

The Internal Logic and Promotion Strategy of Digital Education Empowering the Transformation and Development of Teacher Education Curriculum

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Abstract: Under the wave of the global information technology revolution, education digitalization has become the core engine to drive education modernization and reconstruct education ecology. This study focuses on the internal logic and practical path of the transformation and development of digital education-enabled teacher education curriculum, and systematically analyzes the internal mechanism of technology-enabled education and its deep impact on the teacher education system. It is found that by integrating technologies such as big data and artificial intelligence, educational digitalization reconstructs the logic of educational resource allocation, realizes the leap of teaching efficiency and the accurate supply of personalized learning, and provides innovative momentum for the quality iteration of teacher education curriculum and the cultivation of high-quality teachers. However, the transformation process faces multiple challenges such as insufficient technical resources, insufficient digital literacy of teachers, lagging educational concepts, and unsupported teaching cultural ecology. In this regard, this paper puts forward four promotion strategies: strengthening technical support and resource supply, enhancing teachers' digital literacy and teaching ability, improving teaching methods and means, and creating a good digital education ecological environment, so as to promote the deep integration of education digitalization and teacher education curriculum, and provide theoretical reference and practical paradigm for building a new education ecology of lifelong learning for all.

Keywords: Digital education; Teacher education curriculum; Transformation logic; Promotion strategy

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1. Introduction

The global information technology revolution is reshaping the educational ecology at an unprecedented speed. The process of educational modernization driven by the digital wave has become an irreversible trend of the times. The 20th National Congress of the Communist Party of China clearly put forward the development program of "promoting the digitalization of education and building a learning society of

lifelong learning for all”^[1]. This top-level design pushes teachers’ professional development to the strategic frontier of education reform. On January 12, 2023, the National Education Work Conference also pointed out that the education system vigorously implements the national education digitalization strategic action, emphasizes the in-depth promotion of education digitalization strategic action, promotes the shaping of a new track, new kinetic energy, and new form of education development, and promotes the high-quality development of education through the digital transformation of education. As the source of education, teacher education undertakes the important task of cultivating high-quality professional teachers, and its construction quality directly affects the process of high-quality development of teacher education. At present, there are still many problems in the curriculum of teacher education in China, such as conservative curriculum concept, outdated curriculum content, lagging curriculum reform, unscientific curriculum evaluation, and so on, which not only affect the professional growth of teachers, but also restrict the adaptability and innovation of teacher education in the context of digital transformation of education. With the in-depth development of the digital transformation of education, the paradigm of school education and teaching will inevitably undergo major changes, and teachers will face the adjustment and reshaping of the new development logic in the digital era. Therefore, the reform of teacher education curriculum, as the training of future teachers, must be at the forefront of education reform, keep up with the requirements of the era of digital transformation of education, and explore new paths of change in the continuous collision and integration. Only when educators truly establish a capability map that matches the digital civilization can they effectively control the new education ecology of the integration of virtual and real education and provide continuous kinetic energy for the innovation of talent training mode. Based on this, this study attempts to deconstruct the endogenous logic and practical path of “digital education empowering teacher education curriculum transformation.” By systematically analyzing the value conflict and integration mechanism in the process of technology empowerment, it provides a theoretical reference for the construction of a digital transformation paradigm of teacher education with Chinese characteristics.

2. The internal logic and value connotation of the transformation and development of teacher education curriculum enabled by educational digitalization

At present, the global education pattern is undergoing a century of unprecedented reconstruction. As a typical representative of new productivity, digital technology has become a strategic fulcrum for countries to seize the commanding heights of education reform. Digital technology not only reshapes the path of knowledge dissemination, but also deeply deconstructs the relationship of educational production. Its core essence is to use digital technology to reconstruct the educational ecology, and to realize the leap of teaching efficiency and the iteration of educational quality on the basis of ensuring educational equity.

2.1. Deep integration of digital resources to achieve technological empowerment and ecological reconstruction

Education digitalization is an inevitable choice to cope with the challenges of informationization and globalization in today’s society. With the rapid development of artificial intelligence and other technologies, educational digitalization is not only an application of tools, but also a fundamental change in educational concepts, educational models, and educational goals^[2]. Digital technology provides strong support for the innovation of teacher education curriculum. First of all, digital education tools represented by MOOC

platforms and virtual teaching and research communities break the time and space constraints of traditional classrooms, so that high-quality educational resources can be quickly disseminated to remote areas, providing a technical solution to bridge the digital divide between urban and rural schools. This credit bank based on blockchain technology realizes the cross-platform and cross-regional circulation of educational achievements, so that educational resources can reach different groups in a more efficient way. This environmental optimization not only improves the utilization rate of resources, but also creates fairer and more shared basic conditions for curriculum implementation^[3]. Secondly, blended learning and project-based learning platforms build a multi-dimensional interactive space to promote knowledge transfer from one-way indoctrination to collaborative inquiry. Intelligent recommendation and emotional computing technology make teaching resources and learning needs highly matched, forming a dynamic and personalized learning path. These technological innovations are essential for the construction of multi-dimensional learning scenarios, so that the educational process is transferred from a planar knowledge transfer to a three-dimensional ability incubation system. Finally, digital transformation brings not only the innovation of tools, but also the upgrading of cognitive frameworks. In particular, the preliminary application of brain-computer interface technology in teaching scenarios is opening up new possibilities for quantitative evaluation of cognitive processes. This technology-enabled environment optimization makes teaching more accurate and efficient, and also lays the foundation for building a new picture of 'high-quality and suitable' education equity^[4]. In the deep-water practice of digital transformation of education, we need to realize that the ultimate goal of technology empowerment is not to create a dazzling educational technology landscape, but to build a more inclusive and growing educational ecology^[5]. When the virtual reality helmet and the field practice base form a closed loop of education, and when the algorithm recommendation and humanistic care reach a value consensus, such digital transformation can truly reach the essence of education, that is, every learner can find their own growth coordinates in the educational network woven by technology^[6].

2.2. Deep improvement of teaching quality and efficiency by the transformation of teacher education curriculum

With the in-depth application of big data and artificial intelligence technology in the field of education, it also provides solid technical support and innovation driving force for the optimization and upgrading of teacher education curriculum content with its powerful data analysis ability and intelligent decision-making function^[7]. The use of intelligent sensors, wearable devices, and augmented reality (AR) and virtual reality (VR) technologies enables classrooms to perceive learners' learning status, emotional changes, and even physiological indicators in real time, so as to dynamically adjust environmental parameters, such as light, temperature, and even spatial layout, to support the individual needs of each learner in an optimal state^[8]. Through VR technology, teachers can simulate real teaching scenes, such as the reappearance of ancient battlefields in history classes, the exploration of micro-worlds in scientific experiments, etc., so that students can learn knowledge in immersive experiences and deepen their understanding of the course content^[9].

2.3. Deep promotion path of teacher education curriculum transformation to teachers' professional growth

China's education ecology is undergoing a deep reconstruction of digital transformation, which presents distinct Chinese characteristics under the strong drive of policy engines^[10]. The promulgation of the industry standard of "teachers' digital literacy" not only constructs the measurement of teachers' digital ability, but

also forms the institutional thrust of forcing teachers' professional development. Under the catalysis of policy dividends, the supply-side reform of educational resources has made breakthrough progress. Like the "new infrastructure" in the digital age, the intelligent education cloud platform integrates discrete high-quality resources into a three-dimensional knowledge network, providing teachers with cutting-edge subject knowledge and innovative teaching tools. The popularity of digital technology has changed the limitations of teachers' development time and space. Through 5G technology, teachers are no longer subject to geographical restrictions and can participate in top teaching and research activities at any time; the intelligent learning diagnosis system helps teachers to accurately improve their teaching ability according to specific feedback ^[11]. Digital mirroring and blockchain technology can realize accurate tracking and reflection for teachers' teaching behavior and growth process, thus entering the iterative update stage of "virtual simulation-practical verification-intelligent optimization." These innovative practices make the model of teachers' professional development more flexible and personalized, and provide new support for teachers' professional growth.

3. The realistic dilemma of the transformation of teacher education curriculum empowered by digital education

Although education digitalization can make great contributions to the transformation and development of teacher education curriculum, it still encounters many difficulties in the current practice process.

3.1. Dilemma at the technical and resource level

From the perspective of technical infrastructure, the human-machine ratio of teacher education institutions in eastern, central, and western regions of China shows a gradient gap of 3.8:1, 5.2:1 to 7.6:1. This spatial imbalance leads to the dilemma of "digital pedestal collapse" faced by teachers in underdeveloped areas in core scenarios such as virtual simulation and intelligent training. Liu *et al.* attributed it to the "lack of physical scenes" caused by the lag of new infrastructure, and the global monitoring data of UNESCO further revealed that this kind of technological gap is giving birth to "digital Darwinism" in teacher education. At the ecological level of digital resources, the problem of structural imbalance is particularly prominent: the repetition rate of general resources is 67.3%, while the coverage rate of subject resources is less than 40%. The contradiction between the proportion of static resources exceeding 80% and the shortage of dynamically generated resources makes 78.6% of teachers in normal colleges and universities encounter the practical dilemma that the matching degree between digital resources and curriculum standards is less than 0.6 ^[12]. In addition, the platform island effect leads to the data fusion crisis, which leads to the data sharing rate of less than 28%. Jiao pointed out that it will directly cause the "blind touch" dilemma of teacher portrait construction, and the "Balkanization" phenomenon of the platform revealed by Zheng also leads to the continuous dissipation of data value.

3.2. The dilemma of teachers' ability and accomplishment

In the process of deepening the digital transformation of education, the structural dilemma of teachers' ability and literacy has become a key bottleneck restricting the transformation and development of teacher education curriculum. From the perspective of technology application, teachers' digital ability shows a significant fault: only 34.2% of teachers can skillfully operate intelligent teaching tools, less than 8% of teachers have reached the standard of deep technology application ability, and the technology rejection rate of teachers over 50

years old is 41.3%, forming a contradictory pattern of “superficial application” and “intergenerational digital divide.” Gu’s empirical study further reveals that 62.7% of teachers have alienated intelligent technology as “e-writing tools,” which has led to an increased risk of deep deconstruction of teaching situations. At the level of cognitive iteration, 76.5 % of teachers still adhere to the traditional role of “knowledge transmitter,” and there are cognitive blind spots in new functions such as “digital collaborator” and “learning designer”^[13]. This concept lags behind the structural dislocation of the educational needs of “digital natives” emphasized by UNESCO, resulting in classroom teaching falling into “path dependence under the influence of technology.” Further analysis of data decision-making ability, the teacher group presents the paradox of “data enrichment” and “decision-making poverty”: the effective utilization rate of teaching big data is only 18.4%, and 83.7% of classroom decision-making depends on empirical intuition. The root causes can be traced back to the structural defects of the data analysis module in the normal education curriculum system, which accounts for less than 3%, while the coverage of data ethics training is less than 30%, which derives secondary risks such as algorithm discrimination. The deeper dilemma stems from the psychological seesaw caused by digital transformation. 68.9% of teachers have “technology catch-up anxiety,” and 43.2% of teachers have job burnout due to continuous technological updating. Sato attributes this phenomenon to the adaptive crisis caused by “the speed of technological iteration exceeds the threshold of psychological tolerance,” while 17.6% of teachers’ professional identity crisis further reflects the erosion effect of digital subjectivity resolution on teachers’ professional beliefs. The superposition of these dilemmas essentially constitutes the “ability cocoon room” of teachers as the main body of transformation.

3.3. The dilemma of curriculum and teaching level

The transformation of educational digital empowering teacher education curriculum faces multiple practical difficulties at the curriculum and teaching levels. These difficulties are intertwined and jointly restrict the further advancement of the transformation. First of all, the lag problem of curriculum structure and content presents a multi-dimensional and complex representation. The current teacher education curriculum system is still based on the traditional subject knowledge standard as the core architecture. In the curriculum design concept and content arrangement, the penetration of the core elements of the digital age, such as digital technology and data literacy, is seriously insufficient. This knowledge system construction method makes it difficult for the course content to keep pace with the rapid iterative technological development, and there are significant defects in the timeliness and foresight of knowledge updating. Secondly, the curriculum system generally lacks the modular design concept, which leads to a lack of effective logical connection and organic integration between the digital technology training course and the subject teaching method course. This kind of separation in curriculum setting makes it difficult for students to form a systematic and structured digital teaching ability system through curriculum learning, which cannot meet the new requirements of digital transformation of education for teachers’ professional ability. Finally, the innovation process of teaching mode faces deep-seated development bottlenecks. In teaching practice, most of the digital tools are only used as supplementary tools for traditional teaching methods, and lack a solid theoretical basis and systematic innovative design.^[14] More importantly, the existing teaching model has a significant lack of guidance mechanism for students’ digital learning behavior, and fails to effectively cultivate students’ information screening ability and critical thinking literacy in a massive digital resource environment. As a result, the development of its core digital literacy obviously lags behind the educational needs of the digital era, which seriously hinders the digital transformation process of teacher education curriculum.

3.4. Dilemma at the cultural and ecological levels

In the process of the transformation of teacher education curriculum deeply empowered by educational digitalization, the dual conflict between organizational inertia and value rationality appears at the cultural and ecological levels. From the perspective of organizational culture, the contradiction between conservative cultural genes and digital transformation is particularly significant, which directly leads to the phenomenon of “institutional idling.” At the level of education management, there is a widespread fear of technology, which is manifested in the management’s fear, resistance, or negative attitude towards emerging digital technologies. Some colleges and universities tend to adopt conservative strategies in the face of digital transformation due to fear of potential risks, and lack the motivation and courage to take the initiative to change. This solidified management thinking, rigid organizational structure, and prevailing risk aversion culture have seriously weakened the adaptability of the education governance system to digital transformation. At the same time, “digital bureaucracy” has gradually spread in the field of education, that is, overemphasis on the formal application of digital technology in administrative management, while ignoring its substantive enabling role in education and teaching. The combined effect of technological phobia and “digital bureaucracy” makes it difficult for the curriculum reform program to break through the shackles of the traditional model and fall into the dilemma of “path dependence” ^[15]. In this context, the application of digital technology is often alienated from the essence of education as an administrative symbol, which is only used to meet the formal digital requirements, but not really integrated into the core link of curriculum teaching, and cannot achieve the fundamental goal of improving the quality of education and promoting the professional development of teachers. At the level of collaborative ecological construction, the fracture between the traditional isolated island professional development model and the digital collaborative needs has become increasingly prominent. The virtual teaching and research community has a “information cocoon” effect due to the weak relationship connection and the “information cocoon” effect caused by algorithm recommendation, which makes the density of teachers’ collaborative network significantly lower than the efficiency threshold of knowledge diffusion, reflecting the imbalance between technical logic and educational logic in the collaborative mechanism.

4. Promoting strategies for the transformation and development of teacher education curriculum enabled by digital education

The promotion strategy of digital education empowering the transformation and development of teacher education curriculum is a multi-dimensional and systematic process, involving technical support, teachers’ teaching literacy and teaching methods, and other aspects. Therefore, based on the strategic orientation of “China’s education modernization 2035” and the context of the era in which digital technology is deeply embedded in the education system, we should construct a path to promote the transformation and development of digital education-enabled teacher education curriculum.

4.1. Strengthening technical support and promoting resource sharing and cooperation

The systematic improvement of the intelligent education platform is a basic project. We should focus on building an intelligent platform covering the whole scene of teaching, realize multi-source data integration through standardized interfaces, and crack the platform island effect. At the national level, it is necessary

to promote the new infrastructure of education and strengthen the whole process collection and intelligent diagnosis ability of teaching behavior data. On this basis, we will deepen the educational transformation of 5G, Internet of Things and artificial intelligence technology, build a teacher development laboratory with virtual and real integration through edge computing and intelligent sensing equipment, improve the adaptability of the teaching environment with technology cluster effect, and accurately identify teachers' ability shortcomings with multi-modal data mining. At the same time, the ecological construction of the digital education resource library needs to achieve three breakthroughs: relying on blockchain technology to build a resource confirmation and circulation system, promoting the dynamic correlation between subject knowledge and teaching cases based on knowledge graph technology, and realizing the accurate matching of resource supply and teacher ability portrait through an intelligent recommendation engine. This transformation needs to build an innovative ecology of government-school-enterprise collaboration, weave a national-level intelligent education neural network with the "educational brain" project led by the Ministry of Education, and play a leading role in formulating policies to encourage, fund and strengthen supervision; the virtual teaching and research section jointly built by normal universities and technology giants incubates a new form of teaching method, actively promotes the reform of digital teaching, and trains teachers to adapt to the digital age^[16]. Through the 5G education network, the regional education alliance realizes the capillary-level penetration of high-quality resources, providing technical support and high-quality digital education resources. Through the coordinated development between regions and schools, a strong joint force to promote the digitalization of education is formed, which lays a technical foundation for the systematic transformation of teacher education curriculum.

4.2. Strengthening teachers' digital literacy and teaching ability

First of all, the construction of a new framework for digital literacy development is the foundation. The Global Teacher Digital Literacy Standards released by UNESCO proposes a three-dimensional competency model of "technology application-data decision-ethical reflection," emphasizing that teachers need to break through the limitations of instrumental skills and form educational cognition theory and methodology in the digital age. China should establish a "pre-service-post" digital literacy training system, and realize the dynamic tracking of ability development through the micro-certification mechanism. Secondly, innovating the training mode of teachers' digital teaching ability is the core. It is necessary to carry out the mixed training of "scene embedding-problem driving." The "digital action learning method" proposed by Gu shows that the combination of virtual simulation scenes and real teaching problems can improve teachers' technical integration ability by 53%. At the same time, a hierarchical and classified training mechanism is established to design the "technology application-curriculum design-innovation leading" ability advanced path for novice teachers, backbone teachers, and expert teachers. Thirdly, building an incubation platform for teaching innovation ability is the guarantee. Through the construction of teachers' digital innovation laboratory, a closed-loop innovation mechanism of "design-practice-iteration" is constructed to improve teachers' ability of generative curriculum development. In addition, it is necessary to improve the innovation incentive mechanism, incorporate digital teaching results into the title evaluation and performance evaluation system, and break the institutional bottleneck of "innovation input-return imbalance." Finally, cultivating teachers' professional development community is ecological support. With the help of intelligent technology, a cross-regional teacher collaboration network is constructed, and a "digital tutorial system" mutual aid relationship is formed through data portrait matching. The empirical research of Jiao shows that such a community can

increase the depth of teachers' teaching reflection by 37% and the efficiency of knowledge sharing by 2.8 times. This ability improvement path provides continuous kinetic energy for the transformation of teacher education curriculum through the reconstruction of literacy framework, the innovation of training mode and the support of ecological optimization.

4.3. Improving teaching methods and teaching means

Yang proposed the "digital curriculum ecological tree" model. He believed that the dynamic update and interdisciplinary association of curriculum content through knowledge graph technology can increase the curriculum relevance index from 0.58 to 0.84. Therefore, we can stimulate students' inner thirst for knowledge and realize the digital upgrading of teaching elements by designing the learning scene of virtual and real blending. Based on the map of teachers' professional development needs, a compound curriculum structure of "subject knowledge + digital literacy + educational intelligence" can be constructed. At the same time, the national level also needs to formulate "digital curriculum standards for teacher education," and clarify that emerging modules such as artificial intelligence ethics and educational big data analysis account for no less than 30%. Secondly, the "smart loose-leaf textbook" advocated by Zhu uses AR/VR technology to embed teaching case bases and intelligent diagnostic tools. Its pilot study shows that the efficiency of teacher curriculum design is increased by 41%, and the depth of teaching reflection is increased by 2.3 times, revealing that the development of demonstrative digital textbooks needs to break through the limitations of traditional carriers to maximize their effectiveness. Finally, it is necessary to establish a dynamic revision mechanism of teaching materials, realize real-time feedback and content iteration of teaching data through blockchain technology, construct a "double space teaching method" with virtual and real integration, and realize collaborative teaching among teachers in different places through 5G + holographic projection technology; carry out the "precise teaching and research mode" based on educational big data, and use learning analysis technology to locate teaching improvement points; develop "AI teaching and research assistant" to provide teachers with intelligent teaching design suggestions and ethical risk early warning, and reshape teachers' teaching methods and means in the digital age through the three-dimensional transformation of ecological content, intelligent carrier and precise mode.

4.4. Creating a good ecological environment of digital education

The transformation of teacher education curriculum empowered by educational digitalization must break through the stereotype dominated by instrumental rationality and realize system remodeling at the cultural and ecological levels. The primary task is to establish an education culture oriented by value rationality and promote the digital transformation from "technology center" to "education center." Digital technology should be a means to improve the quality of education and teachers' professional development, rather than a simple administrative symbol or capital profit-seeking tool^[17]. This requires highlighting the essence of education in system design and organizational culture, and forming an open, shared, and inclusive cultural atmosphere. Secondly, we should focus on the construction of a synergistic educational ecology. Teacher education should no longer rely on isolated individual development models, but should realize the efficient flow of knowledge and experience through in-depth collaborative platforms across regions, disciplines and institutions, promote the formation of an ecological pattern of multi-subject participation, co-construction and sharing, maintain a benign interaction between technological development, curriculum reform and social needs, and promote the deep coupling of educational goals and social values. Only under the two-wheel drive of value rationality and

ecological reconstruction can the digital transformation of teacher education curriculum truly break through the institutional inertia and cultural shackles and move towards sustainable high-quality development.

5. Conclusion

Based on the background of education reform in the digital age, this paper focuses on the transformation of digital education-enabled teacher education curriculum, sorts out its internal logic, and points out that digitalization relies on big data and artificial intelligence to reconstruct the allocation of educational resources and help improve the quality of curriculum and teacher training. However, the current transformation still faces multiple obstacles such as a shortage of technical resources, weak digital literacy of teachers, lagging educational concepts, and a lack of digital teaching culture. Based on this, it proposes targeted promotion strategies from four aspects: resource supply, literacy cultivation, teaching innovation, and ecological construction. It provides theoretical support and practical reference for the deep integration of digital technology and teacher education curriculum and the construction of a new ecology of lifelong learning education for all.

Disclosure statement

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