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A study on factors and strategies for digital innovation capability of normal vocational college teachers in China

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Abstract: Based on the Technological Pedagogical Content Knowledge (TPACK) theory and digital innovation capability, this study aims to discuss factors affecting the promotion of digital innovation capability and possible methods for improvement. This paper focuses on teachers of Chinese higher vocational normal colleges as research subjects in studying the influencing factors and strategies for improving their digital innovation capability. Grounded in theories, this research adopts purposive sampling, selecting 12 faculty members at Chinese higher vocational normal colleges for focus group interviews, and 6 experts and scholars in the field of educational technology for semi-structured one-on-one interviews, in order to combine the viewpoints of ordinary teachers and administrators, and comprehensively collect data. The results demonstrate that the influencing factors include the individual, organizational, and macro levels. At the individual level, the factors include the TPACK gap and innovation mindset; the organizational level entails the research and development climate and platform facilities; while the macro level relates to assessment and evaluation systems.

Keywords: *Digital innovation capability, Educational innovation, Higher vocational education, Teacher professional development, TPACK.*

1. Introduction

With a fast-tracked, global digital transformation of education, next-generation digital technologies led by big data, cloud computing, and artificial intelligence have rapidly iterated and evolved while all kinds of industries are increasingly being digitized [1]. The rapid innovation of information technology and heightened economic competition have profoundly changed the educational ecosystem, transformed teaching tools and methods, and refigured the goals and content of education [2-4]. Digital technologies are a main engine of educational reform and have also transformed the demand structure of the labor force market. Consequently, human capital with high-quality digital skills is of significant value and demand [5].

In this worldwide agreement and tendency centered on educational digitalization, teachers' roles are transitioning from knowledge givers to learning facilitators and innovation practitioners [6]. This shift requires new demands on teachers' competencies; it is not just about technological knowledge (TK) but more about an integrated, more complex competence called Technological Pedagogical Content Knowledge (TPACK), which requires an in-depth understanding of the reciprocally revolving relationship between technology, pedagogy, and content [7]. From this, the digital innovation ability to use this integrated knowledge in practice and to construct new teaching experiences has become a core competence for professional practice in the digital age [8].

Vocational education in China has now entered the digital era on all fronts. Yet, in the aftermath of newly enacted policies and frontline practices, the digital innovation capacity among vocational educators in Chinese higher vocational education normal colleges seems improperly calibrated with what is required [9]. Current research suggests a severe lack of training in this key skill for vocational

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teacher educators. Moreover, most staff development programmes in higher vocational education normal colleges are primarily concerned with traditional educational technologies, and training content is largely restricted to knowing basic aspects. Therefore, systematic integration of advanced, TPACK-dependent domains, including intelligent learning analysis, AI-based virtual simulation tools, and educational big data applications, is absent [10]. Furthermore, comparative studies show that educators in Chinese higher vocational normal colleges have significantly lower scores compared to the EU average in the domain of innovative instructional design involving digital technologies [11]. The integration of emerging industry technology with teaching practice remains insufficient, and opportunities to experience real, hands-on digital skills teaching practice are very limited. Furthermore, inadequate institutional support for classroom experimentation has also left teachers with insufficient resources and space to develop their own digital innovation capabilities [12, 13].

As such, the aim of this study is to examine, using in-depth qualitative interviews, the true nature of digital innovation capability of teachers in Chinese higher vocational normal colleges and the complex factors that shape it. This study is particularly focused on answering these two research questions:

1. What are the key factors that shape the digital innovation capability of teachers in Chinese higher vocational normal colleges?
2. What effective strategies can be proposed to improve their digital innovation capability?

2. Literature Review and Theoretical Framework

2.1. Teachers' Digital Innovation Capability

Annarelli et al. [14] view digital innovation capability as a key subdimension of the broader construct of "digitalization capability," emphasizing its agile capacity and innovation-oriented capability. Huang et al. [15] have validated this definition within the Chinese education context, which appears to be highly compatible with the exploratory intentions of the current study. Therefore, the research adopts the framework presented by Annarelli et al. [14], and considering the nature of teachers' education in higher vocational institutions, a definition of teachers' digital innovation capability is as follows for operational purposes: The dynamic capability of faculty in higher vocational normal colleges to innovate in educational practice within a digital environment refers to the deep integration of technological application (TK) with educational innovation (the fusion of PK and CK), specifically manifested as teachers' comprehensive competence to "sense" opportunities for technological change, "seize" resources to restructure teaching models, and ultimately generate new educational value in their instructional practice.

2.2. TPACK Theory

The framework of Technological Pedagogical Content Knowledge (TPACK) provides the theoretical background for this study's interviews and the analysis of teachers' competence characteristics. The TPACK framework was developed by Mishra and Koehler [7] as an expansion of Shulman's [16] Pedagogical Content Knowledge (PCK), in order to address the issues that digital technologies have created within the teaching domain. The framework is based on the concept that teachers' effective technology integration requires a complex and dynamic system of knowledge, in which three primary knowledge bases must be brought together: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). Even more significantly, the interactions between all these three areas collectively lead to four new areas of integrated knowledge: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and lastly, the highest order TPACK at the center of all the integrations [7].

In summary, this research employs the TPACK framework as a guiding and analytical tool to inform interview design, support grounded theory coding, and identify factors influencing teachers' digital innovation capabilities.

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2.3. Factors Influencing Teachers' Use & Innovation of Technology

Current research shows that the factors affecting teachers' adoption and innovation of technology, and consequently their digital innovation capability, can be complex and generally can be considered at three levels: individual, organizational, and technology context.

At the individual level, teachers' attitudes, digital self-efficacy, confidence, and willingness to innovate have been repeatedly validated as significant antecedent factors for adopting and integrating technology [17-20]. In general, innovative teachers are characterized as having more perseverance, risk-taking behavior, and student-centered beliefs [21], while resistance to change and a lack of confidence are listed as primary individual barriers [18, 22].

Supportive frameworks of colleges serve as important moderators of innovation at the organizational and environmental levels. For digital transformation to be effective, powerful leadership, precise strategic planning, and systematic integration have been cited as preconditions [23, 24]. Adequate resources, especially ongoing professional development, technical support, incentives, and sufficient time for planning, are necessary to eliminate barriers associated with technology application [18, 25-27]. Conversely, external barriers also exist, primarily including the lack of a clear vision from institutions, the absence of reward mechanisms, and time restrictions due to heavy workloads [21, 28, 29].

From a technology perspective, the makeup and availability of technology, along with how dependable the infrastructure supporting that technology is, are essential material bases of innovation. The inequitable access to technology has been shown through research to contribute to the teaching capacity of the teachers involved [30]. The positive impact of technology does not exist by default, but rather is determined by the user's specific instructional practice as an educator [31] or, more specifically, by the ability of the educator to utilize technology [19].

However, this systematic review shows that current research has three significant constraints that provide the basis for this paper.

First, the current research lacks an integrated view because it analyzes individual, organizational, and technological factors as distinct elements while not providing any models that explain how they interact or limit or enhance each other's interactions (e.g., an organizational culture that either suppresses or enhances an employee's personality traits). Second, most research on school change identifies various influential factors; however, very little research has examined how these factors operate. Although leadership is considered important for implementing school change, it has not been determined how enlightened leadership translates into teachers' actual innovative practices [32]. Finally, current research is generally characterized by contextual ambiguity. Although there is evidence of studies addressing vocational education [32], little has been published regarding the developing research base for Chinese higher vocational normal colleges. The unique dual role of educators and practitioners in creating innovative practices has been greatly influenced by the dual-teacher training objectives for this group, along with the pressures of industry-education integration and the individual evaluation systems that have yet to be studied in depth.

As a result, this project uses a grounded method rather than simply identifying influential factors to obtain a more thorough understanding of teachers' experiences as they interact with students and create a localized theoretical framework of interactions between these elements.

3. Research Method

3.1. Research Design

The goal of this research is to provide a thorough examination of the features, influencing determinants, and corresponding factors of Chinese higher vocational normal colleges educators' digital innovation ability. However, gathering only qualitative evidence of the experience, perception, and motivation of this group in context-specific situations is not sufficient. To comprehensively understand these phenomena, we adopt a qualitative case study approach using semi-structured interviewing methods to develop an indigenous explanatory model of China. This study combines one-on-one in-

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depth interviews exploring individual experiences with focus groups to discover collective consensus and divergence, thereby achieving both depth and breadth [33, 34]. The triangulation of data provides research validity [35] and allows a robust setting for the development of a specific theoretical framework.

3.2. Procedure and Participants

As pointed out by Guest et al. [36], qualitative research will generally reach data saturation after 6–12 interviews. Therefore, the methodology used in this project involved purposive sampling [37] to conduct interviews with twelve regular course instructors as well as six educational technology scholars and experts. The twelve instructors were organized into focus group interviews based on their professional titles and teaching experience. A list of the participants, with their corresponding codes, is displayed in Tables 1 and 2.

Table 1.
Preliminary Profile Table of One-on-One Interview Participants.

Participant	Gender	Age	Years Teaching	Title	Education	Role	Major
A	Female	35-40	6-15	Professor	Ph.D	Vice Dean	Education
B	Male	35-40	6-15	Professor	Ph.D	Lead Researcher	Linguistics
C	Female	40-55	≥16	Professor	Ph.D	Vice Dean	Education
D	Male	40-55	≥16	Professor	Ph.D	Dean	Electronic Engineering
E	Female	40-55	≥16	Professor	Ph.D	Project Lead	Education
F	Male	40-55	≥16	Professor	Ph.D	Project Lead	Management

Table 2.
Preliminary Profile Table of Focus Group Interview Participants

Participant	Gender	Age	Teaching Experience (Years)	Academic Rank	Highest Degree	Academic Discipline
G	Female	≤35	≤5	Teaching Assistant	Master	Applied English
H	Female	≤35	≤5	Teaching Assistant	Master	Educational Technology
I	Male	≤35	≤5	Teaching Assistant	Master	Mechatronics Engineering
G	Female	36-45	6-15	Lecturer	Master	Art Education
K	Male	36-45	6-15	Lecturer	Master	Preschool Education
L	Female	36-45	6-15	Lecturer	Master	Primary Education
M	Male	36-45	6-15	Lecturer	Master	Primary Education
N	Female	36-45	6-15	Lecturer	Master	Primary Education
O	Male	≥46	≥16	Associate Professor	Master	Mechatronics Engineering
P	Male	≥46	≥16	Professor	Ph.D.	Education
Q	Female	≥46	≥16	Professor	Master	Education
R	Male	≥46	≥16	Associate Professor	Bachelor	Education

3.3. Research Instrument

This study has two categories of interview participants and two different types of interviews. Two protocols are developed for the two kinds of interviews conducted. The first protocol involves conducting semi-structured interviews with individual educational technology experts by asking them seven predefined questions. The main theme is to go beyond describing the personal practices of each individual participant and develop an understanding of educational practice based upon the collective input of educational technology experts, to focus on investigating effective methods for improving teachers' digital innovation capabilities.

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The second protocol consists of seven questions directed toward a total of 12 regular higher vocational normal college educators. This protocol aligns with the Grounded Theory research method [38] and aims to provide insights through collective stories shared by frontline educators, exploring the underlying factors that influence teachers' ability to innovate digitally.

3.4. Coding Method

The coding approach of the present study is shaped by the grounded theory articulated by Glaser and Strauss [38] and follows the three-step coding approach by Strauss and Corbin [39] to categorize and analyze the data. The rules for coding specify that the first letter of the code indicates the participant group: for the six participants in the one-on-one interviews, codes A-F are used. For the twelve participants in the focus group interviews, codes G-R are assigned. The second part denotes the major category (selective coding): KAD (Key Factors Affecting Digital Innovation Capabilities) represents the key factors influencing digital innovation capabilities, while CSI (Countermeasures and Suggestions for Improving Digital Innovation Capabilities) indicates solutions and suggestions for enhancing digital innovation capabilities within organizations in the study. The third part signifies the axial code, using a lowercase letter "a" and progressing through the alphabet. The fourth part indicates the order of the concept, starting with 1. For example, A-KAD-a-1 refers to the first concept provided by the first expert in the one-on-one interviews for the first axial code of the major category.

3.5. Reliability and Validity

To establish reliability and validity in the data, the coding from the interviews was examined by experts who had specialized knowledge of qualitative research and education [40]. Content validity of the interview protocol was established after discussion with five expert educators with experience in pedagogy and digital innovation. After obtaining validation from experts and making necessary amendments, participants were allowed to review the transcripts from the interviews to identify issues and provide amendments if necessary, and it was expected that researchers would accept those requests [41]. In developing a thick description of the participants' experiences, efforts were made to control researchers' subjective bias to further mitigate the distorting of participants' perspectives and feelings.

4. Results and Discussion

4.1. Coding Analysis

For review and organization, the coded data were consolidated and compiled into a coding table. The coding process and the corresponding results are presented in Table 3.

Table 3.
Coding analysis.

Selective coding	Spindle coding
Factors Influencing Teachers' Digital Innovation Capability	
	Learning and Development Atmosphere (a)
	Platform and Infrastructure Foundation (b)
	Technical Complexity and Training Support (c)
	Policy and Institutional Support (d)
	Teachers' Individual Digital Competence (e)
	Teachers' Learning and Innovation Mindset(f)
Strategies for Enhancing Teachers' Digital Innovation Capability	
	Diversifying Digital Innovation Training for Teachers (g)
	Addressing Individual Teacher Needs (h)
	Improving Platform Mechanisms and Institutional Frameworks (i)
	Establishing Mutual Assistance and Collaboration Mechanisms (j)
	Providing Specialized Technical Support (k)

Note: The letters in parentheses represent axial coding identifiers.

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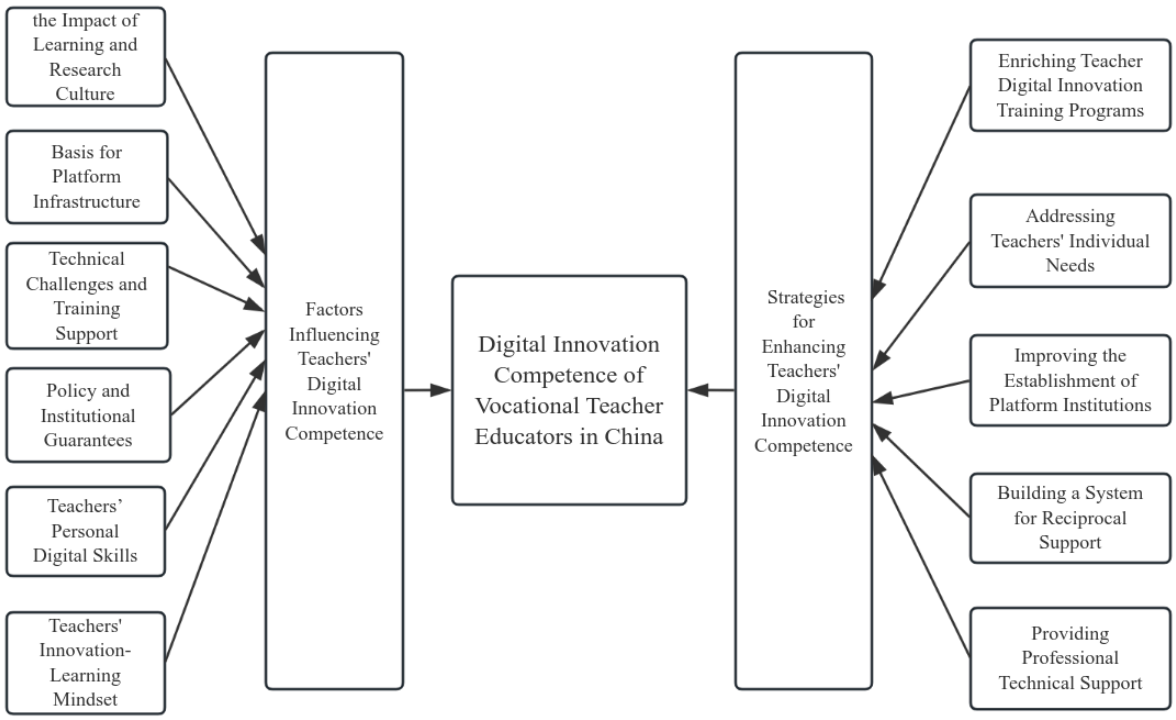

Figure 1.
A Theoretical Model of Influencing Factors and Countermeasures for Teachers in Digital Innovation Capability among Chinese Higher Vocational Normal Colleges.

4.2. Factors Affecting Teachers' Digital Innovation Capabilities

This selective coding examines the factors that influence the digital innovation capabilities of vocational teacher education faculty, revealing a complex ecosystem that spans six levels: macro policies, learning and research culture, platform infrastructure, technical challenges and training support, policy and institutional guarantees, teachers' personal digital skills, and teachers' innovation-learning mindset.

The impact of learning and research culture refers to the extent to which school and organizational culture support or hinder teacher innovation. Afshari et al. [42] demonstrated that school culture is a key factor influencing teacher innovation. A culture that promotes innovation and risk-taking, along with transformational leadership from principals, can significantly enhance teachers' ability to integrate technology. Regarding leadership, it was also found that the primary driver of teachers' digital innovation capabilities is a professional instructional management-led–led approach rather than administrative directives. Participants reported that through the accumulation and sharing of teachers' resources, replicable practices and shareable materials gradually develop. The data indicate that a positive atmosphere is characterized by tolerance and curiosity. Schools openly acknowledge less successful attempts through low-pressure sharing sessions, conveying that the process of exploration is as valuable as the outcomes.

If a teacher is surrounded by colleagues who are willing to share and dare to experiment, forming a small innovation community where members can learn from one another and share lessons from failures, the threshold for innovation is greatly lowered. (C- KAD -a-4)

Well, let me start with expectations. For the projects into which we have invested resources, there are indeed some clear expectations, but the core of these expectations is not evaluation; it is

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accumulation and sharing. We do not want a teacher's innovation to remain confined to their own classroom. What we most hope to achieve are replicable practices and shareable resources. (C- KAD -a-5).

The basis for developing platform infrastructure refers to the fundamental conditions and resource support necessary for teachers to foster digital innovation. Findings indicate that the National Smart Education Platform provides extensive resources for free curricular materials, a significant benefit at the national level. At the college level, developing digital infrastructure, including smart classrooms, future-learning laboratories, high-speed internet, and database resources, has established the hardware foundation for innovation in educational practice. Infrastructure is not solely material; the development of peer-interaction spaces, such as virtual teaching-research rooms and teaching workshops, creates fertile ground for innovation and helps overcome barriers caused by limited technology integration and scarce technological resources [43]. The participants indicated:

In relation to our infrastructure, we have a solid network environment, smart classrooms, and a wealth of database resources, all of which provide the hardware basis for teachers to explore digitally. (F-KAD-b-2).

We have some new buildings for teaching, and the network is excellent; all online tools work smoothly. However, in older buildings, the Wi-Fi connection is unreliable, making it difficult to use interactive platforms; often, buffering an HD video is problematic. You use it once or twice and then avoid internet-dependent activities in that room; thus, these basic hardware conditions effectively set the lower bound for our innovation. (G-KAD-b-4)

Technical challenges and training support concern the user-friendliness of digital tools and the availability of associated professional development support. The data show that when tools are poorly designed or too complicated to use, they significantly reduce the motivation of both teachers and students. Teachers repeatedly claimed that the most valuable training is practice-based, linking directly to their instructional needs. Successful teacher professional development is essential for integrating technical training into actual pedagogical practice. As Lawless and Pellegrino [44] suggest, one-off, theory-based workshops have minimal impact on teachers' training, whereas long-term, practice-based, curriculum-embedded models of training effectively change teaching practice. The participants commented:

Teachers will not gain confidence in or interest in using digital tools simply because they have been told to use them or experienced a one-off session of technical training. These aspects typically arise from a meaningful opportunity for interaction, which connects technologies with their actual instructional purposes, and is supported by a professional culture that values inquiry and discourse. (G4-KAD-c-4).

Training cannot be all theory; it must involve operating the tools. It should be conducted in small groups so that teachers can follow along on the spot and ask questions immediately. (D-KAD-c-6)

Policy and institutional guarantees provide macro-level momentum and protective mechanisms for teacher innovation, representing the policy-level force that guides innovation efforts. China's educational digital transformation is heavily policy-driven, with initiatives at the national level offering clear direction and resource support for school-level innovation [45]. Data indicate that if top-level designs are not translated into effective systems for teachers' evaluation and assessment, and if acceptance of failure is not fostered, the intended policy momentum may be weakened or misinterpreted during implementation. Therefore, the core of policy implementation involves establishing a robust mechanism for teachers' evaluation and assessment. Innovation outcomes should be explicitly integrated into both the teacher promotion system and the annual performance appraisal framework. Additionally, schools should promote an acceptance of failure and publicly recognize noble failures to empower teachers to take risks without fear of penalties. The participants offered the following comments:

At its core, institutional encouragement is about taking the worry out of the knock-on effects... Even if you finally determine that this specific technology won't do what you intended, we would still consider it to be an outstanding project as long as the teacher can rationally explain why it didn't work and then help provide valuable experience for the next research project. (C-KAD-d-7)

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The biggest influencing factors are our evaluation system and workload; these two things are like mountains, just absolutely crushing the little spark of innovation a teacher might have. (M-KAD-d-5)

Teacher digital competency is one of the key individual factors that influence innovation. The data makes a stark distinction between teachers who only use technology and teachers who use it for pedagogy. In the former, or teacher use cases, although one's digital literacy may be considered higher than the average of the general population, technology is mostly used as an efficient means for transmitting knowledge. As such, they are generally not engaged in any real innovation.

The latter, as well as teachers for pedagogy, are more apt to reach the dynamic balance that TPACK describes and take calculated risks to innovate. This finding aligns with Ertmer [43], concept of second-order barriers, including teachers' internal beliefs, attitudes, and pedagogical orientations, which are more difficult to overcome than first-order barriers such as inadequate equipment. Research also indicates that when teachers' instructional beliefs are teacher-centered, they will use technology to simply reinforce a traditional transmission approach even when provided with the best technology [46]. Here are examples of when some of the participants described their experiences:

As to the gap in digital teaching competence, here, I need to separate two ideas: one is the ability to use technology, and one is the ability to use technology for teaching. The first is what is referred to as digital literacy, which can be picked up quickly for most young teachers. The second, we will call Technological Pedagogical Content Knowledge, corresponding to the TPACK framework, the ability to meld technology, content knowledge, and pedagogical knowledge. This is much harder. For example, a teacher could be able to use video editing software but may not know how to design a video project that effectively develops students' higher-order thinking. This gap between knowing how to do and knowing how to teach is the second important reason for the disparity. (F-KAD-e-7).

The main emphasis of teachers' innovation-learning mindset is on the psychological and emotional factors experienced by teachers when confronted with innovative technology. Research indicates that teachers who have had negative experiences with certain types of technology tend to develop mental blocks, perceiving "technology as trouble." For instance, if a teacher invests significant time and effort preparing a lesson that incorporates the latest technology, but the technology fails unexpectedly, the teacher is less likely to integrate technology into future lessons. Such experiences can also generate anxiety about using technology again. Besides unfamiliarity with technology, teachers may worry about losing face among students or peers, or they may have had prior traumatic experiences related to technology failure. Henderson and Corry [47] refer to this phenomenon as Technology Anxiety, describing the fear, worry, and unease individuals feel when facing or using technology. Nonetheless, curiosity and a growth mindset are crucial for overcoming technological apprehension. Participants described their experiences as follows:

There are many teachers experiencing fear toward new technologies, worrying that they will not be able to learn or use them smoothly, and therefore, they do not want to try to implement technology into their classrooms. Some teachers believe their current traditional methods of teaching are effective and do not need to be changed (D-KAD-f-1).

Some teachers are either resistant and fear the constant changes in technology, while others are curious about them and willing to learn more and explore new technologies. These internal motivating factors will determine whether they see new technology as something that would help them and their students grow or as a burden (E-KAD-f-3).

Overall, the coding analysis reveals that the factors affecting the digital innovation capabilities of teachers in Chinese higher vocational normal colleges constitute a multi-level, systemic ecosystem. At the macro level, policy and institutional support provide the driving force for national strategies and the top-level design of schools. At the meso-organizational level, the learning and research climate, the infrastructure for digital platforms, and the complexity of technology, combined with training support, constitute vital external conditions for innovation. At the micro-individual level, we find two major categories of factors: one is the teacher's personal digital skill competence in terms of the difference between knowing how to use technology and knowing how to incorporate it into their teaching

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practices, and the underlying beliefs about teaching as the underlying code to this process; the second category is the teacher's innovation-learning mindset. In this category, a teacher's willingness to be innovative can be directly based on his or her feelings toward new technology (i.e., fearfulness vs. curiosity).

4.3. Countermeasures to Improve Teachers' Digital Innovation Capabilities

This selective coding addresses the third research question of the study. Based on the analyses of characteristics and influencing factors presented in the previous two sections, five dimensions of specific countermeasures are presented: enriching teachers' digital innovation training, meeting teachers' individual needs, improving the platform's system, establishing mutual support and collaboration mechanisms, and providing professional technical support.

Enriching teachers' digital innovation training directly addresses the factors of technical complexity, training support, and individual digital competence. The core of this countermeasure lies in shifting the training approach from technology-focused instruction to competency-oriented development. The primary goal of training should be to cultivate teachers' instructional design thinking rather than merely teaching tool operation. Furthermore, digital thinking should be integrated throughout the entire training process. In addition, the development of training should be more practice-based and emerge as an iterative professional learning model. Participants suggest that professional learning experiences should parallel how design studios function, as opposed to being similar to a traditional seminar room. Finally, the training should develop teachers' confidence to utilize technology, starting with simple tools for successful completion before progressing to more complex ones. By addressing real-world teaching issues, this approach can create opportunities for teachers to further develop their TPACK and capabilities in digital innovation [48]. Participants' statements are as follows:

We need to develop more practice-based and iterative professional learning models. They should involve hands-on experimentation, ideally working with real students, and include follow-up support. Professional learning should resemble a design studio rather than a seminar room (B-CSI-g-4).

We should encourage teachers to be designers and reflective practitioners of education rather than mere operators of technology (E-CSI-g-2).

Focusing on teachers' individual needs addresses both their innovation-learning mindset and personal digital skills, particularly in terms of energy and emotions. Teachers' mental energy and sense of professional well-being are vital for lasting digital innovation. When teachers enjoy the freedom to make choices in their teaching process, their intrinsic motivation increases, and they are more willing to engage in complex tasks for a long time [49]. Giving control and autonomy back to teachers enables them to make decisions according to their own teaching contexts, which strengthens their sense of ownership and provides space for reflective practice to address their experiences, fears, and successes. At the same time, schools should offer abundant tools and resources to encourage and support teachers in their digital innovation capabilities. Participants' statements are as follows:

Teachers need a space to be noticed, heard, and supported, rather than merely receiving training. Therefore, emotional support and reflective dialogue should be integrated into our development programs (B-CSI-h-2).

We should restore choice and autonomy to teachers. Instead of providing a fixed set of tools, we should offer a rich "tool marketplace." When teachers perceive that they are selecting tools themselves to solve their own teaching problems, their sense of ownership and willingness to explore will increase significantly (E-CSI-h-3).

The strategy for improving the system construction of platforms is designed to meet the requirements of both policy and institutional support, as well as the learning and R&D environment. Its core objectives include reforming teacher evaluation systems, incorporating outcomes of digital teaching innovation, establishing institutionalized spaces for reflective practice such as Professional Learning Communities (PLCs), providing organized experimental settings, and formalizing a culture of tolerance

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for mistakes. Edmondson [50] emphasizes that the primary condition for stimulating team innovation is creating an environment of psychological safety, where mistakes are tolerated and embraced. Teachers are more willing to experiment with new and potentially risky teaching methods when they believe failures will not be punished or ridiculed. Informal salons or workshops can facilitate making trial and error a normal part of the learning process, thereby alleviating teachers' fear of losing face. Participants' statements are as follows:

At the school level, it is necessary to create a relaxed environment for teachers, letting them know that it is acceptable when experiments with new technology do not work. (D-CSI-i-3)

If colleges adjust their evaluation frameworks to support teaching reform, action research, or digital course design, we will see more energy directed toward these areas. (B-CSI-i-4)

Establishing a mutual assistance and cooperation mechanism addresses the characteristics of organizational collaboration, whose aim is to institutionalize spontaneous cooperation into a sustainable system. Teachers' professional development is largely a socialized process, in which learning occurs through observation, imitation, and interaction with role models and peers [51]. An important aspect of utilizing teachers' existing expertise is facilitating participation in external exchanges by observing how exemplary teachers conduct their classes. Additionally, this model supports promoting collaborative work across disciplines and establishing long-term partnerships with colleges, transitioning from the role of service provider to partner. As an alternative, a mentoring program can be established where digitally proficient mentors are available to support novice teachers with emotional and practical assistance. Some examples of these participant statements include:

Very often, the person who can actually give a teacher the greatest sense of confidence is not an outside expert but a colleague who has simply taken one small step ahead. (F-CSI-j-1)

Many of the most compelling innovations tend to emerge when teachers from different disciplines co-develop curriculum content or work together to integrate technology into collaborative teaching. (A-CSI-j-2)

Professional technical support is essential for infrastructure construction of platforms and managing the complexity of technology; therefore, the quality of technical support is critical because it represents the "last mile" in helping new technology take root and thrive. Investigations show that when technology is supplied without being backed by timely, effective, and contextualized technical support systems, it generally results in technology being discontinued by users [52]. To prevent this, it is important to establish a dedicated team to provide professional technical support. Additionally, when enhancing digital infrastructure, attention must be paid to inclusivity, ensuring that support is accessible to rural educators and older teachers through personalized, ongoing, and contextualized assistance; otherwise, the gaps between these groups will only widen. Below are comments provided by participants:

Technical support must be ensured. If teachers encounter problems while using a new tool and can quickly find someone to help resolve them, they will feel reassured. (D-CSI-k-4)

If only urban teachers with better infrastructure or younger teachers who are more technologically proficient can benefit from digital innovation, the gap will only widen. We must ensure that the rural teacher, veteran teachers, and those with low self-confidence when using technology have access to personalized, continuous, and context-aware support. The paradigm for innovation must be inclusive. It should not be limited exclusively to the few. (B-CSI-k-2).

In short, the coding analysis produced a set of directed recommendations that correspond to the aforementioned influencing factors. These recommendations encompass five distinct areas. The first area is providing teacher training for digital innovation through an expansion of the current teacher-training programs to focus on developing instructional design skills rather than solely tool usage. The second area focuses on the individual needs of teachers, which includes providing autonomy and choice as well as support for their professional well-being. The third area includes enhancing institutional platforms and mechanisms, especially in reforming teacher performance evaluation practices and ensuring that there is a psychological safety climate supporting teachers in making mistakes when using

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technology. The fourth area provides mutual collaborative mechanisms that utilize peer coaching and interdisciplinary cooperation. Lastly, increasing the amount of professional technical support available to teachers ensures that technical services are delivered timely and inclusive manner to reduce the anxiety that exists when implementing new technologies.

5. Conclusion

5.1. Conclusion and Recommendations

In this paper, the researchers identify and discuss various elements that influence educators' ability to innovate digitally within China's higher vocational normal colleges and the strategies that can be utilized to increase their ability to innovate digitally. The researchers describe how the identified factors are interdependent, relate to one another, and interact within a multi-layered ecosystem. At the individual level, a central impediment to digital innovation is educators' personal digital competence and innovation-learning mindset; at the organizational level, important contextual elements include the research and learning climate, the foundational infrastructure for platforms, and the technological challenges educators face, including the training supports related to technology use. At the institutional level, teacher evaluation systems serve as the ultimate mechanisms to guide teachers' actions and behaviors. Consequently, any strategy aimed at supporting and enhancing educators' digital innovative capabilities must go beyond fragmented technology training; it must offer a systematic, human-centered model for empowerment. Such an approach should include restructuring training modes, acknowledging educators' emotional needs, reforming evaluation systems, and establishing collaborative mechanisms and professional support services. These measures will create the necessary conditions for fostering teacher innovation.

Based on the understanding, several recommendations can be made to educational administrators and policymakers regarding institutional platforms: first, improving institutional platforms should begin with the reform of educator evaluation systems; and teaching innovation should be integrated into educator assessment frameworks. Second, the establishment of safe environments that do not punish failure and that encourage educators to take risks by celebrating "noble failure," thereby relieving any potential feelings of shame for perceived lack of success. Third, educator professional development programs must also focus on developing educators' pedagogical design thinking as part of the educator professional development programs, in addition to learning how to incorporate digital innovations into their instruction, rather than simply providing training on using the tools. In addition, professional development programs should also address the needs of educators as individuals and offer them more options and autonomy with respect to their learning experiences, creating a greater sense of ownership in the development process. Finally, it is important for educators to cultivate an inquisitive nature and to develop a growth mindset by addressing their own learning barriers, particularly with regard to their fear of failure, and by becoming proactive in seeking out collaborative and peer support systems that will enable them to be more successful through collaboration and the exploration of similarities and differences.

5.2. Limitations

This study has certain limitations. First, it primarily relies on qualitative research methods. While this ensures depth and a detailed understanding of the context, it also limits the generalizability of the findings. The results may depend heavily on the specific contexts of the selected sample, and caution is required when extending them to the broader population of vocational teacher-training faculty in China. Second, the data are mainly drawn from teachers' self-reports and personal accounts. This may introduce self-reporting bias, meaning that teachers' perceptions and beliefs might not fully reflect their actual digital innovation practices in the classroom. Future research could consider adopting a mixed-method approach, incorporating classroom observations or quantitative analyses of instructional design, to triangulate the qualitative findings and provide broader empirical validation.

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Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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