive variable in the formation of new quality productive forces [1].

Education, especially higher education, as the crucial intersection of technology as the primary productive force, talent as the primary resource, and innovation as the primary driver, is the strategic cornerstone for nurturing and developing new quality productive forces [2]. Computer science and technology, as a highly universal and enabling key field, directly determines the digital literacy and innovative capabilities of future workers in all industries through the quality of its basic education. It is the starting point project for cultivating "new quality talents" who can adapt to and create new quality productive forces [3]. However, examining the widely offered basic computer courses in Chinese universities (such as "University Computer Fundamentals" and "Programming Fundamentals"), common problems include insufficient depth in understanding and exploring digital transformation, teaching content lagging behind technological development, inadequate integration of digital technology in teaching design, rigid teaching models, failure to effectively connect various platforms and use intelligent assistants for teaching feedback and checks before and after classes during implementation, simplistic evaluation methods, lack of development and application of digital resources, and even insufficient investment in digital infrastructure and smart equipment in some universities [4]. These issues make it difficult to meet the composite ability requirements for talents who are "proficient in technology, good at integration, and courageous in innovation" as proposed by new quality productive forces. Therefore, it is necessary to actively conform to the development trend of new quality productive forces, empower teaching in basic computer education with them, and carry out exploration and practice of digital transformation.

This research will analyze the fundamental requirements for basic computer education put forward by the empowerment of high-quality educational development by new quality productive forces, diagnose the problems existing in current basic computer teaching practices, and construct a reform framework for basic computer education driven by new quality productive forces and guided by digital transformation pathways, aiming to provide references for relevant educators, administrators, and policymakers.

2 New Requirements for Talent Competency Structure by New Quality Productive Forces

In the early stages of information technology development, basic computer education focused primarily on imparting various cultural knowledge and application skills. With the proposal of computational thinking in 2006, basic computer education began to shift towards emphasizing both practical skills and thinking abilities, stressing the capability to understand reality and solve problems with the aid of information technology. Entering the intelligent era, basic computer education should no longer focus on learning a specific computer system or program as its core. Instead, it should be human-needs-centered, forming connections between various forms of intelligence[4]. The intellectualization of the teaching environment, the precision of teaching, and the diversification of educational evaluation will become important characteristics of future education, and basic computer education is no exception. Matching the development of new quality productive forces requires cultivating qualified "new quality talents." As the "source" of digital capability cultivation, the goal of basic computer education must be upgraded from traditional "tool use" and "skill transmission" to shaping the following core abilities:

2.1 Advanced Digital Literacy and Computational Thinking

Go beyond simple office software operation to deeply understand computational principles, data logic, algorithmic thinking, and system architecture. Be able to use computational thinking (decomposition, pattern recognition, abstraction, algorithm design) to analyze and solve complex cross-domain problems.

2.2 Human-Computer Collaboration and Mastery of Intelligent Tools

Be able to skillfully and critically use various common AI tools (such as code generation, data analysis, knowledge retrieval), understand their capabilities and limitations and ethical constraints, and achieve efficient collaboration that complements human and machine strengths.

2.3 Interdisciplinary Integration and Practical Innovation Capability

Possess the awareness and ability to deeply integrate computing technology and data methods with their own professional fields, and be able to use digital technology to drive model innovation, product innovation, and service innovation in their own discipline.

2.4 Continuous Learning and Adaptive Ability

In a rapidly iterating technological environment, possess the ability to independently explore and quickly learn new technologies, frameworks, and paradigms, forming the habit and self-drive for lifelong learning.

2.5 Digital Ethics and Social Responsibility Awareness

Deeply understand ethical issues such as data security, privacy protection, algorithmic fairness, and technology for good, and adhere to ethical bottom lines and social responsibility in technological innovation and application.

3 Main Problems and Challenges in Current Basic Computer Education

Facing the requirements of new quality productive forces, the traditional basic computer education system clearly has the following problems:

3.1 Lagging Teaching Objectives, Disconnected from Industry Needs

The teaching objectives of basic computer courses in many universities still remain at the level of mastering basic computer operations, commonly used office software, or outdated programming language syntax. There is insufficient emphasis on core literacies such as computational thinking, data literacy, and intelligent technology application, creating a gap with actual industry needs and the development requirements of new quality productive forces [5].

3.2 Slow Updating of Teaching Content, Lacking Dynamism and Frontiers

The content of textbooks for many basic computer courses is outdated. Although basic concepts of big data, AI, cloud computing, and IoT are included, there is a lack of practical application, and the coverage is limited. The teaching content is rigid, with emerging technologies only briefly introduced, making it difficult to reflect the rapidly evolving technological ecosystem (e.g., AI programming tools, low-code platforms)[6].

3.3 Backward Teaching Models, Lack of Student Agency

Teaching in basic computer courses in many universities or by many teachers still primarily relies on the indoctrinative and imitative approach of "teacher lectures, students listen, and practice in the computer lab." Project-based, inquiry-based, and collaborative learning are insufficiently implemented, making it difficult to stimulate students' innovative potential and ability to solve complex problems. Exploration of new teaching forms involving human-computer collaboration is just beginning.

3.4 One-sided Course Evaluation Methods, Difficulty in Measuring Real Ability

The evaluation of most basic computer courses still relies mainly on standardized written tests and computer operation questions, focusing on the assessment of isolated knowledge points and fixed problem-solving procedures. This cannot effectively evaluate students' computational thinking processes, project practical abilities, innovative thinking, and teamwork levels.

3.5 Isolated Teaching Environment, Incongruent with Professional Application Scenarios

Basic computer courses in most universities usually exist as isolated public courses, not closely integrated with the specific application scenarios of various disciplines. Students find it difficult to appreciate the enormous enabling value of computing technology in their own fields, leading to insufficient learning motivation and application transfer ability [7].

3.6 Teacher Capability Bottleneck, Huge Pressure for Transformation

Some teachers themselves lack sufficient follow-up learning of new technologies, lack the ability to transform cutting-edge technologies into teaching resources, and also lack the experience and motivation to design and implement new teaching models. The digital literacy of teachers needs improvement.

4 Exploration of Practical Pathways for the Digital Transformation of Basic Computer Education

4.1 Transformation of Teaching Objectives

In the systematic project of "digital transformation of basic computer education driven by new quality productive forces," the transformation of teaching objectives is the fundamental premise and core guide. If the objectives remain locked on operational skills and fixed knowledge, it will be difficult to touch the essence of educational reform. The transformation of teaching objectives is not a simple patch to the traditional three-dimensional goals of "knowledge, skills, and affect," but a structural and directional paradigm shift. Its core connotation should shift from a "tool application orientation" to a "foundation for innovation capability and digital literacy orientation"[8], building a "trinity" teaching objective system that "takes computational thinking as the core, digital literacy as the foundation, and innovative practice as the application." In the statement of teaching objectives in the syllabus, observable and measurable action verbs such as "able to analyze...", "able to design...", "able to evaluate..." should be used.

4.1.1 Cultivating Computational Thinking as the Core

Computational thinking is not only for computer scientists but a fundamental thinking mode that all modern professionals should possess. Through basic computer education, enable students to transcend specific programming languages, strip irrelevant details from concrete problems, and decompose complex problems into hierarchical, manageable sub-problems or modules, forming a universal problem-solving mindset that enables knowledge transfer.

4.1.2 Enhancing Digital Literacy as the Foundation

Digital literacy endows students with the essential knowledge, skills, and attitudes needed to learn, work, and live safely, effectively, and responsibly in the digital world. This is the "survival foundation" of the digital age. Through basic computer education, enable students to skillfully and critically use mainstream AI-assisted tools, data analysis platforms, collaborative office software, etc., understanding their boundaries; be able to efficiently retrieve, evaluate, integrate, create, and disseminate digital information, read, process, analyze, visualize data, and make reasoning and decisions based on data; and possess cybersecurity awareness, understanding and adhering to norms of data privacy, intellectual property, algorithmic ethics, etc.

4.1.3 Applying Innovative Practical Ability as the Goal

Guide students to apply computational thinking and digital literacy to real or simulated interdisciplinary scenarios through basic computer education, completing the leap from understanding and application to initial innovation. This is the "bridge" connecting foundation and specialty, learning and creation.

4.2 Transformation of the Teaching Content System

With the goal of laying the foundation for innovation capability and digital literacy, teaching content should no longer be a list of software functions but organized around "problems." The structure of basic computer courses should be optimized to build a progressively advancing teaching content system of "core-frontier-integration" that supports the teaching objectives of computational thinking, digital literacy, and innovative practice.

4.2.1 Strengthen the "Core" Layer

The teaching content of basic computer courses should strengthen, not weaken, the core principles of computer science, such as computational thinking, algorithms and data structures, fundamentals of computer systems, networks, and security principles. This is the "cornerstone" for students to cope with ever-changing technologies.

4.2.2 Expand the "Frontier" Layer

Use modular, plug-and-play methods to dynamically introduce introductions to cutting-edge technologies into the teaching content, such as fundamentals of artificial intelligence, data science fundamentals, cloud computing technology and services, and Internet of Things fundamentals. The content format can be micro-lectures, cases, or expert lectures.

4.2.3 Deepen the "Integration" Layer

Design "Computer + [Discipline]" characteristic projects or case libraries integrated with different majors. For example, design financial data analysis cases for economics and management majors, design personalized tourist route recommendation projects for tourism majors. Through practical cases, allow students to truly feel the enabling value of computing.

4.3 Transformation of Teaching Resources

4.3.1 Continuously Update Various Teaching Resources

Convert all existing online and offline teaching resources, such as courseware, exercise and question banks, extended materials, micro-lectures, practical training animations, practical training materials, and hands-on training, into digital resources and update them regularly to ensure the nature of cutting-edge and real-time of the teaching content, meeting the needs of the digital transformation of "teaching" and "learning".

4.3.2 Introduce Intelligent Teaching Assistants and Tools

Reasonably utilize code-generation AI (e. g., GitHub Copilot) to assist programming learning, using it as a "pair programming" partner to guide students in understanding, modifying, and optimizing AI-generated code. Use conversational AI for Q&A and concept clarification.

4.3.3 Build an Integrated Cloud-Based Teaching Platform

Build or improve existing teaching platforms to integrate functions such as online learning, automated code evaluation, virtual experiments, project collaboration, and AI teaching assistants, creating an intelligent learning space for "human-computer collaboration." By statistically analyzing student's learning data, it helps teachers conduct precise learning analytics, laying the foundation for personalized teaching design, and can also push differentiated learning resources to students with different progress levels [9].

4.4 Transformation of Teaching Models

4.4.1 Precisely Implement Layered and Classified Teaching

Use preliminary learning analytics data to stratify students by ability, designing learning tasks and projects with different difficulties and focuses to meet the diverse needs from "remedial" to "excellence."

4.4.2 Promote Inquiry-Based and Collaborative Learning

Design open-ended questions, encourage students to conduct independent inquiry through consulting materials, experimental verification, and group discussions. Also, utilize online collaboration tools to support cross-spacetime team project development, cultivating students' digital collaboration skills.

4.4.3 Comprehensively Implement Project-Based Learning, Constructing a "PBL+OBE" Blended Classroom Teaching Model

Before Class: Organize students to self-study and complete learning from PPTs, videos, or other teaching resources on the online learning platform, complete pre-class tests, and feedback learning problems. Teachers use the teaching platform to analyze learning data, reconstruct the teaching process with comprehensive projects from the real world or simulated real scenarios as the main thread, and formulate teaching plans.

During Class: Be student-centered and problem-oriented. By adopting group discussion formats, students independently collect information around problems, discover problems, and solve problems, cultivating students' independent learning ability and innovation ability, which is the continuous training of Project-Based Learning (PBL) ability. In the process of completing projects, students independently learn and apply the required knowledge and skills, while teachers provide scaffolding and process guidance.

After Class: Focus on learning outcomes as the goal, student-oriented, for course construction and learning effectiveness assessment. Based on the course's practical skill requirements, conduct course assessment and evaluation, which is the goal evaluation of Outcome-Based Education (OBE).

By rationally designing online and offline teaching content, while balancing practical skill training and assessment, find the best balance and complementarity between online and offline, and construct a four-dimensional learning space of "online learning + offline deepening + practical training + assessment empowerment."

4.5 Transformation of Evaluation Methods

Basic computer courses should not only cultivate students' basic abilities in computational thinking and computer application during learning and employment but also comprehensively consider students' comprehensive abilities such as professional expression, coordination, proactiveness, and hands-on ability in teamwork. Combine students' "apparent grades" with their "hidden abilities," focus on learning outcomes, build an assessment and evaluation system that evaluates both apparent and hidden aspects, set corresponding weights and implement dynamic grade management, create data-empowered teaching evaluation, achieve more diverse process evaluation and value-added evaluation, making the evaluation process more scientific, results more accurate, and forms richer [10].

4.5.1 Intellectualization of Process Evaluation

Use the teaching platform to automatically record students' learning process data, such as learning duration, code submission status, discussion participation, and homework quality, and automatically analyze student learning situations.

4.5.2 Multidimensionalization of Comprehensive Evaluation

Use project outcomes as the main basis for evaluation, such as executable programs, project analysis reports, problem solution designs, etc. Adopt various methods such as presentations, demonstrations, teacher-student or peer evaluation, focusing on evaluating their innovation, practicality, collaboration, and problem-solving ability.

4.5.3 Constructing Learner Digital Profiles

Integrate multi-source learning data to form dynamic digital profiles reflecting students' knowledge structure, skill level, ability strengths, learning styles, and growth trajectories. These profiles serve both students' self-awareness and future learning planning, and provide references for teachers' precise guidance and employers' scientific talent selection.

4.6 Enhancement of Teachers' Digital Literacy

The improvement of teachers' digital literacy is the key to the digital transformation of education. The cultivation of digital literacy should be based on a scientific evaluation and certification system. Following the industry standard "Teacher Digital Literacy" issued by China's Ministry of Education, the digital literacy of basic computer teachers can be trained from five dimensions: digital awareness, digital technology knowledge and skills, digital application, digital social responsibility, and professional development, to meet the needs of the digital transformation of basic computer education.

5 Conclusion and Outlook

Higher education's mission is to cultivate future builders and successors. The vigorous rise of new quality productive forces urges profound changes in higher education. Basic computer education, as the "cornerstone" of talent literacy in the digital age, finds its digital transformation imperative. The digital transformation of basic computer education is by no means a simple application of information technology, but a systematic and deep-seated revolution touching educational concepts, teaching objectives, content systems, teaching models, evaluation standards, and even teachers' digital literacy. Its core lies in being guided by the development needs of new quality productive forces, fully utilizing the empowerment of new-generation information technologies to construct a new teaching paradigm that is student-development-centered, capable of stimulating students' innovative potential, and adaptable to rapid changes. This paper systematically expounded the new requirements for talent cultivation under the background of new quality productive forces, analyzed the problems existing in current basic computer education, and proposed a practical pathway centered on the six-in-one transformation of "teaching objectives, content system, teaching resources, teaching models, evaluation methods, and teacher capabilities." However, the current digital transformation of basic computer education is still constrained by many factors. For instance, universities need to continuously invest in building intelligent teaching platforms and virtual experiment resources, establish special projects for "digital course resource construction," support teachers in developing modular and cutting-edge digital teaching content and cases, establish more flexible dynamic course update mechanisms, organize extensive seminars and training, set up special funds to support teachers' participation in cutting-edge technology training, industry practice, and pedagogy research, etc. Looking forward, with the continuous evolution of technology and the ongoing development of new quality productive forces, basic computer education will become more intelligent, personalized, and diversified. Only by actively embracing change and continuously promoting digital transformation can basic computer education truly exert its irreplaceable foundational power in cultivating qualified talents for building a country with education、science and technology power.

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