Mechanisms for Forming Digital Literacy of College Teachers under the Digital Transformation of Education

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Abstract:

With the rapid development of information technology, the digital transformation of education has become an important trend of global higher education reform. In this context, the digital literacy of higher education teachers is not only related to their personal career development, but also a key factor affecting the quality of teaching and the development of students' abilities. Several problems have been identified through the research study, such as unbalanced distribution of resources, limited opportunities for professional development, missing evaluation system, insufficient social interaction and cooperation, and low self-efficacy, which collectively affect the formation of digital literacy among college teachers. Based on this, this study puts forward a series of recommendations, such as exploring the digital literacy hierarchy of college teachers under the digital transformation of education, clarifying the direction of cultivating digital literacy of college teachers under the digital transformation of education, and constructing a cultivation mechanism of multi-party collaboration and cooperation, with a view to promoting the enhancement of the digital literacy of college teachers, and then promoting the digital transformation of higher education.

Keywords: digital transformation; university teachers; digital literacy; formation mechanisms

1. Introduction

With the rapid development of information technology, the digital transformation of education1 has become a global higher education reform1 The European Union has issued the Action Plan for Digital Education (2021-2027). The European Union has issued the Action Plan for Digital Education (2021-2027), Germany has launched the Digital Education Initiative, and France has launched the "Education Digital Territory" program. Through top-level design, countries have implemented a series of strategic initiatives in various aspects to strengthen the process of promoting the transformation of digital education in order to seize the commanding heights of development. In this context, the digital literacy of college teachers is not only related to the improvement of teaching quality, but also an important indicator of national soft power. Taking Shanghai as an example, the "Implementation Plan for Shanghai's Digital Transformation of Education (2021-2023)" breaks a new blueprint for Shanghai to holistically promote the digital transformation of education, omni-directionally empower the comprehensive reform of education, revolutionize and reshape the high-quality education system, and serve the national strategy and Shanghai's urban development.

The report of the 20th Party Congress in the "implementation of the strategy of science and education to develop the country3 The report of the Twentieth National Congress of the CPC made the deployment of "promoting the digitalization of education" in the part of "implementing the strategy of developing the country through science and education and strengthening the support of talents for modernization", reflecting the requirement of the times that digitalization will lead the technological change in the future. Teachers, as the supporting force of education development, are the core and key to the implementation of education digitization strategy, innovation of education concepts and profound changes in education models. Therefore, for teachers and teacher trainers, the digital transformation of education is both a great challenge and a rare opportunity. 2022, the Ministry of Education's Work Points for 2022 explicitly put forward the "implementation of the national education digitalization strategy action", and for the

cultivation of teachers' digital literacy, the Ministry of Education in 2023 specifically developed a digital literacy training program for teachers, which will help to improve teachers' digital literacy.4 In 2023, the Ministry of Education (MOE) developed and released the education industry standard of "Teachers' Digital Literacy", which proposes that teachers' digital literacy consists of five first-level dimensions: digital awareness, digital technology knowledge and skills, digital application, digital social responsibility and professional development. From this, it can be seen that the digital transformation of education is an inevitable trend of the times, which is driven by science and technology5 that reshapes the way of teaching and learning. In this process, the digital literacy of college teachers becomes critical, which directly affects the quality of education and student development. Enhancing digital literacy involves not only technology operation, but also multi-dimensional abilities such as information processing and online collaboration. Therefore, strengthening teachers' digital literacy training, building a support system, and integrating it into daily teaching practices are crucial to realizing effective transformation.

2. Literature review

The most direct impact of the digital transformation is to change the teaching method. Fu Zhongnan et al. established the idea of building an educational digital private network by analyzing multimedia protocols and network protocols, and proposed a construction scheme based on software-defined network6 The software-defined network construction program, which makes the teaching become more convenient and efficient. Traditional teaching methods are usually face-to-face lectures, while digital education can be multi-form learning through the network, teachers and students can learn and communicate at any time and any place, the learning efficiency and effectiveness have been greatly improved. Secondly, educational resources can be shared to a large extent, Sun Mingyuan takes Mucous Class as an example and proposes that while breaking the time and space limitations of education, the course platform provides an effective way for sharing and optimizing the allocation of educational resources.7 . Through digital technology, teachers and students can share educational resources globally, which enables students to obtain more comprehensive and diversified learning resources, while teachers can share their teaching experience and teaching resources to improve the quality and level of teaching. Peng Yanning et al. suggest that the novel technological tool of "meta-universe" will be able to create balanced teaching resources, and through careful planning and innovative use of hardware devices such as AR and VR, it can give students a more diversified, personalized and enriched learning experience, and also make up for the shortage of educational resources in remote areas, and further promote the digital reform of educational resources. Digital Reform of Educational Resources8 The

Although the existing literature provides us with valuable insights, there are still some research gaps. The research in this paper focuses on micro, meso, and macro to form a hierarchical exploration to analyze the formation process of digital literacy among college teachers from multiple perspectives and to construct a multi-party synergistic and collaborative cultivation mechanism in order to comprehensively understand and promote the development of digital literacy among college teachers.

3. Problems in the formation mechanism of digital literacy of university teachers under the digital transformation of education

As the digital transformation of education continues to advance, the digital literacy of college teachers has become a key component of their professional development. However, there are a series of problems in the current formation mechanism of digital literacy of college teachers, which hinder the effective improvement of digital literacy and the in-depth implementation of digital teaching, as shown in Figure 1.
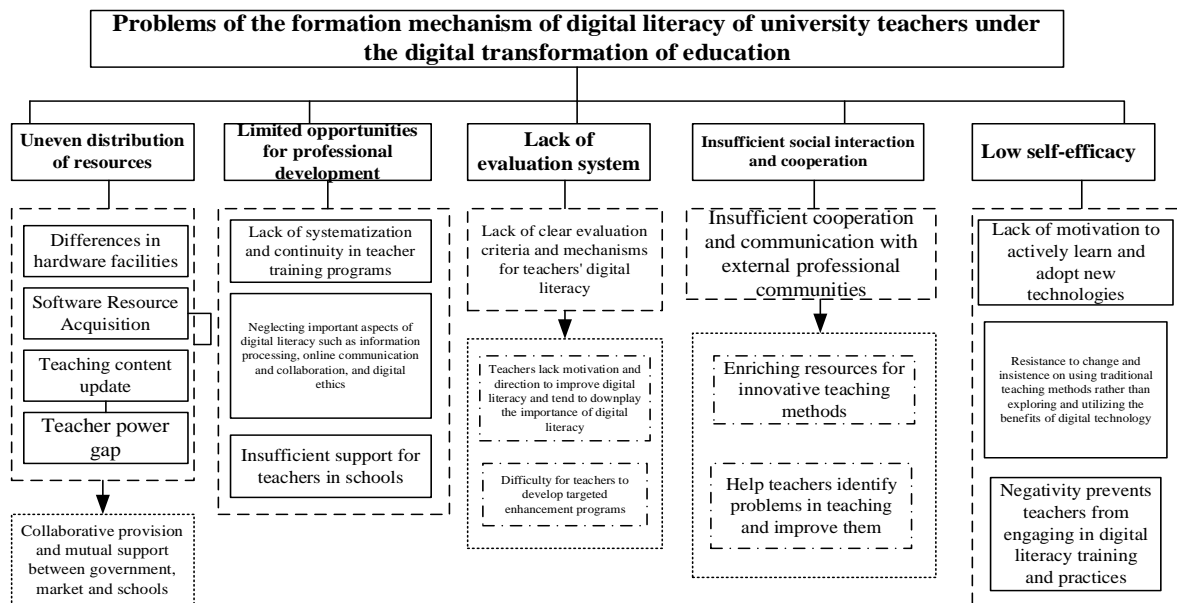
Fig. 1 Problems in the formation mechanism of digital literacy of university teachers under the digital transformation of education

a. Uneven distribution of resources

There is a clear imbalance in the distribution of digital resources in higher education, especially in terms of hardware facility differences and access to software resources,

The updating of teaching content and the gap in teachers' strength are most obvious and prominent. Collaborative supply and mutual support among the government, market and schools are the prerequisites for the effective supply of digital education resources, and the government, as the implementer of the national education policy, should play a good role in guiding and guaranteeing. There is a significant difference between the types of digital education resources that teachers expect to use and the types of digital education resources that are currently frequently used, and teachers in all regions have higher expectations for all types of resources.

b. Limited opportunities for professional development

Although some colleges and universities offer teacher training programs, these programs tend to be sporadic and lack systematicity and continuity. As a result, it is difficult for teachers to achieve sustained professional growth and development. In addition, these trainings tend to focus on the transfer of technical skills, neglecting important aspects of digital literacy such as information processing, online communication and collaboration, and digital ethics. Schools are currently not supporting teachers enough in this area, and there is much room for improvement. Specifically, training topics should be based on teachers' needs, and training should not be imposed on teachers, thus becoming a burden; in the form of training, it can be flexible and diversified, avoiding a single "lecture hall" type of training, including the use of some online channels, as well as remote seminars, etc., which do not necessarily have to be all face-to-face forms; in the form of training content, it can be flexible and diversified, avoiding a single "lecture hall" type of training. In terms of the content of the training, it is important to consider not only the reality of the school, but also future trends, including the international frontiers of development, in order to enhance the comprehensive digital competence of teachers.

c. Lack of evaluation system

Currently, most colleges and universities lack clear evaluation criteria and mechanisms for teachers' digital literacy. Without clear evaluation criteria and systems, teachers may lack the motivation and direction to improve their digital literacy and have difficulty recognizing and understanding the importance of digital literacy and its impact on teaching quality. In addition, in the absence of an evaluation system, teachers cannot accurately understand their own strengths and areas for improvement in various aspects of digital literacy, and it is difficult for them to formulate targeted improvement plans. At the same time, in the absence of effective evaluation, even if training opportunities are provided, it is difficult to ensure the actual effectiveness and quality of these opportunities. For decision-makers in universities and educational administrations who formulate or adjust relevant policies, the lack of such data will make it difficult to accurately grasp the current status and trends of digital literacy development, thus affecting the formulation and implementation of effective policies. Effective Evaluation System9 is the key to motivate and guide teachers to continuously

improve digital literacy.

d. Insufficient social interaction and cooperation

Although social cognition emphasizes the social interaction[10] and observational learning in the formation of digital literacy, the reality is that there is still insufficient cooperation and communication within HEIs and with external professional communities. Professional communities are important platforms for knowledge exchange and updating, and insufficient interactions may lead to a lack of understanding of the latest educational technologies, teaching philosophies, and practice methods among university teachers, which may affect the level of modernization of their teaching content and methods. Through interactions with external professional communities, teachers can be exposed to new teaching tools, strategies and research trends that promote innovation in teaching methods. External professional communities are often rich in online resources, including online courses, seminars, and workshops and can provide teachers with valuable feedback to help them identify problems in their teaching and improve it. Thus, insufficient social interaction and collaboration limits teachers' opportunities to improve digital literacy through social interaction.

e. Low self-efficacy

Teachers' confidence in their ability to use digital technology - i.e., self-efficacy[11] that is critical to the development of digital literacy. Teachers with low self-efficacy may lack the motivation to actively learn and adopt new technologies. They may doubt their own abilities and avoid engaging in digital literacy enhancement activities for fear of not being able to master new digital tools or methods. When teachers do not believe they can successfully adapt to the digital transformation, they may resist change and stick to traditional ways of teaching and learning rather than exploring and utilizing the benefits of digital technologies. Teachers' digital literacy is a key component of professional development in the modern educational environment. A low sense of self-efficacy may lead to missed opportunities for teachers' career development; they may not believe they have what it takes to accept a higher position or take on more responsibility, and it may also lead to anxiety, stress, and dissatisfaction, psychological states that can further discourage teachers from actively engaging in digital literacy training and practice.

In summary, the problems of the existing mechanisms highlight the urgent need for research on the mechanism of digital literacy formation among college teachers in order to develop more effective strategies and measures to promote teachers' digital literacy and achieve the goal of digital transformation of education. Solving the above problems requires not only resource optimization and policy support within HEIs, but also the establishment of cross-disciplinary and cross-institutional partnerships, as well as the strengthening of teachers' self-efficacy and social interaction. Only in this way can we provide a comprehensive and sustainable digital literacy development environment for university teachers.

4. **Exploration of Digital Literacy Formation Mechanisms for College Teachers under the Digital Transformation of Education**

a. Exploring the digital literacy hierarchy of university teachers under the digital transformation of education

In the context of the era of digital transformation of education, the digital literacy of college teachers has become a key indicator of their teaching ability and professional development. Digital literacy involves not only basic technical operational skills, but also the comprehensive ability to utilize digital technology for instructional design, resource integration and academic communication. In order to deeply understand the formation mechanism of digital literacy of college teachers, this study will explore it from three levels, micro-individual, meso-education industry, and macro-society. Specifically as shown in Figure 2.
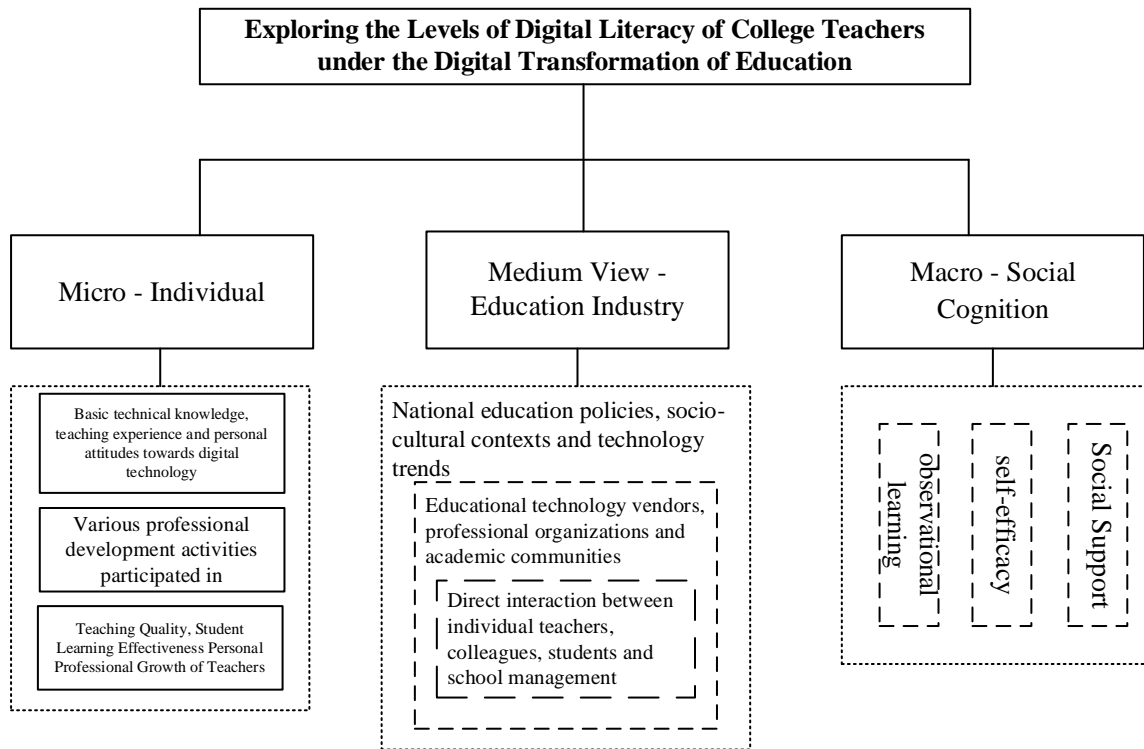
Fig. 2 Exploring the levels of digital literacy of university teachers under the digital transformation of education

micro-individual, addressed through the initial conditions that teachers have before they start the training, including basic technological knowledge, teaching experience, and personal attitudes toward digital technology, to the various professional development activities that teachers engage in, such as seminars, online courses, and workshops, and how they incorporate the new technology into their teaching practices. Finally, it is reflected in the improvement of teaching quality, the enhancement of student learning outcomes, and the teachers' personal professional growth.

Medium View - In the education industry, the formation of digital literacy among college and university teachers is a multilevel interactive process, with direct interactions among individual teachers, colleagues, students, and school administration; connections with educational technology vendors, professional organizations, and the academic community; and broader national educational policies, socio-cultural context, and technological trends. environmental factors that influence teachers.

Macro - Social Cognition, focuses on the impact of social interactions on the formation of digital literacy among college teachers, ranging from observational learning, where teachers learn new pedagogical methods and tools by observing the way their peers and students use digital technologies, to self-efficacy, which refers to the beliefs of teachers about their own ability to use digital technologies and thus influences their willingness to adopt and integration of new technologies and finally social support which is support from colleagues, leaders and family members can enhance teachers' digital literacy and motivation for continuous learning. By integrating these three levels and exploring in depth the factors and their interactions at the individual, organizational and social levels, we can better understand and promote the development of teachers' digital literacy. This will help us better understand the development process of digital literacy, thus providing theoretical support and practical guidance for enhancing teachers' digital literacy and promoting the digital transformation of education.

5. **Clarifying the Direction of Digital Literacy Development for College Teachers under the Digital Transformation of Education**
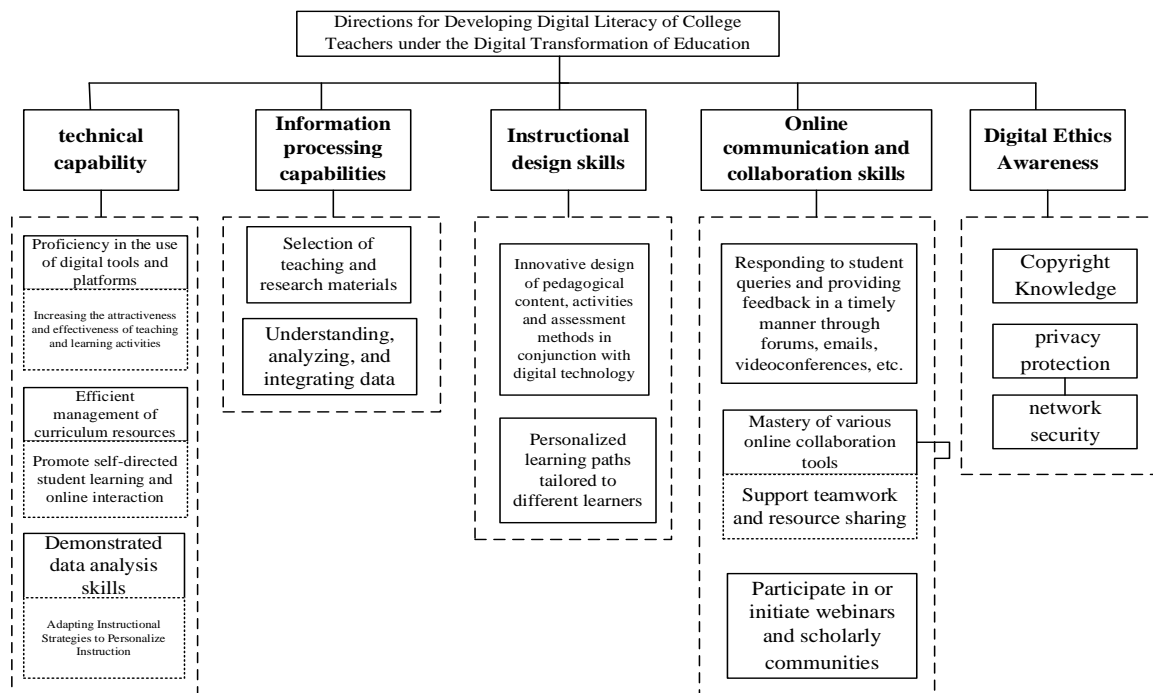
The specific training directions are shown in Figure 3.

Fig. 3 Directions for the development of digital literacy of university teachers under the digital transformation of education

a.Technical operational capability

This means that this includes proficiency in the use of a variety of digital tools and platforms, such as learning management systems (LMS), office software, online collaboration tools, and multimedia authoring software. Teachers with these technological skills are able to design interactive and content-rich digital teaching and learning materials12 that enhance the attractiveness and effectiveness of teaching activities. At the same time, they are also able to manage course resources efficiently in the online environment, and promote students' independent learning and online interaction. In addition, technology competence involves data analysis skills, enabling teachers to adjust teaching strategies and personalize teaching by analyzing students' learning data.

b.Information processing capabilities

This includes being able to skillfully retrieve, filter, evaluate and utilize vast quantities of digital information resources. Teachers need to be able to quickly locate high-quality teaching and research materials from a variety of databases, online libraries, scholarly journals and open educational resources. In addition, information processing skills involve understanding, analyzing, and integrating data so that teachers can construct a body of knowledge, develop critical judgment, and effectively incorporate this information into teaching content and scholarly seminars. In the digital environment, teachers' information processing skills play a crucial role in maintaining academic integrity, complying with copyright regulations, and enhancing pedagogical interactivity and scholarly innovation. Therefore, colleges and universities should support faculty's continuing professional development in this area to adapt to the ever-changing landscape of educational technology.

c. Instructional design skills

The digital environment involves teachers who are able to incorporate digital technologies in the innovative design of content, activities and assessment methods. Teachers with this competency are able to create interactive and engaging learning environments, using multimedia resources and online tools to enhance the student learning experience. They are able to design instructional programs that are appropriate for blended online and offline modes, as well as utilize data-driven methods to assess student progress and adjust instructional strategies. In addition, instructional design skills include understanding the needs of diverse learners and tailoring personalized learning paths for them. Effective digital instructional design13 not only enhances the quality of instruction, but also promotes critical thinking, collaboration, and self-directed learning among students.

d. Online communication and collaboration skills

This involves the use of digital tools for effective communication, teamwork and online teaching and research activities. It enables teachers to establish good interactions with students in a virtual environment, responding to students' queries and providing feedback in a timely manner through forums, emails and video conferencing. Teachers also need to master various online collaboration tools,

such as shared document editing and project management platforms, to support teamwork and resource sharing. Online communication and collaboration skills also include the ability to participate in or initiate webinars and scholarly communities to facilitate knowledge dissemination and scholarly dialog. These skills not only enhance the interactivity and flexibility of teaching and learning, but also broaden the boundaries of education and pave the way for globalized academic exchanges. Therefore, in order to adapt to the trend of digitalization of education, teachers' online communication and collaboration skills are indispensable.

e. Digital ethics awareness

Teachers should have a sense of ethics in the online environment, including knowledge of copyright, privacy protection, and cybersecurity. This awareness includes respect for intellectual property rights, protection of students' privacy, knowledge of network security, and an attitude of responsible use of digital technology. Teachers should be able to understand and comply with relevant laws and regulations, such as copyright and data protection laws, to ensure that teaching resources are used legally, as well as educating students about these laws. In addition, teachers need to be aware of the potential impact of publishing information in the digital environment and should set an example by demonstrating good digital behavior. Reinforcing teachers' awareness of digital ethics can help create a safe, respectful and positive learning environment that not only promotes the holistic development of students, but also upholds the reputation and legal responsibility of educational institutions.

6. Building a multi-party collaborative training mechanism

In the context of the digital transformation of education, the digital literacy of college teachers is the key to achieving effective teaching and promoting student development. Through the research in this paper, we recognize that the formation of digital literacy is a multidimensional, dynamic and complex process. Based on the theoretical analysis of the three approaches, we put forward the following discussion and suggestions, as shown in Figure 4.
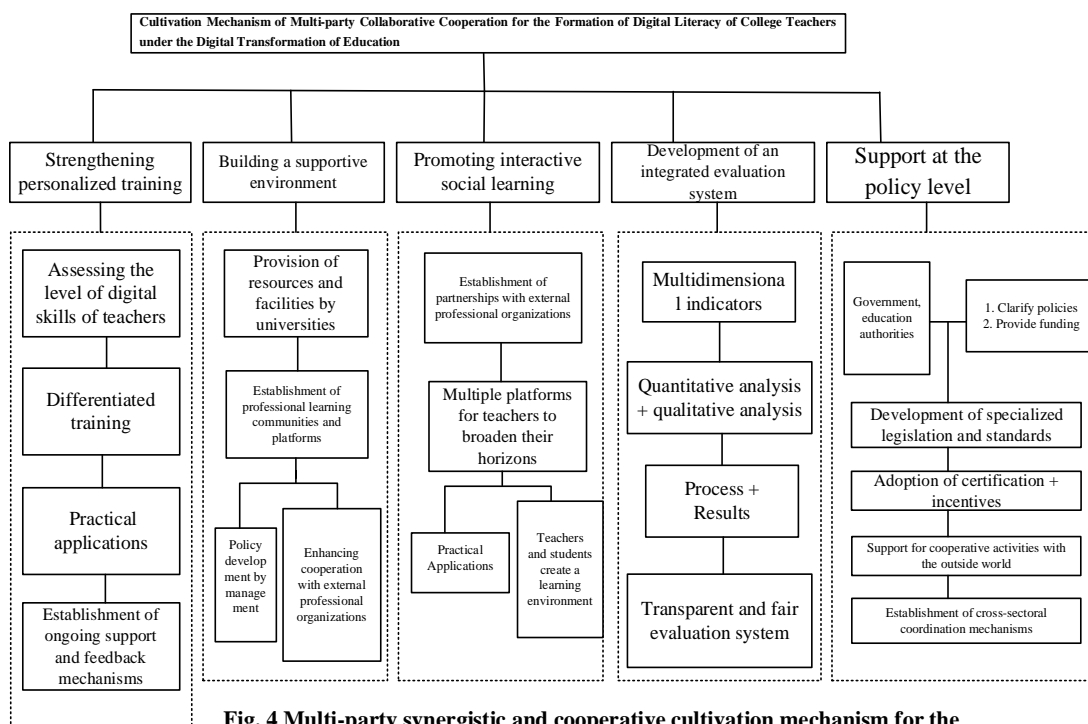

Fig. 4 Multi-party synergistic and cooperative cultivation mechanism for the formation of digital literacy of university teachers under the digital transformation of education

a. Strengthening personalized training

Personalized training should be designed to meet the individual differences of teachers14 , providing diversified learning paths to meet teachers with different foundations and needs. First, a diagnostic assessment of teachers' digital skill levels can be used to understand the specific needs of each teacher in terms of technology operation, information processing, instructional design, online communication and collaboration, and awareness of digital ethics. Based on these assessment results, differentiated training programs are designed to provide customized learning paths and resources. Secondly, flexible training modes including online self-study, workshops, group seminars and one-on-one tutorials are implemented to meet the needs of different learning styles and time schedules. In addition, teachers are encouraged to participate in practical projects and teaching experiments to apply what they

have learned in real-life teaching scenarios in order to facilitate the application of what they have learned. Finally, a continuous support and feedback mechanism15 that ensures teachers receive the necessary guidance and assistance in their practice.

b. Building a supportive environment

Schools should establish a technology support system to optimize the allocation of digital resources and create a positive organizational culture that encourages teachers to explore and apply new technologies. First, universities should provide adequate technological resources and infrastructure, such as high-speed Internet connections, modern hardware and software equipment, and convenient technical support services, to ensure that teachers are able to explore and apply digital tools in an optimized environment. Second, professional learning communities and platforms should be established to encourage exchanges and collaborations among teachers and the sharing of best practices and experiences, thus creating a positive learning atmosphere. In addition, the management should promote the development of a clear policy on digital literacy enhancement, including regular assessment and incentive mechanisms to recognize and reward teachers' efforts and achievements in digital literacy. At the same time, collaboration with external professional organizations should be strengthened to provide teachers with a wider range of learning and development opportunities.

c. Promote social interactive learning

It is recommended that communication and collaboration among teachers be enhanced through the establishment of professional communities and peer review to jointly improve digital literacy. First, colleges and universities can establish partnerships with industry experts, other educational institutions, and the community to provide teachers with opportunities for interdisciplinary exchanges through seminars, workshops, and conferences. Second, teachers are encouraged to participate in online forums, social media and professional networks, which are platforms that can broaden their horizons and provide access to the latest educational technologies and pedagogies. In addition, through project cooperation or academic exchanges, teachers should be involved in wider social practices that are oriented to practical problems, so as to enhance their application ability and innovative thinking. At the same time, the establishment of a co-created learning environment between teachers and students should be advocated to allow students to participate in the instructional design process and to promote interaction and common growth between teachers and students. By promoting social interactive learning16 that enhances the digital literacy of college teachers.

d. Development of an integrated evaluation system

To establish and improve the evaluation mechanism of teachers' digital literacy, and to include digital literacy as one of the indicators in teachers' performance appraisal, in order to motivate teachers' continuous learning and growth. First of all, this evaluation system needs to include multi-dimensional indicators, such as technical operation ability, information processing ability, instructional design ability, online communication and collaboration ability, and digital ethics awareness. These indicators should reflect teachers' digital literacy performance in their daily teaching and professional development. Second, evaluation methods can combine quantitative and qualitative analysis17 that include self-assessment, peer review, student feedback, and examination of actual teaching results. In addition, the evaluation system should emphasize the combination of process and result to encourage teachers to learn and improve continuously. Finally, universities should ensure the transparency and fairness of the evaluation system and provide teachers with clear feedback and development suggestions.

e. Policy-level support

Provide the necessary financial support and policy guarantee for the improvement of teachers' digital literacy. First, the government and education authorities should introduce a clear policy to make digital literacy one of the core competencies for teachers' professional development and provide appropriate financial support for training and resource building. Second, specialized regulations and standards should be developed to ensure that educational institutions follow best practices and industry standards when implementing digital teaching and learning. In addition, certification and incentive mechanisms, such as award schemes and bonus points in title evaluation, can be used to encourage teachers to actively participate in digital literacy enhancement activities. Policies should also support teachers' participation in domestic and international training, academic exchanges, and industry-university-research collaborations to broaden their professional horizons. Finally, policymakers should consider establishing a cross-sectoral coordination mechanism18 to ensure policy consistency and effective implementation of digital transformation in education.

(2024SCG240).

References

1. GU Xiaoqing,LU Linmeng,WAN Ping. Paradigm change of educational research under the digital transformation of education[J]. China Distance Education,2024,44(02):36-46.

2. Zhao Ying. Value orientation and measures of higher education reform in the era of big data[J]. Journal of Heilongjiang Teachers' Development Institute,2024,43(02):41-44.

3. Zuo Wenjing,Wang Zhanren. The Connotation, Strategic Needs and Realization Path of the Strategy of Developing the Country through Science and Education in the New Era[J]. Journal of National College of Education Administration,2023,(02):16-24.

4. Yang Liwen. The new requirements of information technology teaching on the quality of teachers[J]. Examination Weekly,2018,(32):163.

5. Ren Huiying,Ji Yukun. Internal Logic and Realization Path of "Education, Science and Technology, and Talents Leading and Driving as One"[J]. Journal of Taiyuan Normal University (Social Science Edition),2023,22(04):1-7.

6. FU Zhongnan,GUO Qiang,CHEN Junjun et al. Research and Practice on the Construction of "Internet+Education Platform" in Colleges and Universities--Taking Peking University as an Example[C]//Chinese Computer Users Association Network Application Branch. Proceedings of the twenty-seventh annual conference on new network technologies and applications of China Computer Users Association Network Application Branch 2023. Computing Center of Peking University;,2023:5.

7. Sun Mingyuan. Let the world share China's quality education resources[N]. Science and Technology Daily, 2024-03-20(005).

8. PENG Yanning,SHI Qihang. Research on the application of balanced teaching resources of digital technology in the context of meta-universe[J]. Popular Literature and Art,2024,(02):208-210.

9. Huang Yun,Wang Yuan. The construction of open university teacher evaluation system based on teacher development[J]. Journal of Inner Mongolia Electric University,2022,(05):96-102.

10. Du Jing,Wang Xiaofang. On teacher cooperation based on social interaction theory[J]. Educational Research,2016,37(11):113-118.

11. Wang Jia,Zhong Guanxiu,Peng Hanyu et al. Is Research Performance of Higher Education Teachers Related to Their Personality Traits? --The mediating role of self-efficacy[J]. Journal of Jingchu Institute of Technology,2023,38(05):59-67.

12. Wei Yanmin,Zhang Hui. Discussion on the quality of professional teachers in applied technology colleges and universities[J]. Inner Mongolia Science and Economy,2015,(13):48-49.

13. Liu J. Research on the theoretical framework and instructional design of deep learning[J]. Journal of Nanchang Normal College,2023,44(06):127-131.

14. Bian Bo. Research on personalized training for college teachers in the era of big data[J]. Continuing Education Research,2023,(10):74-78.

15. Zhou Yike,Xiong Xiaoxiao. Exploration of constructing feedback mechanism for teachers and students in the context of modern university governance[J]. Great Horizons,2023,(05):64-68.

16. Hao L ,Zhao-Hua W ,Bin Z .How social interaction induce energy-saving behaviors in buildings: interpersonal passive interactions v.s. public active interactions[J].Energy Economics,2023,118

17. Wang W ,Wang Z ,Dong D .A Comprehensive Quality Evaluation System for University Students Based on Teacher Performance Coefficients[J]. Journal of New Developments in Education,2023,5(16).

18. Ek Maolin. Cross-sectoral coordination in education reform:An analytical framework and its application[J]. Journal of East China Normal University (Education Science Edition),2019,37(06):137-148.