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Reconstruction of Teachers' Knowledge Structure Driven by "AI+ Middle School Geography Education"—On the Integration of TPACK Framework and Its Development Model

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Abstract: *The application of artificial intelligence (AI) technology in the field of education has brought new changes to teachers' teaching model. From the innovation of AI geography teaching in digital teaching environment to the presentation of teaching materials, the influence of information AI continues to deepen, but at the same time it faces challenges and risks. Entering the era of artificial intelligence, geography teachers played a new role and asked to reshape the knowledge structure of teachers. To this end, based on the conceptual framework of TPACK, artificial intelligence is integrated into geography teaching, and the knowledge framework of "AI +Subject Geography Teaching" (AITPACK) is proposed and constructed, that is, the basic knowledge framework of teachers includes geography teaching knowledge, subject theory, and AI knowledge. Based on the original TPACK framework, new compound knowledge is generated. The proposal of AITPACK is conducive to showing the new features and theoretical connotations of teachers' knowledge framework in the digital era, to provide a new analysis model for geographic teachers' knowledge framework research and education and teaching practice.*

Keywords: *artificial intelligence; middle school geography education; knowledge of "AI +Subject Geography Teaching"*

1. Introduction

The "Standards for Compulsory Education Geographical Curriculum", hereinafter referred to as the 2022 version of the curriculum standard, emphasizes that the geographical curriculum system will prioritize nurturing students' knowledge and skills in the subject and modern science and technology, while paying greater attention to diversified teaching methodologies. In the era of artificial intelligence, geography teaching methods in middle schools have undergone profound transformations. Traditional geography teaching methods can no longer satisfy the developmental needs of middle school students. Consequently, middle school geography must deepen its curriculum reform. During this process, with the continuous advancement of information technology, the new technologies developed by artificial intelligence have become increasingly intertwined with middle school geography teaching. Artificial intelligence (AI) is a high-tech field rooted in information technology, utilizing sophisticated algorithms based on big data as its core, with the aim of simulating, extending, and transcending human intelligence[1]. AI technology can tailor personalized learning paths for middle school students and adjust teaching methods and pace based on their learning behaviors and feedback. Furthermore, AI harnesses multimedia and virtual reality technologies to enhance students' intuitive understanding of abstract geographical concepts.

In the context of integrating AI and middle school geography education, it is integrated into the TPACK framework to forge a teaching environment that integrates technological, pedagogical, and content expertise. The TPACK framework serves as a pivotal tool for teachers to leverage technology to enrich the learning experience. The TPACK framework directly reflects the novel requirements posed by the knowledge structure of educators in the information age. It imposes vital prerequisites for teachers' knowledge structure in this era[2]. The TPACK framework underscores the integration of technology, teaching methodologies, and content knowledge, empowering educators to better

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comprehend and adopt suitable technological approaches to enhance teaching efficacy. Nevertheless, it is crucial to recognize that while AI presents novel opportunities, it also poses limitations and challenges. While AI can supplant teachers in executing certain cognitive and routine tasks, it cannot replace teachers entirely. Teachers will continue to be the cornerstone and leaders of AI education applications. The nascent intelligent transformations in the realm of education and teaching will present fresh challenges and prerequisites for teachers' knowledge structures and competencies[3]. Balancing the utilization of AI with the role of teachers, leveraging AI to refine teaching methodologies and improve instruction, preempting unforeseen issues stemming from AI, and integrating artificial intelligence with the TPACK framework to achieve superior outcomes in middle school geography teaching have emerged as pressing issues for educators at the forefront.

Thus, teachers propelled by the fusion of "Artificial Intelligence + Geographical Education" in middle schools must possess fundamental AI knowledge and literacy, applying AI scientifically and judiciously to enhance teaching. Contemporary middle school geography teachers necessitate a novel knowledge structure and competency set. Drawing upon the TPACK framework, this article proposes and constructs the knowledge framework of "AI + Middle School Geography Teaching". Under the guidance of teachers, students can leverage AI to attain personalized and adaptive learning, fostering a deeper understanding and proficiency in key concepts, thereby enhancing the quality and effectiveness of geography teaching in middle schools.

2. The complexity of integrating “AI+ teachers” with geography teaching in the information age

2.1. New role: “AI+ teacher” complementary teaching

The use of AI for intelligent data processing and information automation can provide geography teachers in middle schools with more assistance from multiple angles. AI can automatically handle the evaluation of the geographical teaching process, students' classroom learning records, and data analysis of test scores, etc., helping teachers reduce complicated and mundane teaching burdens, and enabling them to focus on innovative and intelligent teaching design content. However, there are numerous deficiencies in the process of geography education in middle schools, particularly in the areas of personalized learning materials management and the functions of teacher-student interaction and communication, which AI does not currently support. Therefore, it is necessary to elevate education and teaching to a higher level. Consequently, in the context of AI, the role of geography teachers in middle schools will continue to evolve.

Moreover, there is also a shortcoming in AI education during geographical teaching. AI automatically collects students' data and employs analytical methods to address practical issues in geography teaching. When the smart geography class fails to provide more high-quality data, AI's problem-solving ability becomes weaker. Additionally, AI has limitations in knowledge transfer and abstract generalization capabilities. Although middle school teachers may not be exhaustive in their cognition and geographical information processing, they can make abstract generalizations based on teaching experience and common sense. Thus, geography teachers need to utilize the concepts and relationships with AI, actively engage in learning about AI intelligent systems, reason with and share teaching experiences with AI, establish a model of geographic knowledge within its domain, and ensure that AI understands the goals and teaching tasks of teachers. Teachers and AI will forge an inseparable, friendly, and cooperative partnership, building a teaching mutual assistance model known as "AI+Teacher".

2.2. Complexity of integrating AI and geography education

AI presents new development opportunities for geography teachers in middle schools, enhancing their application and analysis skills, optimizing teaching designs, and effectively supporting students' differentiated learning. However, it also poses some intricate challenges. For instance, disparities in geographical teaching resources and information technology standards have exacerbated educational inequity. Furthermore, data collected by AI for training purposes can lead to misconceptions in student evaluations. In response to these issues arising from AI's application in geography teaching, teachers must be equipped to address the emerging dilemmas scientifically:

1) With the deep integration of AI and geography teaching, how can teachers position the relationship between their new roles and balance their responsibilities with those of AI-powered tools?

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2) When utilizing AI to collect data on students, how can teachers effectively safeguard students' personal privacy?

3) Teachers need a solid theoretical foundation in intelligence and informatization. How can they adhere to AI-related standards to make informed decisions?

Therefore, in an informatized teaching environment, geography teachers must possess high levels of competency and a novel knowledge structure. They must be capable of designing, developing, and applying AI and geography teaching content in a rational, scientific, and effective manner. By leveraging AI, teachers can accurately diagnose students' learning progress in online geography classes, guiding them scientifically and efficiently, and ultimately adapting to the significant changes that AI has brought to geography teaching.

3. The Development of the Information Age and the Update of TPACK

The knowledge and skill structure possessed by teachers serves as the foundation for their education and teaching practices. As intelligence evolves and the educational environment undergoes transformations, teachers are compelled to incorporate new knowledge structures. According to the TPACK (Technological Pedagogical Content Knowledge) theory, subject knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK) constitute the knowledge base of teachers. These three elements intertwine and blend to form four types of composite knowledge: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK) [4].

Entering the 21st century, AI has emerged as the cornerstone of teachers' technological knowledge, profoundly altering the representation of geography teaching knowledge. Consequently, the TPACK framework necessitates the infusion of new connotations to cater to the demands of geography teachers in contemporary times and teaching practices. Yan Zhiming and others advocate for the inclusion of AI technology knowledge and thinking within the professional knowledge system of teachers, proposing an AI-integrated Subject Teaching Knowledge Model (AI-TPACK) [5].

AI technology fosters the emergence of novel knowledge components within TPACK:

1) From TK to AIK: In the realm of geography teaching, teachers master advanced technologies such as AI, VR (Virtual Reality), AR (Augmented Reality), and GIS (Geographic Information Systems). They integrate these technologies into their instruction, enabling students to explore and comprehend intricate geographical phenomena through virtual simulations.2) Integration of AI and CK: Teachers must comprehend the workings of AI to apply it effectively within the context of geography subject systems. They learn to utilize AI systems for logical reasoning in geography teaching, thereby refining the content and enhancing its depth.3) Integration of AI and PK: Leveraging AI technology, teachers innovate teaching methodologies and refine the teaching evaluation system. This optimization of the intelligent teaching environment boosts students' enthusiasm for geography learning. Additionally, AI enhances teaching interactions, fostering collaboration among students and improving their self-regulatory learning abilities.4) Integration of AI and PCK: By harnessing the power of AI technologies in geography subjects, teachers achieve intelligent analysis of teaching processes. Through human-machine collaboration, the intelligent teaching system is thoroughly explored, leading to the scientific development of geography teaching materials and the rational design of geography lessons. Ultimately, this collaboration results in intelligent teaching decisions.

4. The significance of building the AITPACK framework and its development model

4.1. It is conducive to deepen the new characteristics of geography teachers' knowledge structure in the information age

The proposal of the AITPACK framework aids teachers in fully acknowledging that AI has become an integral component of the core of intelligent technology knowledge and will significantly impact the content and delivery of geography education. This framework equips teachers with the means to continually update their educational ideologies and skills, aligning them with evolving educational requirements through the provision of up-to-date educational resources, online courses, and workshops.

The TPACK framework theory incorporates AI knowledge, which fosters teachers' innovative mindset, enabling them to harness AI technology to develop novel teaching tools, devise creative

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instructional activities, and thereby propel the innovation of geography teaching. Furthermore, AITPACK underscores the profound integration of AI knowledge with subject matter expertise, creating a new intellectual paradigm through their synthesis. This underscores the complexity involved in geography teachers leveraging AI to enhance their teaching methodologies and deepen their understanding of geographical subject matter, which is of paramount importance.

4.2. It lays a theoretical foundation for the professional development of geography teachers in the information age

The proposal of the AITPACK framework introduces a novel theoretical foundation for the development of geography teachers in the information age. By blending theory with practical applications in geography education, AITPACK enables teachers to comprehend and proficiently utilize modern teaching tools, including Geographic Information Systems (GIS) and remote sensing technology, thereby enhancing their comprehension of geography and bolstering the efficacy and creativity of their teaching methods.

In terms of data-driven instructional decision-making, AITPACK harnesses big data and machine learning technologies to facilitate teachers in analyzing students' geographical learning data. This allows for a more precise identification of students' learning needs and potential challenges, empowering teachers to make more tailored adjustments and optimizations to their teaching strategies.

Geography teachers in the information age confront the challenges of managing increasingly intricate textbook updates and the deep integration of geography with AI. AI knowledge has emerged as a crucial component in the knowledge base of geography teachers that cannot be overlooked. Concurrently, it is imperative for teachers to foster strong connections with other elements of geographical knowledge, enabling them to comprehensively incorporate the information learning process of geographical knowledge into their systematic design, development, and utilization efforts. Ultimately, this will contribute to the realization of precision and intelligence in geography teaching.

4.3. It provides a new analytical framework for geography teachers' knowledge structure exploration and teaching practice in the information age

The AITPACK framework offers a fresh analytical lens for examining the knowledge structure and teaching practices of geography teachers in the digital era. It poses vital questions: What kind of knowledge structure should geography teachers possess? How can the elements of this knowledge structure be effectively leveraged in teaching practice? And how can AI be seamlessly integrated with geographic knowledge? This represents a groundbreaking perspective on characterizing and analyzing the knowledge structure of geography teachers in the information age.

The AITPACK framework employs advanced data analysis tools and artificial intelligence algorithms to assist geography teachers in distilling valuable insights from vast amounts of educational resource data. It enables teachers to adjust their teaching strategies based on students' actual performance and needs, inform teaching decisions and curriculum design, ultimately making geography instruction more precise and efficient.

Furthermore, the AITPACK framework serves as a comprehensive analytical tool that integrates the knowledge structure, theory, and practice of geography teachers in the digital era. It provides teachers with more scientific guidance in practical applications, leveraging the full potential of AITPACK to enhance their teaching methodologies.

5. AITPACK development model

5.1. Requirements Model for AITPACK Development

The integration of AI knowledge into the knowledge structure of geography teachers indeed adds complexity. This complexity arises from the intersections of PK (Pedagogical Knowledge), CK (Content Knowledge), and TK (Technological Knowledge), giving rise to constructs such as AIPK, AICK, AIPCK, and AITPK. The multitude of combinations within teachers' knowledge structure poses new challenges for their professional development.

Drawing upon the characteristics of AITPACK and building upon the TPACK development model alongside existing research findings, we have devised a demand model for geography teachers'

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AITPACK development, as illustrated in Figure 1. This model categorizes teachers' knowledge development needs into distinct levels based on the comprehensiveness of their geographical knowledge:

1) Single Knowledge Development Needs encompass the foundational knowledge of geography subjects, geography teaching methodologies, and AI-specific knowledge.

2) Dual Knowledge Development Needs require geography teachers to apply two complementary knowledge sets: teaching knowledge of geography, "AI+Geography" integrated knowledge, and "AI for Geography Teaching" knowledge.

3) Triple Knowledge Development Needs necessitate teachers' ability to bridge three types of geographical knowledge to form coherent teaching practices, including geography teaching knowledge, "AI+Subject Geography Teaching" expertise, and the development of "AI+Subject" geographical knowledge.

4) Four-Fold Knowledge Development Needs challenge teachers to utilize four distinct knowledge domains to create practical teaching approaches, specifically, the integration of "AI+Subject Teaching" geographical knowledge.

In summary, the AITPACK development demand model represents a general objective trajectory that aligns with teachers' growth, progressing from basic to advanced, from easy to complex, with each level posing progressively higher demands. As the level of knowledge increases, so do the requirements for diverse geographical knowledge, particularly for educators at the grassroots level. Teachers should embark on this journey by identifying their internal development needs or responding to external pressures and challenges in intelligent and information-driven geography teaching. They should adhere to a developmental path that moves from low to high levels and from simplicity to complexity, beginning with mastering fundamental and straightforward geographical knowledge before advancing to dual knowledge capable of comprehensive application. Once foundational knowledge needs are met, teachers can gradually progress to higher-level knowledge development needs.

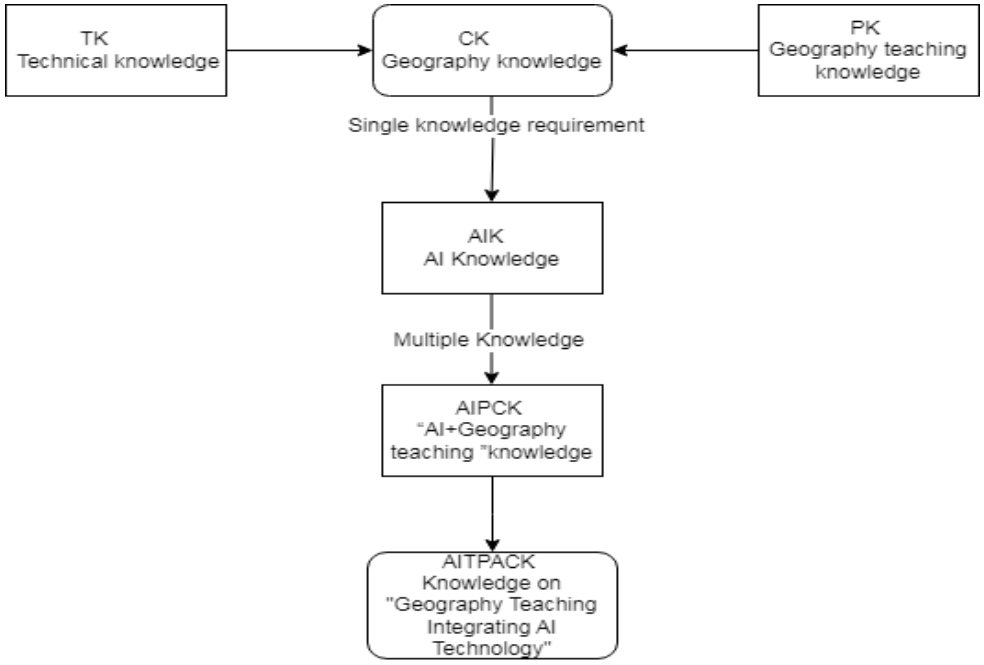

Figure 1: The Tower Needs Model for the Development of AITPACK for Geography Teachers

5.2. Establish an online community of practice to improve thinking and collaboration on "AI+ Geography Teaching"

The integration of "AI+Geography Teaching" will confront teachers with increasingly complex and acute teaching challenges. The fusion of AI and geographical knowledge is characterized by its empirical nature, collaborative construction, diversity, as well as a blend of logical reasoning and intuitive judgment. Consequently, integrating "AI+Subject Geography Teaching" into the TPACK framework cannot merely involve rote memorization of geographical facts. Rather, it necessitates

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students' active participation in community activities, collaborative communication and analysis, the construction and internalization of relevant "AI+Geography Teaching" theoretical knowledge through case studies and further research summaries, ultimately enhancing teachers' reflective abilities and geographical practice.

The Online Community of Practice, a novel situational learning environment in the context of AI-integrated subject knowledge, effectively facilitates highly integrated interdisciplinary geography teaching.Drawing upon the knowledge management model, we propose the AITPACK teachers' development model, grounded in the online practice community, which encompasses key elements of personnel, processes, and technology[6]. Firstly, the personnel component comprises teachers equipped with "AI+Geography Teaching" knowledge. In the course of "AI+Geography Teaching," they accumulate teaching cases, resources, narratives, and theoretical practices related to various locations, forming the cornerstone of AITPACK for teachers. This encompasses both explicit and tacit knowledge. Additionally, "AI+Geography Teaching" is influenced by external environments and internal variables. The external environment comprises the teaching, organizational, and AI environments. Internal variables, on the other hand, involve personal cognition and intuition. Cognition represents the explicit knowledge related to geography teachers' cognitive activities within AITPACK, while intuition encapsulates teachers' tacit knowledge and internal behavioral patterns, significantly impacting their integration process of "AI+Geography Teaching." Technologically, the transformation, communication, and iteration of AITPACK within the community are facilitated by the collaborative, interactive, and dialogic functions of the online community, thereby enriching and expanding geography teachers' AITPACK knowledge base.

5.3. Project-driven: Solve problems arising from the integration of "AI geography teaching" during the project completion process

In the process of integration of "AI+Subject Geography Teaching", it is full of tedious and comprehensiveness, and the cultivation goals of geography teachers AITPACK focuses on changes in emotional training, attitudes and cognitive behaviors, rather than limited to simple knowledge. Therefore, we can use the project -driven teaching method driven by group mutual assistance cooperation to allow geography teachers to study "AI+Geography Teaching" to apply to specific themes, or complete solutions to problems in the integration of "AI+Geography Teaching" integration. Design allows teachers to highly integrate "AI+Geography Teaching" in the process of completing the project. First of all, geography teachers must study the literature and materials of AI teaching, intelligent teaching systems and personalized learning, virtual reality (VR) and augmented reality (AR) technology. Secondly, geography teachers should implement investigations and research, such as discussing artificial intelligence with geographic experts in using of geographic teaching modules, and understand the ethics and transparency, continuous evaluation and improvement criteria that should be followed in the process of geographic teaching practice. Thirdly, the teachers team designs the solution strategy, research report or curriculum design of the integration of "AI+Subject Geography Teaching" and complete it. Finally, by holding special group meetings to exchange experience, geography teachers can realize the cognition, construction and development of AITPACK during the collaborative completion of the project[7].

6. Conclusion

The application of "AI+Subject Geography Teaching" has sparked unprecedented intelligent innovation in teaching atmosphere, materials, and techniques, undoubtedly posing new challenges and demands for geography teachers' knowledge systems and professional competencies, and facilitating further transformation of teachers' roles in the era of artificial intelligence. At present, the majority of geography teachers' TPACK (Technological Pedagogical Content Knowledge) frameworks do not prioritize the updating of geography knowledge potentially driven by AI-based teaching, nor the issues arising from the integration of "AI+Geography Teaching." Consequently, these frameworks require expansion and reorganization.

Drawing upon the TPACK framework, this article delves into prevalent AI technology discussions and incorporates geography subject knowledge, introducing the AITPACK (AI-integrated TPACK) framework to further expand and innovate teachers' knowledge structures. Rooted in AITPACK's intricacy, practicality, collaborative construction, diversity, and logical reasoning, we propose an AITPACK development model. Naturally, future research and practice necessitate continuous

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refinement and optimization of the AITPACK framework, fully exploring its functional value and potential in digital geography teaching design, classroom implementation, and instructional evaluation, aiming to formulate a more comprehensive "AI+Subject Geography Teaching" practice plan.

References

[1] Sun Weiping. Artificial Intelligence and the "New Alienation" of Humans[J]. Chinese Social Sciences, 2020(12):119-137 202-203.

[2] Liu Lingyan. Research on teacher role transformation under the TPACK framework[J]. Educational Theory and Practice, 2019, 39(19): 39-42.

[3] Deng Guomin, Li Yunchun, Zhu Yonghai. Reconstruction of teachers' knowledge structure driven by "artificial intelligence education" - On the AIPCEK framework and its development model integrated with ethics[J]. Journal of Distance Education, 2021, 39(01): 63-73.

[4] Mishra P, Koehler M. Technological pedagogical content knowledge: A framework for teacher knowledge [J]. The Teachers CollegeRecord, 2006, 108(6): 1017-1054.

[5] Yan Zhiming, Fu Jialiu, Zhu Youliang, Duan Yuanmei. Artificial Intelligence Technology-Integrated Teaching and Learning Knowledge (AI-TPACK): Connotation, Teaching Practice and Future Issues[J]. Journal of Distance Education, 2020, 38(5):23-34.

[6] Pillai S, Gupta R K, Saxena K B C. From rhetoric to reality: An enquiry into KM initiatives in an organisation of higher learning[J]. Journal of Information & Knowledge Management, 2008, 7 (3):135-143.

[7] Martens B. IT, ethics and education: Teaching the teachers (and their Pupils) [M]// Goujon P, Lavelle S, et al. The Information Society: Innovation, Legitimacy, Ethics and Democracy, MA: Springer, 2007: 181-193.