DOI: 10.5281/zenodo.15769464
Vol. 2(1); 2024
Received 25 March 2024; Accepted 22 June 2025
Available online 30, June, 2025 /© 2024

Journal of Interdisciplinary Insights
ISSN (Online) :2995-6587
Published by Global Insight Publishing Ltd, USA

A Study on the Pathways for Enhancing Primary and Secondary School Teachers' TPACK Competence Empowered by Artificial Intelligence

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Abstract: Teachers' TPACK competence is a fundamental capability that every teacher must possess in the stage of educational informatization and intelligent development. It is an indispensable knowledge for teachers to conduct effective teaching. This paper elaborates on the connotation and structure of TPACK competence of primary and secondary school teachers, analyzes the necessity of enhancing their TPACK competence and the factors influencing primary and secondary school teachers' TPACK competence in the context of artificial intelligence. Based on this, it explores the optimized pathways for enhancing primary and secondary school teachers' TPACK competence empowered by artificial intelligence from multiple perspectives.
Keywords: Artificial Intelligence; Teachers' TPACK Competence; Influencing Factors; Enhancement Pathways

I. Introduction

With the rapid development of information technology and the advent of the information age, education is undergoing unprecedented changes. The report of the 20th National Congress of the Communist Party of China proposed to promote educational digitalization and build a learning society and a learning powerhouse. China is currently in the stage of educational digital and intelligent transformation. In May 2023, General Secretary Xi Jinping emphasized that the foundation of building an educational powerhouse lies in basic education[1]. Under the era of artificial intelligence, educational and teaching activities tend to be digital and intelligent. This means that in addition to using conventional teaching models, teachers also need to leverage the value and function of information technology in educational transformation and grasp the trend of integrating information technology with subject teaching[2]. However, although teachers have achieved good results in using information technology to solve real teaching problems and are steadily advancing, the overall situation is still not optimistic from a micro perspective. A series of real problems are also presented to teachers, such as which information technologies can be utilized, how to more fully use information technology to change the presentation of teaching content, students' learning methods, and teacher-student interaction methods, and how to achieve deep integration of information technology and educational teaching. The research and cultivation of Technological Pedagogical Content Knowledge（TPACK）competence can better reveal the essence of these problems and guide teachers to improve the current situation, thereby promoting teachers' professional development.

II. Analysis of Teachers' TPACK Competence Structure

2.1Connotation of TPACK Competence

TPACK competence is the integration of technological pedagogical content knowledge, which includes three core elements: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK), as well as four composite elements: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK)[3]. The components of TPACK competence are shown in the figure below:

2.2 Competence Structure

From the above analysis of the connotation of TPACK competence, it is known that subject content knowledge, technological knowledge, teaching methods and strategies knowledge, and the corresponding teaching abilities are three types of knowledge and abilities that teachers must possess. Moreover, in the digital age, as teachers' teaching experience continuously enriches and their self-quality continuously improves, these three types of knowledge will also interact and integrate with each other to form new knowledge. To analyze the structure of TPACK competence in detail, the following points can be considered:

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2.2.1 Mastery and Application of Information Technology

Essentially, TPACK competence is the integration of technological subject teaching knowledge. It refers to the fact that teachers should fully utilize information technology to carry out information-based teaching in teaching[4]. This includes multimedia technology, artificial intelligence technology, micro-lesson resources, and related software and hardware facilities. For example, using the Internet to collect rich learning resources, screening and processing resources from the Internet and other learning platforms, or being able to perform simple maintenance on the equipment used. Therefore, in the era of artificial intelligence, teachers need to master various types of artificial intelligence education tools, such as intelligent tutoring systems and teaching resource recommendation platforms, and be able to proficiently use these tools to obtain, analyze, manage, and apply teaching resources.

2.2.2Mastery and Application of Curriculum Content

Comprehensively mastering and scientifically applying subject content knowledge is the foundation of teachers' TPACK competence. Teachers should have a profound understanding of the nature of the subject they teach and the direction of talent cultivation. They should fully grasp the teaching material content, have rich teaching experience, and high educational teaching ability. At the same time, they should pay attention to the new developments and applications of the subject field under the background of artificial intelligence and integrate relevant content into teaching. Only by possessing rich professional subject knowledge and integrating artificial intelligence knowledge with subject teaching can teachers lead students to experience the joy of learning and the charm of curriculum knowledge from a higher perspective and vision. This will enable students to develop a strong interest in learning and cultivate their comprehensive quality.

2.2.3Flexible Application of Teaching Process Design and Strategies

The design and implementation of teaching activities are key elements that affect the quality of the entire teaching activity. The scientific nature of teaching activity design is also influenced by the ability to apply teaching methods and strategies. Therefore, for every teacher, the ability to flexibly apply teaching methods and strategies to design the teaching process is essential[5]. Teachers should determine teaching objectives based on teaching requirements, teaching content, and students' actual needs. Then, they should design the teaching process, rhythm, and various teaching methods and strategies around the teaching objectives. They should integrate the teaching process with artificial intelligence technology and be able to flexibly use various resources and tools to deal with various situations in teaching. This will encourage students to actively participate in teaching and better and faster accept knowledge.

2.2.4 Integration of Information Technology and Subject Teaching

The new curriculum standards propose the requirement that "in the process of teaching design and implementation, modern information technology should be reasonably used according to the actual situation, and the deep integration of information technology and subject teaching should be effectively achieved"[6]. This means that in current primary and secondary education, teachers should not only possess professional content knowledge and teaching knowledge but also have good information literacy and application ability. With the help of the visualization and interactivity of artificial intelligence technology, teachers can present abstract subject knowledge to students in a more intuitive and vivid way and integrate it into subject teaching to achieve information-based teaching. This meets the needs of educational informatization development and promotes the in-depth reform of educational teaching.

III. Factors Affecting the Development of Primary and Secondary School Teachers' TPACK Competence

3.1Psychological Factors

3.1.1Motivation and Interest

Although teachers are the organizers and implementers of teaching, in fact, whether teachers have a high sense of identification with their profession and whether there is a meaning to continue also needs to be supported by motivation and interest. The development of teachers' TPACK competence is the same, with motivation and interest playing a core role. Motivation is the intrinsic driving force for teachers to actively learn and use information technology, which is closely related to teachers' professional goals and development direction. Interest, on the other hand, can enhance teachers' desire to explore and apply technology, making them more actively and proactively engage in teaching, exploring, and practicing more new teaching tools and methods. With the support of both, teachers will continuously enhance their TPACK competence to achieve personalized and innovative teaching.

3.1.2Attitude and Belief

Attitude and belief have a decisive impact on teachers' acceptance and integration of new technologies. Teachers' attitudes can be reflected in their views on technology and their willingness to use it. These views are usually rooted in their educational philosophy and beliefs about the role of technology in education. If teachers believe that technology

can effectively support student learning, they will tend to explore and apply these technologies, thereby improving their TPACK competence. Conversely, if they hold conservative teaching beliefs, they may be skeptical about adopting new technologies, thereby limiting the development of TPACK.

3.1.3Strategies and Habits

Teachers develop a variety of learning methods during their growth and form fixed learning habits over a long period of learning. This is actually a behavioral pattern of teachers' self-development[7], which plays a foundational role in the development of TPACK competence. Effective learning strategies can help teachers learn new knowledge more efficiently, accumulate rich experience, and enhance teaching quality by combining it with their own teaching ability and actual teaching. For example, teachers generally participate in seminars, master teachers' studios, various online and offline learning activities organized by schools, and self-study through different channels to update their educational technology knowledge. Good learning habits help teachers continuously adjust and optimize teaching strategies, thereby enhancing their TPACK competence. For example, teachers often reflect on the teaching process and various technical tools used in teaching, and then make adjustments.

3.2Information Technology Literacy

The components of TPACK competence include the mastery and application ability of information technology, that is, teachers need to have good information technology literacy in teaching to efficiently complete teaching activities. Information technology literacy here is not limited to proficiency in computer use but also includes in-depth exploration and effective use of modern educational technologies such as big data technology, AI technology, and virtual VR technology. This is a technology that teachers must master and a capability they must possess in the process of promoting educational and teaching activities with artificial intelligence technology. For example, using micro-lesson technology to create courseware, using virtual technology to conduct experimental teaching, using artificial intelligence technology to enliven classroom atmosphere and optimize teaching process, and using electronic dictionaries or electronic schoolbags to look up words, translate sentences, and collect different materials. However, at present, most primary and secondary school teachers generally have the problem of "information technology literacy and ability to be improved," which invisibly affects the development of teachers' TPACK competence.

IV. Optimized Pathways for Enhancing Primary and Secondary School Teachers' TPACK Competence Empowered by Artificial Intelligence

4.1Strengthening the Integration of Information Technology and Subject Knowledge

The improvement of TCK requires higher demands on the technology and subject knowledge that teachers themselves possess. To truly integrate technology and subject knowledge efficiently, teachers need to choose a variety of technological means to better understand students' needs and design teaching content and interesting classroom activities that are more suitable for students' learning based on their interests and hobbies. This will stimulate students' enthusiasm for learning and encourage them to actively participate in teaching to acquire knowledge and develop abilities.

For example, in the teaching of mathematical geometry, teachers can use information technology to create teaching scenarios, making the teaching content more concrete and vivid, and easier for students to understand and remember. Take "axially symmetric figures" as an example. Teachers can use the drawing function of the Seewo whiteboard to draw some axially symmetric figures and play buildings and other figures and objects with axial symmetry characteristics. They can also demonstrate the dynamic process of how an axially symmetric figure is symmetric, forming an intuitive teaching scenario and allowing students to observe and think. This mode of listening, watching, and thinking together greatly impacts students' senses, stimulating their enthusiasm for learning and cultivating their core literacy in active learning.

Similarly, in Chinese reading teaching, teachers can combine students' characteristics of "loving to play computer games" and use information technology to create electronic games. By using the simulated scenes in the games to explain knowledge, students can have an immersive experience, thereby achieving a deep understanding of the text content. Take the reading teaching of "Guilin Landscape" as an example. Teachers can use the simulated scene of "Guilin Landscape" in the VR game to explain to students, guide them to conduct independent reading, and also enable students to connect subject knowledge with real life, thereby achieving a deep understanding of the text content and improving reading comprehension ability.

4.2Strengthening the Integration of Information Technology and Teaching Methods, and Teaching Methods and Subject Knowledge

The essence of teachers' TPACK competence is to guide teachers on how to correctly and effectively use information technology in teaching to achieve efficient teaching[8]. This means that teachers need to solve the substantive problems

of "when to use educational technology, which technology to use, and how to use it." Only by solving these problems can teachers truly achieve the effective integration of technology and teaching method knowledge, and teaching methods and subject knowledge in teaching. This is also the key to enhancing teachers' TPACK competence. Observations of current primary and secondary school classroom teaching processes have found that teachers commonly use technological means in teaching, including multimedia teaching, micro-lessons, artificial intelligence technology, network resources, and smart education platforms. The teaching methods used include inquiry cooperation, role-playing, project-based learning, virtual character creation, and situational performance. The application of these technological means and teaching methods has effectively integrated technology and teaching methods, thereby guiding students to actively participate in teaching and achieve a deep understanding and flexible application of knowledge.

For example, in English teaching, teachers can use online platforms to collect materials related to the teaching content to supplement students' cultural background knowledge, expand their learning scope and thinking vision, and thus improve their comprehension ability. Take the junior high school lesson "Merry Christmas" as an example. Teachers can use information technology to collect relevant resources and show them to students, helping them understand the origin, development, and significance of the festival. At the same time, teachers can use information technology to solve the different meanings and application scenarios of vocabulary in the text. For example, the words "decorate" and "ornament" can both be explained as "decorate," but "ornament" appears as a noun in the text: There is an ornament made of shells on the wall and I ornamented my room with flowers. To distinguish between them, teachers can use the animation and color functions of multimedia to mark these two points in different colors, allowing students to watch and learn, thereby strengthening their memory.

Similarly, some experiments in junior high school chemistry cannot be completed offline. Teachers can use artificial intelligence technology to create virtual laboratories, allowing students to deepen their understanding of knowledge and master experimental steps through hands-on operations. For example, in the experiment of chemical reactions between nitrogen, hydrogen, and oxygen, teachers can use artificial intelligence technology to create a virtual laboratory with three-dimensional stereoscopic effects and vivid realism. The experimental process and reaction principles are presented to students in the form of animations. Students can conduct experiments through mouse operations and human-computer dialogue, verifying experimental steps and conclusions.

4.3Strengthening Teachers' Self-Development in Various Forms

The cultivation and enhancement of teachers' TPACK competence require an opportunity and platform. This means that not only should schools provide specialized training activities, learning activities, and teaching research opportunities and platforms, but teachers, as the main participants, should also fully exert their subjective initiative. Under the guidance of a "lifelong learning consciousness," they should conduct self-study through various means and channels, and cultivate and enhance teachers' TPACK competence in an all-round way with the joint efforts of inter-school and intra-school forces.

Firstly, break through the educational barriers between primary, secondary, and higher education institutions to build a cloud-based teaching and research model that spans schools, stages, and regions. With the help of advanced information technology, this model transcends geographical, school, and educational stage boundaries, closely integrating various educational resources and connecting teachers from primary, secondary, and higher education institutions. University teachers can bring in-depth and cutting-edge subject knowledge (CK) to the discussion, guiding primary and secondary school teachers to review teaching content from a higher disciplinary perspective and understand the origins and development of knowledge, making primary and secondary school knowledge teaching more systematic. It also allows teachers from different schools in the same region to come together and share their unique teaching experiences and wisdom. Teachers from key schools can share their expertise in curriculum design and classroom management, providing references for teachers from ordinary schools. At the same time, cross-regional cloud teaching and research breaks through geographical limitations, enabling teachers from resource-rich and relatively underdeveloped regions to exchange ideas. Teachers from developed regions can bring advanced technological application cases and teaching concepts to help teachers from underdeveloped regions enhance their technological knowledge (TK). In return, teachers from underdeveloped regions can share their touching stories of perseverance in education under difficult conditions and how they use limited resources to inspire students' enthusiasm for learning, providing all teachers with spiritual motivation and practical wisdom. Through this cloud-based teaching and research model that spans schools, stages, and regions, teachers from all parties can collaborate and continuously learn on educational platforms, breaking down educational barriers.

Secondly, at the school level, it is important to respect the individual differences and development needs of each teacher. A strategy combining offline training and online self-selection can be adopted to enhance teachers' TPACK competence[9]. In this process, schools can develop a series of micro-courses for improving teachers' information technology teaching ability and push them to teachers' learning platforms, work groups, official accounts, school websites, and other platforms. Teachers can then select the corresponding courses for study based on their actual needs

and development directions. Meanwhile, combined with offline training on the integration of information technology and teaching tools, concepts, and methods, teachers can be triggered from multiple aspects to update their concepts and integrate knowledge, technology, and methods. On the other hand, schools can use online surveys to understand the problems or difficulties teachers encounter in teaching and incorporate these issues into the teacher research and development content system. With the main line of restoring problems, analyzing problems, and solving problems, teachers can be guided to think about and study teaching problems. Teachers participating in teaching and research are also required to discuss, communicate, or share their insights. A crucial point is to build a comprehensive training course system for teachers' capability enhancement[10]. This should include the development, application, and case analysis of blended teaching, various artificial intelligence technologies, network platforms, online tools in education, the collection and production of teaching videos, knowledge construction and graphical representation, the building and sharing of excellent courses, and course practice. Such a training course system enables teachers to learn, master, and apply artificial intelligence technology to enhance their information technology teaching ability.

Thirdly, in their spare time, teachers can watch excellent teaching videos from national and local primary and secondary school smart education platforms, learn the latest cases of integrating technology and teaching methods, participate in online thematic discussions, and record teaching reflections to comprehensively enhance their TPACK competence. On the one hand, the platform provides teachers with a vast array of teaching resources, including rich technological application cases, high-quality courses in various subjects, and displays of innovative teaching practices, to help teachers improve their technological knowledge (TK), subject content knowledge (CK), and the integration of technology and subject content knowledge (TCK). Teachers can learn the latest methods for operating intelligent teaching tools and observe how to use technological means to present abstract subject knowledge. On the other hand, the platform also serves as an online community for teacher communication and sharing. Teachers can participate in online discussions, post teaching reflections, and draw on the experience of their peers to further optimize their teaching method knowledge (PK) and the integration of teaching methods and subject content knowledge (PCK). Teachers can collect materials, literature, and excellent teacher teaching case videos related to educational informatization through online and offline channels. They can actively learn in their spare time, supplement their existing knowledge, and accumulate teaching experience. Finally, they can combine specific teaching requirements and content to form their unique teaching ability and style. At the same time, continuous reflection is crucial for critically recognizing the rationality, effectiveness, and value of teaching behaviors and identifying existing problems. Through further study, teachers can improve their teaching plans and practice again. In the continuous cycle of "practice - reflection - re-practice," teachers can reorganize and transform their teaching experience, thereby comprehensively enhancing their TPACK competence.

V. Conclusion

In summary, teachers' TPACK competence is an important factor affecting intelligent and information-based teaching. To better cultivate the TPACK competence of primary and secondary school teachers, an in-depth analysis has been conducted on the connotation and structure of artificial intelligence empowerment. Combined with specific teaching activities and related measures to strengthen the integration of information technology and subject knowledge, the integration of information technology and teaching methods, and the integration of teaching methods and subject knowledge, as well as to strengthen teachers' self-construction in various forms, a favorable development environment has been created. References:

***Acknowledgments*:** The author acknowledges the support of many primary and secondary School teachers participating in the research. This research is approved by 2024 "Digital Empowerment in Education" project of the China Association for Adult Education Inner Mongolia Autonomous Region Educational Science Planning Institute (Grant No.:2024-SJYB-052S)).

REFERENCES

The CPC Central Committee and the State Council issued the "China Education Modernization 2035" [N]. People's Daily, 2019-02-24(001).

[2] Liu Yang. The Transformation of Classroom Teaching under Educational Digitalization [J]. Journal of Heilongjiang Institute of Education, 2024(03): 135-138.

[3] Li Chunyan. Exploration of Development Strategies for Primary and Secondary School Teachers' TPACK Competence [J]. Basic Education Forum, 2024(02): 21-23.

[4] Zhang Chanchao. The Connotation, Composition, and Enhancement of Key Teaching Competence for Primary and Secondary School Teachers in the New Era [J]. Journal of Chongqing Normal University, 2024(01): 51-58.

[5] Wang Zhichao. Primary and Secondary School Teachers' Teaching Competence under the Perspective of Education Modernization: Characteristics, Problems, and Enhancement Strategies [J]. Teacher Development Research, 2024(04): 82-87.

[6] Yuan Xiuli. Research on the Development of Primary and Secondary School Teachers' TPACK Knowledge in Inner Mongolia under the Background of Information Technology 2.0 [J]. Yinshan Academic Journal, 2024(04): 99-105.

[7] Huang Jiao. Strategies for Enhancing Primary and Secondary School Teachers' Information Technology Application Competence Based on the TPACK Framework [J]. Western Quality Education, 2023(02): 142-145.

[8] Zhang Dongjun. Enhancement of College Teachers' Competence and Quality under the Background of Smart Education [J]. Educating People, 2023(12): 28-34.

[9] Zhang Lei. Psychological Factors Analysis of TPACK Competence Development for Preschool Education Teachers in Higher Vocational Education [J]. Man Science, 2024(10): 185-187.

[10] Zhang Luolu. Design and Practice of Training Courses for the Cultivation of TPACK Competence of Primary and Secondary School Music Teachers [J]. Primary and Secondary School Teacher Training, 2019(02): 16-20.