

INTEGRATION OF ARTIFICIAL INTELLIGENCE IN PRIMARY SCHOOL MUSIC EDUCATION IN CHINA: A REVIEW BASED ON THE AI-TPACK-AK FRAMEWORK

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Abstract

The integration of Artificial Intelligence (AI) into primary school music education represents a significant transformation with important pedagogical implications. This study reviews and synthesizes global research on the historical development of AI, its current applications in music education, and teachers' perceptions and attitudes toward AI within the Technological Pedagogical Content Knowledge–Arts Knowledge (TPACK-AK) framework. Using a comprehensive literature analysis approach, the study examines the current status of AI adoption in primary school music education and identifies the key factors influencing teachers' perceptions and instructional adaptations. The findings indicate that AI-based tools can enhance personalized learning, provide real-time feedback, and support students' musical creativity and engagement. However, several challenges remain, including algorithmic cultural bias, teachers' technological anxiety, and disparities in digital infrastructure between urban and rural schools. Analysis based on the AI-TPACK-AK framework suggests that effective AI integration requires teachers to balance technological competence, pedagogical innovation, artistic sensitivity, and disciplinary knowledge. To address these challenges, the study proposes three strategies: developing culturally responsive adaptive algorithms, establishing collaborative teacher-AI lesson planning mechanisms, and promoting digital equity initiatives to reduce resource disparities. A limitation of this study is that most of the existing evidence is derived from developed countries; therefore, further research is needed to examine the applicability of these findings within the contexts of developing economies. This study provides theoretical insights and practical implications for the sustainable and equitable integration of AI in primary school music education.

Keywords: Artificial Intelligence, Music Education, TPACK, Arts Knowledge, Primary School

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Introduction

Artificial Intelligence has evolved from a theoretical concept in the 1950s to a widespread educational tool, fundamentally reshaping teaching methods across various disciplines. In music education, AI integration encompasses composition assistance, performance analysis, adaptive learning systems, and immersive simulation technologies. The global educational AI market is projected to reach \$404 billion by 2025, reflecting its accelerating adoption (Williamson, 2022). China actively promotes educational technology through initiatives such as the “Education Informatization 2.0 Action Plan” (Ministry of Education of the People’s Republic of China, 2018), making it a crucial context for examining this transformation.

Primary music education in the AI era faces unique challenges. Traditional teaching methods emphasize the acquisition of technical skills through direct instruction and performance-based assessment, while AI introduces new paradigms for creative exploration and personalized learning. This technological shift has raised fundamental questions about the emotional dimensions of music, cultural authenticity, and the preservation of teaching values (Porayska-Pomsta et al., 2022). Understanding how teachers respond to these tensions requires a robust theoretical framework that acknowledges the domains of expertise involved in technology integration.

The TPACK (Technological Pedagogical Content Knowledge) framework, first introduced by Mishra and Koehler (2006), provides a foundation for analyzing teachers’ capabilities at the intersection of technology, pedagogy, and subject content. Recent academic research has extended this model to include Artistic Knowledge (AK), recognizing the unique aesthetic, creative, and cultural dimensions of music education (Merchán Sánchez-Jara et al., 2024). This AI-TPACK-AK framework offers a comprehensive perspective for examining how primary school music teachers conceptualize, adapt, and implement AI technologies while preserving music’s fundamental artistic qualities.

Despite the rapid growth of research on Artificial Intelligence in education, existing reviews show three main limitations: (1) They focus disproportionately on higher education or general education, with limited attention to primary school music education’s unique needs; (2) Most studies apply the original TPACK framework without integrating AK, failing to address music education’s aesthetic and cultural particularities; (3) Few reviews link international theoretical discussions with China’s specific policy context and urban-rural disparities, resulting in a lack of contextually relevant practical guidance. This review addresses these gaps by synthesizing international literature through the AI-TPACK-AK framework and situating China as a representative policy and practice case.

Purpose

This study aims to explore the current state of AI technology in primary school music education, teachers’ perceptions and attitudes, and the influencing factors behind them. Based on the AI-TPACK-AK framework, the study also proposes optimization strategies to help teachers better integrate AI tools, enhancing teaching effectiveness while addressing challenges such as cultural bias, technological anxiety, and urban-rural resource disparities.

Methods

This study adopted a systematic literature review approach. Literature was retrieved from three core databases—Web of Science, SCOPUS, and CNKI (China National Knowledge Infrastructure)—using combinations of Boolean operators (AND/OR) with search keywords including “Artificial Intelligence,” “primary school music education,” “TPACK,” and “Artistic Knowledge.” To reflect the latest developments in the fields of AI and education, only studies published between 2018 and 2025 were included, with inclusion criteria limited to empirical research, systematic reviews, or policy documents. The study selection process involved removing duplicate records ($n = 42$) from 287 initial entries, followed by title/abstract screening ($n = 156$ excluded for irrelevance) and full-text assessment ($n = 100$ excluded for failing to meet the inclusion criteria), resulting in 31 studies ultimately included for synthesis.

1. The Historical Development and Current Situation of Artificial Intelligence

The development of AI reflects a cycle of alternating enthusiasm and disillusionment, namely the so-called “AI winter” (Frana & Klein, 2021). The foundational work emerged in the 1940s-1950s, with the neural model of McCulloch and Pitts (1943) and the perceptron of Rosenblatt (1958). The Dartmouth Conference in 1956 formally established AI as a discipline, but the early optimism was tempered by Minsky and Papert (1969) demonstrating the limitations of perceptrons in solving non-linear problems. The following decades witnessed the rise of expert systems, such as MYCIN for medical diagnosis (Shortliffe, 1976), and then a reduction in funding triggered the first “AI winter”. The revival in the 1980s-1990s was characterized by breakthroughs such as backpropagation, support vector machines, and Long Short-Term Memory networks (LSTM) (Hochreiter & Schmidhuber, 1997), although commercial failures led to the second winter (Toosi et al., 2021).

The 21st century has witnessed the deep learning revolution, thanks to the improvement of computing power and the support of big data. Major developments include Hinton’s Deep Belief Network, the victory of AlexNet in the 2012 ImageNet competition, and the transformer architecture, which has made models like GPT-3 and BERT possible. Current frontiers include multimodal systems (such as GPT-4V), generative tools (such as Stable Diffusion 3.0, Sora), and embodied AI for robotics (Driess et al., 2023). Modern AI systems demonstrate unprecedented capabilities and have a profound impact on education: AI algorithms analyze student performance, providing customized content and adaptive paths. Platforms like DreamBox and Century Tech have proven their effectiveness in the field of mathematics, and similar applications have also emerged in the music field through tools like Smart Music and Yousician. In addition, AI-driven analysis provides real-time assessment of pitch accuracy, rhythm, and dynamics, supporting targeted skill development.

Despite rapid progress, significant challenges persist. Training data imbalance leads to cultural marginalization—over 86% of training data in music-generating AI systems comes from the “Global North,” severely underestimating non-Western musical traditions (Mehta et al., 2024). Regulatory frameworks struggle to keep up with technological changes, as seen in the EU AI Act’s risk-classification system, which is insufficient to address multimodal models’ emerging capabilities.

2. Music Education in China: Policies and Practices

2.1 Policy Evolution

Since 1949, China's aesthetic education policies have undergone significant evolution. The early Soviet-influenced approach emphasized technical training rather than cultural contextualization. The Compulsory Education Law of China in 1986 established the legal status of music, while the Decision on Deepening Educational Reform in 1999 elevated aesthetic education to a strategic priority. The Guiding Opinions on Strengthening Aesthetic Education in Schools in 2015 was a landmark shift. This document stipulated the minimum teaching hours and expanded art forms to include dance, drama, and multimedia art (General Office of the State Council of the People's Republic of China, 2015). The Art Curriculum Standards for Compulsory Education in 2022 redirected the goals towards four core competencies: aesthetic perception, artistic expression, cultural understanding, and creative practice (Ministry of Education of the People's Republic of China, 2022). In 2025, China's Ministry of Education proposed integrating traditional aesthetic education methods with intelligent technical means into school educational activities. The Ministry of Education is also committed to promoting the digital development of aesthetic education by utilizing various resources (Ministry of Education of the People's Republic of China, 2025).

2.2 Implementation Status

The urban-rural gap remains a major challenge in the field of music education during policy implementation. Data from the Ministry of Education of the People's Republic of China (2022) shows that approximately 15% of professional music teachers are allocated to rural areas, forcing some rural schools to rely on substitute teachers or recorded broadcast resources. A questionnaire survey and interviews with 28 rural primary schools in Northeast China found that local music education faces real dilemmas such as insufficient teaching staff, backward teaching facilities, easy cancellation of courses, and the conversion of teaching content into recorded broadcast resources (Leung & Sun, 2013). In contrast, urban schools have more professional teaching staff, MIDI (Musical Instrument Digital Interface) laboratories, and rich extracurricular music programs. This structural advantage provides students with a more complete music experience. Technological inequality is also a key factor exacerbating the urban-rural gap. Relevant research points out that although many urban classrooms are equipped with interactive whiteboards and multimedia devices, teachers in rural schools often cannot use these devices effectively or simply lack audio playback tools (Yu, 2025).

The teaching tradition has also become a major obstacle to reform. In rural music classrooms in China, the "demonstration-imitation" approach still prevails, emphasizing skill training while neglecting the cultivation of musical expressiveness and cultural emotions. Rural teachers lack support and training in the integration of ICT (Information and Communication Technology) and the use of digital resources. An international study pointed out that "virtual choirs" using remote audio/video tools can effectively connect urban and rural student groups, enhancing the sense of collaboration and music learning opportunities

(Eren & Öztuğ, 2020). In summary, the gaps in hardware, teaching staff, and educational concepts between urban and rural areas have made rural music education face significant challenges in terms of quality, sustainability, and cultural expression. In contrast, urban schools are already in a relatively leading position in terms of resources and teaching methods.

2.3 Technology Integration

Digital technology provides new possibilities for alleviating the uneven distribution of music education resources between urban and rural areas by enabling the sharing of high-quality teaching resources. However, disparities in access to digital technologies still exist. For example, the internet penetration rate in China reached 85.3% in urban areas compared with 65.6% in rural areas, reflecting a persistent digital divide that may influence the adoption of digital learning tools in schools (China Internet Network Information Center [CNNIC], 2025). Similarly, the Global Education Monitoring Report highlights that emerging educational technologies such as Artificial Intelligence and virtual reality are increasingly being integrated into classrooms, while inequalities in technological access remain significant across regions (United Nations Educational, Scientific and Cultural Organization, 2023). In addition, Sun (2024) found that after adopting a VR-based music learning system, students showed significant improvements in immersion, learning motivation, and conceptual understanding.

However, while actively spreading the achievements of digital teaching, risks should not be ignored. Neumann and Neumann (2017) warned that a screen-intensive learning environment may weaken children's tactile contact with physical musical instruments in music learning, posing a potential obstacle to the development of motor skills. At the same time, the "AI and the Future of Teaching Report" released by the U.S. Department of Education also emphasized that unregulated AI platforms pose a risk of student privacy leakage. In 2023, some teachers were investigated for uploading student data in violation of regulations (U.S. Department of Education, 2023). These studies fully demonstrate that when promoting AI digital technology, the protection of student information and ethical norms urgently need to be strengthened simultaneously.

3. AI in International Art Education: A Comparative Perspective

Against the backdrop of multiple countries promoting the integration of technology into art education, practices in different countries indicate that technological means have significant advantages in enhancing artistic skills, while also having limitations in cultural interpretation. For example, the e-David robot developed by the University of Konstanz in Germany analyzes the painting process through computer vision and provides students with feedback on brushstrokes and colors, thereby improving technical accuracy. However, this system relies on fixed algorithms when dealing with abstract expressions and lacks an understanding of subjective intentions (Deussen et al., 2012). In France, research by Avci et al. (2024) shows that the digital game ARTè: Lumière has improved students' knowledge acquisition and learning interest in art history teaching. But when it comes to in-depth interpretations of cultural symbols and historical contexts, students still prefer the guidance of human teachers. In Japan,

the LLaVA-Docent multimodal system developed by Lee et al. (2024) is used in calligraphy teaching and significantly improves the accuracy of stroke structures. However, it has also raised concerns among teachers about the weakening of the traditional aesthetic dimension, especially in traditional expressions that emphasize “verve” and “vivid charm.” In cross-cultural art generation applications, Wang et al. (2023) pointed out that although using the CycleGAN model for style transfer can generate images with a Ukiyo-e style, without historical control, it is easy to mix the Edo and Meiji styles, leading to misinterpretations of history. Similarly, in the teaching of Ram Thai traditional dance in Thailand, although the AI system can improve students’ mastery of dance sequences, the teaching process often shows the phenomenon of “mechanical repetition,” unable to reflect the religious spirit and cultural atmosphere in the sacred gestures. In summary, the application of technology in art education can improve the effect at the technical execution level, but its conveyance of culture, emotion, and historical context still depends on the guidance of teachers and human intervention to achieve a more balanced and in-depth art learning experience.

4. TPACK-AK Framework: Theoretical Foundations and Extensions

4.1 The Original TPACK (Technological, Pedagogical, and Content Knowledge) Model

The TPACK framework by Mishra and Koehler (2006) conceptualizes teacher knowledge into three intersecting domains: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). This model emphasizes that effective technology integration requires understanding how tools transform teaching methods in specific disciplines, rather than merely digitizing traditional practices. Empirical validation indicates that the effectiveness of TPACK depends on contextual adaptation, especially in resource-constrained environments. However, measurement challenges persist as self-assessment often overestimates actual capabilities. This model emphasizes that effective technology integration requires understanding how tools transform teaching methods in specific disciplines, rather than merely digitizing traditional practices. Empirical validation indicates that the effectiveness of TPACK depends on contextual adaptation, especially in resource-constrained environments (Schmid et al., 2021). Teachers tend to overestimate their capabilities in self-assessment. There are significant differences between objective measurements, lesson plan analysis, and self-assessment. Although pre-service teachers generally have high self-assessment scores, the degree of technology integration in the lesson plans they design may not be consistent with their self-assessment.

4.2 Integration of Artistic Knowledge (AK) with TPACK

The TPACK-AK extension meets the unique needs of art education by adding artistic knowledge. It addresses the shortcomings of traditional TPACK in the sociocultural dimension by introducing “AK” (Artistic Knowledge). This extension responds to the criticism that TPACK does not pay sufficient attention to the sociocultural dimension and acknowledges that artistic thinking is the foundation of cognitive development and culturally responsive teaching. Artistic Knowledge is defined as “the interaction between material art skills and the ability to decode cultural meanings through multimodal representations” (Burnard & Colucci-Gray, 2021). Globally, institutional barriers still exist: A UNESCO

(2023) survey points out that the standardized testing system and resource allocation policies marginalize art integration in 68% of national curricula, leading to the so-called “aesthetic segregation,” which has a particularly greater impact on marginalized students.

In the continuous development of the TPACK framework, scholars have begun to focus on its adaptability and limitations in the field of art education, especially the integration of “Artistic Knowledge (AK)”. Burnard and Colucci-Gray (2021) pointed out that while the traditional TPACK model emphasizes the intersection of technology, teaching, and subject knowledge, it ignores the importance of multimodal representation and cultural meaning decoding in art education. They advocate introducing the AK dimension to make TPACK better reflect the complexity and cultural nature of artistic thinking, emphasizing that the mastery of technology in art education should be equally important as the critical understanding of the social and political impacts of digital tools, thus expanding the theoretical boundaries and practical applicability of TPACK in art education.

AI technology is redefining the boundaries of AK (Artistic Knowledge). Generative AI models represented by DALL-E and Stable Diffusion have become new media that cannot be ignored in artistic creation and teaching. Dehouche and Dehouche (2023) pointed out that these text-image models can not only effectively support students’ visual experiments and exploration of artistic styles, but also force educators to re-examine the definitions of creativity and artistic copyright. In addition, Epstein et al. (2023) emphasized in their review of generative AI that such AI tools have significant aesthetic and cultural embedding capabilities, and pointed out that the education system needs to introduce an interdisciplinary teaching framework to promote the integration of algorithmic literacy and art criticism in order to meet the challenges of technological change. At the same time, blockchain technology has triggered a new model of competence certification in art education.

The AI-TPACK-AK model conceptualizes Artificial Intelligence as an enabling layer that interacts dynamically with Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), and Artistic Knowledge (AK). In primary school music education, AI enhances diagnostic feedback (TK), supports adaptive pedagogy (PK), strengthens music content understanding (CK), and expands creative and cultural expression (AK). Teachers play a central mediating role in balancing these components to preserve artistic integrity.

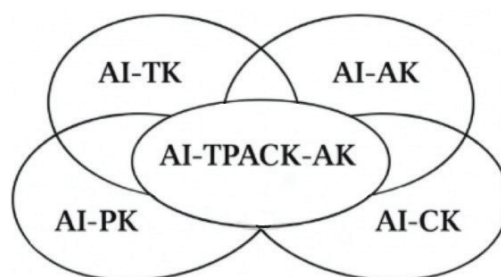


Figure 1 Theoretical Model Diagram

4.3 Synthesis of AI Applications in Primary School Music Education and TPACK-AK Alignment

Table 1 AI Applications in Music Education and Alignment with AI-TPACK-AK Framework

AI Application Category	Representative Tools	Learning Outcomes	Success Factors	Potential Risks	AI-TPACK-AK Alignment
Skills Practice	SmartMusic, Yousician	Improved pitch accuracy	Real-time feedback	Over-reliance on automation	TK (tool operation), CK (music skills), PK (adaptive teaching)
Performance Assessment	AI-driven rhythm analysis tools	Targeted skill improvement	Objective evaluation criteria	Neglect of expressive qualities	TK (data analysis), CK (assessment standards), AK (artistic expression awareness)
Creative Composition Assistance	AIVA, Soundful	Enhanced creative thinking	Cultural music database	Cultural bias in algorithms	TK (generative tool use), CK (music theory), AK (creative expression, cultural authenticity)
VR-based Immersive Learning	VR music performance simulators	Increased immersion	Stable network	Cost barriers	TK (VR technology), PK (immersive teaching design), AK (aesthetic perception)
Teacher-Assistant Tools	AI lesson planners, resource recommenders	Improved teaching efficiency	User-friendly design	Over-reliance on AI	TK (tool integration), PK (lesson planning), CK (curriculum knowledge), AK (artistic value preservation)

Sources: Developed by the author

5. Teachers' Cognition, Attitude and Adaptation

5.1 Cognitive Dimension

Teachers' understanding of AI mainly stays at the "tool" level, rather than an in-depth understanding of the technical logic. For example, although music-generating tools like AIVA provide new ways of teaching, research shows that most teachers cannot explain the machine-learning principles

behind them. Globally, the surface understanding of AI is significantly higher than the understanding of its underlying mechanisms: a study indicates that while about 70% to 80% of teachers can list practical AI applications (such as AIVA), less than 35% of teachers understand their algorithmic principles (Nazaretsky et al., 2022). This cognitive disconnect exacerbates the implementation anxiety of senior teachers, as they worry about losing control of the technology. In South Korea, teachers who have received AI training are on average about 30% more confident in using AI tools than those who have not (Ravi et al., 2023). Although teachers are aware of the potential of AI in personalized diagnosis, they still emphasize the dominance of teaching, and more than 70% of teachers oppose completely entrusting curriculum design to AI. In addition, constructivism-oriented teachers are more inclined to accept AI tools and regard them as a way to support student-centered teaching (Holmes & Tuomi, 2022).

In the field of art education, there is a tension among teachers between practicality and emotional authenticity. Research shows that approximately 60% of music teachers recognize the value of AI in style exploration and creative assistance, but they remain skeptical about the emotional depth of AI-generated works (Culliton, 2024). Cultural background also significantly influences its application orientation: for example, Italian teachers tend to view AI as an experimental medium, while Chinese teachers are more concerned about its practical utility in skill training. In terms of content integration, most teachers find it difficult to effectively align AI resources with established curriculum goals, and only about 40% can adapt platform suggestions to local teaching needs (Zhang, 2023). In music preservation and interdisciplinary integration projects, such as “AI + Traditional Music Preservation,” the new knowledge integration challenges faced by curriculum designers further highlight the integration obstacles.

5.2 Attitude Formation

Teachers generally hold a cautiously optimistic attitude towards the integration of Artificial Intelligence (AI) into courses, but there are also significant concerns. For example, Zhang (2022) found in an empirical study of music education in China that about 64% of teachers believe that AI can improve teaching efficiency, but a considerable proportion of teachers are concerned about data privacy and system reliability. At the same time, age and teaching experience have a moderating effect on teachers' attitudes: novice teachers are more inclined to try AI teaching tools, while senior teachers show a reserved attitude due to concerns about the weakening of teaching autonomy and authority (Yu et al., 2023). Teachers' views on AI automatic feedback also present an “efficiency-dependence” dilemma: although most teachers affirm the immediacy and time-saving nature of AI feedback, they also worry that excessive dependence may lead to the rigidity of teaching strategies and a lack of human judgment (Zhang et al., 2024).

In the field of art teaching, the creative ability of AI has triggered teachers' dual judgment on “technical assistance” and “emotional expression”. Some research indicates that music teachers generally recognize the potential of AI in stimulating creativity when using it for assisted creation, but they still have reservations about whether AI works can truly express emotions (Zhang & Wan, 2020). In addition, cultural background also affects teachers' attention to AI ethical issues to a certain extent. For example,

some research points out that teachers in Europe and Asia have different concerns regarding copyright, intellectual property rights, and cultural inheritance (Yu et al., 2023).

At the level of curriculum content integration, teachers generally welcome the supportive role of AI in theoretical teaching. For example, tools used to assist in rhythm, harmony, or melody analysis can enhance students' mastery of basic knowledge. However, some research also warns that the introduction of such technologies may lead to learning remaining at a surface level of understanding, and the development of students' critical and creative thinking may not necessarily improve synchronously (Zhang et al., 2024). Globally, AI-led content recommendation may also bring the risk of cultural homogenization, weakening the diverse expressions of local musical traditions (Yu et al., 2023).

5.3 Adaptation Path

When primary school music teachers adapt to AI technology, they face the tension between tool selectivity and teaching autonomy. Research has found that teachers have a “critical selectivity” towards AI-assisted tools. They are more willing to use functions that are highly consistent with teaching objectives and will actively avoid complex or opaque modules. For example, in the practice of the AIVA system, the dependence of some teachers on it may compress the space for teaching autonomy. Especially in areas with unstable offline conditions, the adaptation scores of teachers to AI tools are significantly lower (García-Martínez et al., 2020). The teaching structure also needs to be reshaped: from the traditional “demonstration-practice” to the “diagnosis-intervention” cycle, in order to achieve more targeted teaching improvement.

In art teaching, the boundaries of “collaboration” have become the focus of attention. Research shows that when AI tools are used to generate initial creative materials, teachers are more likely to accept this “semi-open” collaborative approach if students incorporate original elements based on these materials. Such collaboration emphasizes transparent attribution and role differentiation, forming an “AI-human collaboration” model. In addition, combining AI-generated content with local music culture can also help enhance learning effects and avoid cultural homogenization. All these practices indicate that the rational application of AI in primary school music education needs to be premised on teachers' autonomy, cultural context, and the adjustment of teaching structure.

6. Discussion: Towards Balanced Integration

The integration of AI-TPACK-AK into primary school music education continues to reveal the tension between its transformative potential and systemic challenges. Successful implementation will depend on the following interrelated dimensions:

Infrastructure equity and teacher development form the fundamental support. The technological gap seriously hinders accessibility-the AI adaptation efficiency of rural schools is 40% lower (García-Martínez et al., 2020), and only 37% of rural schools in China have sufficient bandwidth for music applications (UNESCO, 2023). This requires the fair distribution of resources through lightweight intelligent solutions, such as mobile projection systems, and policy interventions. At the same time, the

systematic cultivation of teachers' AI-TPACK-AK capabilities is crucial, including the integration of pre-service training, cooperation with artists, differentiated professional development compared with traditional training, and an ethical framework to address privacy and algorithmic bias.

Ethical governance and curriculum innovation determine the implementation quality. Algorithmic transparency, cultural inclusivity, and copyright reform constitute the core ethical pillars. It is necessary to address the dominance of Western art in training data and improve policies for AI-generated content. At the same time, local ethical guidelines (such as those in Shanghai) should be expanded into national art-specific regulations. Curriculum design must maintain cultural authenticity through algorithm localization, balance the participation of digital tools and physical instruments, and ensure students' creative autonomy to preserve the essence of art. In these dimensions, a sustainable ecosystem for technology-enabled music education has been jointly established.

6.1 Implications for Practice

To promote the effective integration of AI into Chinese primary school music education, the following actionable recommendations are proposed for teachers, schools, and policymakers:

1) **Phased Teacher Development Roadmap:** Design a three-stage training program based on AI-TPACK-AK: (a) Initiation stage-train teachers to use user-friendly AI tools; (b) Pilot implementation stage-guide teachers to design AI-assisted lessons that balance technical practice and artistic expression; (c) Scaling-up stage-support teachers to develop AI tools adapted to local musical traditions.

2) **Urban-Rural Resource Sharing Mechanism:** Establish a "cloud music classroom" platform connecting urban and rural schools, providing: (a) Pre-recorded AI-assisted lessons by urban professional teachers; (b) Virtual choir collaboration tools to enhance interaction between urban and rural students; (c) Low-cost hardware support for rural schools through government funding.

3) **Balanced Teaching Model Design:** Combine AI tools with traditional teaching methods: (a) Use AI for technical training and human teachers for emotional expression guidance; (b) Allocate 60-70% of class time to physical instrument practice and 30-40% to AI-assisted creative or immersive activities; (c) Incorporate local musical culture into AI applications.

4) **Ethical Guidelines for Primary School Music Education:** Develop age-appropriate ethical norms: (a) Teach students to distinguish between AI-generated and human-created music; (b) Emphasize copyright attribution when using AI-generated content; (c) Limit screen time to avoid affecting motor skill development.

5) **Policy Implementation Monitoring:** Establish a dynamic evaluation system to track: (a) The penetration rate of AI tools in rural primary schools; (b) Teachers' AI-TPACK-AK competence improvement; (c) Students' artistic expression and cultural identity development.

Conclusions

Core Findings

AI tools offer significant potential for primary school music education, including personalized learning support, real-time performance feedback, and expanded creative expression, but their effectiveness is constrained by urban-rural infrastructure gaps, algorithmic cultural bias, and teachers' technological anxiety.

The AI-TPACK-AK framework is a valid analytical tool for understanding teachers' technology integration capabilities, with Artistic Knowledge (AK) playing a critical role in preserving music's aesthetic and cultural essence amid technological change.

China's policy context provides strong impetus for AI-in-education development, but the implementation gap between urban and rural areas, as well as traditional teaching models, hinder equitable access to technological benefits.

Teachers' attitudes toward AI are cautiously optimistic, with cognitive depth, teaching experience, and cultural background influencing their adaptation paths, highlighting the need for targeted professional development.

Recommendations

Integrating Artificial Intelligence into the AI-TPACK-AK framework is effective because it aligns technical functions with teaching intentions and artistic values. The main advantages include personalized learning, timely feedback, and more creative opportunities, while the main limitations involve cultural bias, over-reliance on automation, and the potential erosion of teachers' professional autonomy.

Specifically, this study argues that effective AI integration in primary school music education requires:

1. Longitudinal Adaptation Research: Tracking the development of teachers at various stages of their careers.
2. Culturally Responsive AI Design: Co-creating tools with diverse music communities.
3. Blended Learning Model: Optimizing the integration of AI and traditional music teaching.
4. Policy Implementation Analysis: Evaluating the effectiveness of regulation in different scenarios.
5. Student Experience Research: Focusing on learners' perspectives on AI-enhanced music education.

With the rapid development of AI, continuous teacher development, critical policy engagement, and student-centered teaching innovation remain crucial for realizing the potential of technology while preserving the irreplaceable human essence of music. The principles and practices outlined in this article provide a foundation for this ongoing work in the context of global education.

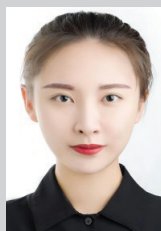
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