https://doi.org/10.30775/KMES.54.1.333
음악교육연구 제54권 제1호 pp. 333-350 (2025년 2월) ISSN 1229-4179 (Print)
Korean Journal of Research in Music Education Vol.54, No.1, (February, 2025) ISSN 2713-3788 (Online)

TPACK 프레임워크를 통한 태국 중등 음악 교사의 요구와 해결 방법

Needs and Solutions for Secondary Music Teachers in Thailand through the Lens of TPACK Framework

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Abstract This study explored the needs and solutions for integrating technology into secondary music education in Thailand using the TPACK framework, adapted as MTPACK for music teachers. The researcher focused on teachers in the music intensive program from 18 schools. Despite technology being included in the curriculum, many teachers struggle to use it effectively due to limited professional development. A mixed-methods approach was used, involving surveys with 38 teachers and interviews with five teachers from schools with the largest number of music students. Quantitative analysis using the Priority Needs Index highlighted significant gaps in Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Pedagogical Content Knowledge (PCK). Qualitative findings confirmed these challenges and emphasized the need for 1) practical training, 2) exposure to music education software, and 3) structured lesson plans. The study concludes with a proposed analyzed list of free software and strategies to support teachers in improving their technological integration.

Key words: TPACK framework, music education, professional development, need assessment

초록 본 연구는 태국 중등 음악 교육에서 기술 통합의 필요성과 해결책을 탐구하며, 음악 교사를 위해 TPACK 프레임워크를 MTPACK으로 조정하여 적용했습니다. 연구는 19개 학교 음악 집중 프로그램 교사들을 대상으로 진행되었습니다. 커리큘럼에 기술이 포함되어 있지만, 많은 교사들이 제한된 전문성 개발로 인해 기술 활용에 어려움을 겪고 있습니다. 본 연구는 혼합 연구 방법을 사용하여 38명의 교사를 설문조사하고, 음악 학생이 많은 학교의 5명을 인터뷰했습니다. 우선순위 필요 지수(Priority Needs Index) 분석에서 기술적 교육학적 지식(TPK), 기술 콘텐츠 지식(TCK), 교육 콘텐츠 지식(PCK) 간 격차가 확인되었습니다. 분석 분석 결과, 1) 실용적 훈련, 2) 음악 교육 소프트웨어 노출, 3) 구조적 수업 계획 필요성이 강조되었습니다. 연구는 교사의 기술 통합 능력 향상을 위한 무료 소프트웨어와 전략을 제안하며 결론을 맺습니다.

주제어: TPACK 프레임워크, 음악 교육, 기술 통합, 교사 전문성 개발, 요구 평가

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Received: 30 November 2024, Reviewed (Revised): 8 January (16 January) 2025, Accepted: 3 February 2025

Ⅰ. Introduction

The integration of technology into music education is increasingly important, particularly within Thailand's Music Intensive Program, a specialized initiative program funded by Thailand Ministry of Education, launched in 2017 to promote musical talent, reduce educational inequality, and foster peace through the arts. By 2022, the program had expanded to include over 1,800 students across 18 schools, offering a three-year-long curriculum aligned with international standards like ABRSM. This program is available for students in Grade 7-9 and Grade 10-12, focusing on practical music performance, ensemble performance, music arrangement, keyboard skills, music theory, music history, and music technology providing a comprehensive education in both technical and cultural aspects of music. These schools are unique in their strong focus on music and the arts, supported by funding and dedicated personnel, making them ideal settings for exploring the integration of technology into music education.

This study, conducted in the context of these well-resourced schools, serves as an exploration of the most favorable conditions for implementing technology in music classrooms. The research objectives were: (1) to perform a needs assessment of music teachers' technological integration using surveys and interviews, and (2) to analyze music education software and teaching strategies aligned with the MTPACK framework (Music Technological Pedagogical Content Knowledge), where the intersection of technology, pedagogy, and music content knowledge has been emphasized.

The findings aimed to benefit both the music intensive program itself and to inform broader applications in general music classrooms nationwide, providing insights and strategies that can enhance music education across diverse educational contexts in Thailand and other countries alike.

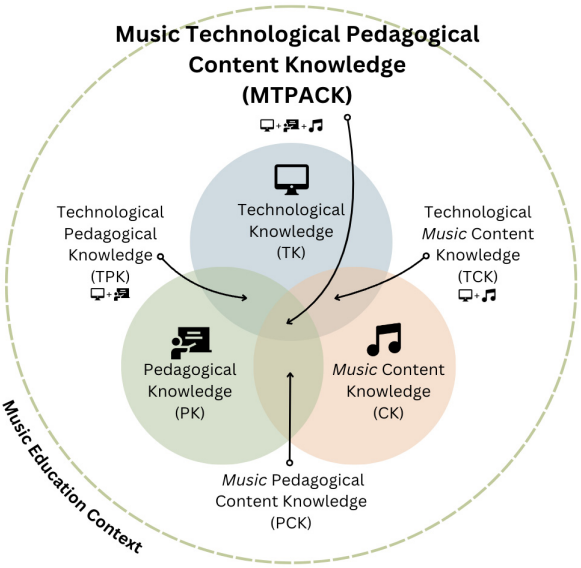
Ⅱ. Literature Review

1. TPACK framework in music education

Technological and computer literacy is a crucial in current teaching and learning as UN had suggested in sustainable development. Accordingly, the Technological Pedagogical Content Knowledge (TPACK) framework provides a structured approach for integrating technology into teaching practices. It consists of seven interconnected components: Technological Knowledge

(TK), Pedagogical Knowledge (PK), and Content Knowledge (CK), along with their intersections. These intersections include Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and the integrative Technological Pedagogical Content Knowledge (TPACK). This model highlights the importance of understanding how these domains interact to create effective, technology-enhanced teaching strategies. (Schmidt et al., 2009)

In the context of music education, the existing literature on TPACK in music education highlights the frameworks' adaptability to different contexts. Bauer's work extensively explores TPACK in the context of in-service music educators in the United States, focusing on a broad application of technology integration across music teaching practices (Bauer, 2013). His research introduces the MTPACK model, which aligns TPACK principles with the unique pedagogical and technological needs of music education, emphasizing teacher self-efficacy and professional development. Bauer developed the MTPACK-Q questionnaire to measure music teachers' self-efficacy in each TPACK component areas. This research builds on Bauer's foundation, further refining the MTPACK framework to align with the specific needs of secondary music education, as depicted in [Figure 1].



[Figure 1] MTPACK Framework Developed by the Researchers Adapted from the original TPACK (Schmidt et al., 2009) with inspiration from MTPACK-Q (Bauer, 2013)

Teacher self-efficacy, which refers to their belief in their ability to impact student learning, plays a crucial role in the effective integration of technology. High self-efficacy has been shown to promote the adoption of new technologies and innovative teaching practices (Bauer, 2013; Doherty, 2021).

In contrast, Gall's research investigates the pre-service music teacher education context in England, offering an in-depth analysis of TPACK. This study highlights the significant distinctions between Technological Knowledge (TK) and Technological Content Knowledge (TCK), particularly in relation to addressing students' needs. Gall emphasizes the importance of providing adequate time for pre-service teachers to develop their music technology skills, recognizing that these skills are foundational for effectively integrating technology into classroom practices (Gall, 2016).

Professional development programs geared toward enhancing TPACK competencies are thus critical for empowering music educators to optimize technology integration in their teaching. Recent studies suggest that hands-on and experiential training models are especially effective. By adopting these approaches, music teachers can better navigate the complexities of digital resources and software, ultimately strengthening student learning outcomes (Partti, Weber, & Rolle, 2021).

2. Music teachers in current music classroom

While technology, media, and software programs have greatly supported music education, they cannot replace the essential role of music teachers. Teachers must carefully craft lessons that integrate technology effectively while meeting instructional objectives (Ho, 2004). Dorfman's (2022) framework for Technology-Based Music Instruction (TBMI) highlights how technology, when paired with pedagogical strategies, enables students to actively build knowledge by composing, performing, and analyzing music. TBMI fosters personalized and collaborative learning through tools like DAWs, notation software, and interactive platforms, allowing students to explore diverse musical styles while engaging with constructivist education principles.

However, teachers who have limited experience with digital tools encounter significant challenges in implementing technology-based pedagogies, echoing Gall's (2016) observation that many pre-service music teacher programs do not adequately emphasize technological training. As a consequence, many educators struggle to translate their limited exposure to music technology into meaningful classroom applications. Addressing this shortfall necessitates the development of ongoing professional development opportunities focused on building digital competencies and

pedagogical strategies simultaneously (Partti, Weber, & Rolle, 2021).

Moreover, as information and resources become more readily accessible through technology, there is a tendency for students to prioritize memorization over understanding. Some students focus on recalling details retrieved from information technology, neglecting the connective understanding between music theory, history, and literature (Udtaisuk, 2016). Similarly, abundant internet resources can lead to learning by mere replication of physical movements when performing, often disregarding the value of pedagogical feedback. This highlights the necessity for teacher-guided, reflective learning processes that engage higher cognitive functions and encourage deeper understanding (Udtaisuk, 2016).

Incorporating these insights into the TPACK framework, particularly Technological Pedagogical Knowledge (TPK) and Technological Content Knowledge (TCK), underscores the importance of professional development programs. These programs must equip teachers with the skills to integrate technology effectively, balancing guidance and autonomy to ensure technology enhances rather than replaces the human element of teaching. By leveraging such tools and strategies, music educators can foster student-centered learning environments that reflect the dynamic interaction between human and technological actors, reshaping modern pedagogical approaches (You, 2024).

While TPK and TCK are critical, music educators must not overlook Pedagogical Knowledge (PK), which emphasizes foundational teaching strategies like fostering active engagement, critical thinking, and student motivation. Student-centered education rooted in PK connects activities to students' prior knowledge and experiences, promoting intuitive understanding (López-Íñiguez et al., 2022). Authentic problem-solving, collaboration, and feedback nurture creativity, group dynamics, and learning from errors (Sun et al., 2024), aligning with the shift toward personal goals and meaningful challenges (Cremades-Andreu & Lage-Gómez, 2023). Integrating traditional strategies like inquiry-based and project-based learning with music technology enriches education while preserving educators' guidance roles (Chen, 2017; Krajcik & Shin, 2022; Scott, 2008; Supe et al., 2024; Zohar, 2023).

Ⅲ. Method

This explanatory research employed a mixed-methods design, with quantitative data collection and analysis conducted before qualitative data collection and analysis (Creswell, 2021). To ensure result validity and descriptive depth, data triangulation was implemented.

1. Quantitative phase

The quantitative phase aimed to assess the technological integration and self-efficacy of music teachers using a structured questionnaire grounded in the MTPACK framework. The survey questions were derived from two foundational studies: Schmidt et al. (2009), who developed and validated TPACK instruments, and Bauer (2013), who adapted TPACK for music education. From Schmidt's study, the four highest-scoring questions from factor analysis were selected, translated into Thai as shown in <Table 1>, and reviewed by three experts using the Index of Item-Objective Congruence (IOC) to ensured the clarity and relevance of the questions provided internal validity, as the results from the three experts qualified the items for their suitability in addressing the study's aims.

<Table 1> Sample of translated questions in Thai from the questionnaire

TPACK domains	Original questions in english	Translated questions in Thai
Technological knowledge (TK)	I know how to solve my own technical problems.	เมื่อเกิดปัญหาทางเทคนิคในการใช้เทคโนโลยีต่างๆ ในชีวิตประจำวัน ฉันสามารถแก้ไขปัญหาได้ด้วยตนเอง
Content knowledge (CK)	I have sufficient knowledge and skill as a musical performer (singing and/or playing instruments, reading and notating music).	ฉันรู้และเข้าใจหลักการในการแสดงดนตรีที่ถูกต้องเป็นอย่างดี (การแสดงดนตรี: การร้องเพลง หรือ การเล่นเครื่องดนตรี, การอ่านและการเขียนโน้ตเพลง)
Pedagogical knowledge (PK)	I know how to assess student performance in a classroom.	ฉันสามารถประเมินผลผู้เรียนในชั้นเรียนของฉันได้
Pedagogical content knowledge (PCK)	I know how to select effective teaching and learning strategies to guide student knowledge and skill development in music performance	ฉันรู้วิธีคัดเลือกกลยุทธ์การสอนที่มีประสิทธิภาพเพื่อจัดการเรียนการสอนเกี่ยวกับการแสดงดนตรีให้ผู้เรียน
Technological content knowledge (TCK)	I know about technologies that I can use for listening to music.	ฉันรู้จักเทคโนโลยีที่สามารถนำไปใช้เพื่อส่งเสริมการเรียนรู้เกี่ยวกับการฟังดนตรี
Technological pedagogical knowledge (TPK)	I can choose technologies that enhance students' learning for a lesson.	ฉันสามารถเลือกเทคโนโลยี เพื่อส่งเสริมกลยุทธ์และวิธีการสอนให้ดียิ่งขึ้นสำหรับบทเรียนได้
Technological pedagogical and content knowledge (TPACK)	I can teach lessons that appropriately combine music theory, history, genres/styles, and/or cultural contexts, technologies, and teaching and learning strategies.	ฉันสามารถปรับใช้เทคโนโลยีเพื่อส่งเสริมกลยุทธ์และวิธีการสอนในบทเรียนที่เกี่ยวกับเนื้อหาดนตรีได้อย่างมีประสิทธิภาพ (เนื้อหาดนตรี: ทฤษฎีดนตรี องค์ประกอบของดนตรี วรรณคดีดนตรี ประวัติศาสตร์ดนตรี)

The survey distributing to 120 music teacher in 18 schools under the music intensive program, receiving 38 responses (response rate: 31.67%). Teachers were asked to assess their current state of competence and their ideal state across the MTPACK components.

<Table 2> Total numbers of teachers and students in music intensive program

Regions	School name	Teachers	Students (grade 9 & 12)
Central Thailand	Horwang School	41	57
	Rachawinit Bangkaeo School	12	61
	Amphawan Wittayalai School	4	5
	Kanchanaphisek Wittayalai Suphanburi School	1	34
	Uthai Wittayakhom School	5	30
	Phichit Pittayakom School	3	53
Northern Thailand	Chiang Kham Wittayakhom School	5	33
	Chakkham Khanathon School, Lamphun	3	0
	Lampang Kanlayanee School	5	34
Northeastern Thailand	Suranaree Wittaya School	3	37
	Kanchanaphisek Wittayalai Kalasin School	1	4
	Sisaket Wittayalai School	10	37
	Mathayom Wanorn Niwat School	5	11
Southern Thailand	Mahavajiravudh Songkhla School	5	47
	Thung Song School	2	5
	Saparachinee Trang School	9	47
	Benjamarachutit Pattani School	5	30
	Su-ngai Kolok School	1	0

Data analysis included calculating the mean (μ) by first finding the average score for each question across all respondents, then averaging these question-level means to get the domain-level mean and standard deviation (σ) by determining the variability of the question means around the domain mean, providing a measure of score dispersion for the domain. To identify areas requiring improvement, the Priority Needs Index (PNI) was calculated using the Modified Priority Needs Index (PNI modified) formula described by Wongwanich (2015) PNI modified = (I - D) / D where I (Important) represents the mean score of the ideal state, or the state teachers aspire to achieve. D (Degree of success) represents the mean score of the current state, or the teachers' present level of competence. This formula highlights the gap between the current and

ideal states, with higher PNI values indicating greater need for improvement. The highest PNI score reveals the most signification gaps between the current state of competence and the ideal state, which then verifies the priority of needs and solutions.

2. Qualitative phase

To complement the quantitative findings, semi-structured interviews were conducted with five participants selected from schools with the highest number of grade 9 and 12 music students graduating in 2023. Key informants were from the following schools: (T1) Rachawinit Bangkaeo School, (T2) Horwang School, (T3) Phichit Pittayakom School, (T4) Mahavajiravudh Songkhla School, and (T5) Saparachinee Trang School. All participants hold bachelor's degrees in music education and have over five years of teaching experience. These interviews explored teachers' lived experiences, challenges, and aspirations regarding the integration of technology into their teaching practices. The interviews focused on four main questions: (1) How do teachers perceive technology's role in enhancing teaching and learning? (2) What challenges do teachers face in integrating technology, including hardware, software, and AI tools? (3) What type of professional development do teachers need to improve their technological competencies? The qualitative data were analyzed thematically, focusing on recurring patterns and insights. The analytic tools included questioning, drawing upon personal experiences, and examining expressed emotions (Corbin & Strauss, 2015). These approaches enabled the researcher to gather detailed data, which were carefully interpreted to extract meaningful results.

3. Mixed-methods integration

The mixed-methods approach combined quantitative and qualitative findings to offer a comprehensive view of the needs and challenges faced by music teachers. Quantitative data identified priority areas, while qualitative interviews provided context and detailed insights. At this stage, qualitative results were analyzed in order to explain or support quantitative information, which followed mixed method strategy (Creswell, 2012)

Ⅳ. Results

The findings of this study are organized into two sections: 1) the needs of secondary school music teachers based on the TPACK framework, and 2) an analysis of software and teaching strategies to address these needs. Quantitative results included descriptive statistics summarizing 1) participating teachers' demographics and 2) survey data analyzed with the Priority Needs Index (PNI) to evaluate needs in each TPACK component. Qualitative results identified the current status and needs through thematic analysis. These findings, combined with PNI values in a joint display, highlighted major challenges. To address these, a list of free music education software tools and practical teaching strategies was proposed, aligned with the TPACK framework.

1. Quantitative findings

The table summarizes the demographics of 38 surveyed music teachers, detailing gender, years of experience, and highest degrees. Of the participants, 34.21% were female and 65.79% male. Most (52.63%) had 1-5 years of experience, 39.47% had 6-10 years, and 7.89% had 11-15 years. In education, 78.95% held a Bachelor's degree, and 21.05% a Master's degree. Despite a small sample size and limited response rates due to data collection challenges across Thailand, the study achieved comprehensive regional coverage: Central Thailand (50.00%), Northeastern and Southern Thailand each (18.42%), and Northern Thailand (13.16%).

The reliability of the instrument was confirmed through Cronbach's alpha, with values exceeding ranged from 0.71 to 0.94 for each measured component as shown in <Table 4>, indicating acceptable internal consistency and validity (Cronbach, 1951; Nunnally, 1978).

The analysis of the questionnaire data revealed significant areas of challenges in the TPACK components, particularly in the top four complicated areas (integration of two subjects) (TPACK), (TPK), (TCK), and (PCK) with PNImodified = 0.52, 0.46, 0.44, 0.41 respectively) The lower values of PNImodified were pointed at another three areas in the less complicated level (focus on one component) namely technological (TK), pedagogical (PK), and music content knowledge (CK) with PNImodified = 0.37, 0.26, 0. 25 respectively.

<Table 3> Descriptive statistic for demographics of music teachers

Survey item	N = 38	Percent
Gender		
Female	13	34.21
Male	25	65.79
Years of experience		
"1-5"	20	52.63
"6-10"	15	39.47
"11-15"	3	7.89
Higest degree earned		
Bachelor's	36	78.95
Master's	2	21.05
Regions		
Central Thailand	19	50.00
Northern Thailand	5	13.16
Northeastern Thailand	7	18.42
Southern Thailand	7	18.42

<Table 4> MTPACK self-efficacy of music teacher sorted by Priority Needs Index (PNI)

MTPACK Self-efficacy	Music teachers'current state			Music teachers'ideal state			Priority Needs Index (PNI)	
	$\bar{x}$	SD	Alpha	$\bar{x}$	SD	Alpha	PNImodified	Priority
TPACK	2.21	0.82	0.84	4.64	0.45	0.91	0.52	1
TPK	2.54	0.53	0.82	4.71	0.55	0.90	0.46	2
TCK	2.61	0.59	0.71	4.63	0.38	0.75	0.44	3
PCK	2.75	0.96	0.88	4.64	0.35	0.75	0.41	4
TK	2.79	0.59	0.74	4.46	0.55	0.94	0.37	5
PK	3.39	1.08	0.93	4.59	0.35	0.84	0.26	6
CK	3.43	0.59	0.72	4.60	0.32	0.72	0.25	7

The analysis of the Priority Needs Index (PNImodified) highlights the gaps in self-efficacy between separate and combined components of the MTPACK framework as follow:

1. Technological Knowledge (TK) vs. Combined Components (TPK, TCK): TK, with a PNImodified value of 0.37, indicates basic proficiency in technology use. However, the significantly higher PNImodified values of TPK (0.52) and TCK (0.44) reveal that teachers face challenges in integrating technology effectively into pedagogy and content. This

reflects a need for professional development in blending technological tools with teaching and subject matter practices.

2. Pedagogical Knowledge (PK) and Content Knowledge (CK) vs. Combined Components (PCK): PK (0.26) and CK (0.25) show teachers' confidence in traditional methods and subject expertise. However, PCK's higher PNImodified value of 0.41 suggests difficulty in merging pedagogy with content. Teachers need support to align their teaching strategies with subject matter, particularly when integrating technological applications.

The Priority Needs Index indicated a strong desire for professional development across all TPACK components, with the highest priority in enhancing TPK and TCK competencies.

2. Qualitative findings

Interview data reveals key themes including attitudes toward technology, hardware and software challenges, and the need for structured professional development and teaching materials.

1) Theme 1: Positive attitudes toward technology

Teachers expressed generally positive attitudes toward adopting technology in their teaching. Many enjoyed discovering new tools alongside their students, highlighting a collaborative learning environment. Two teacher (T1,T2) remarked, "Learning new technologies with my students keeps the classroom dynamic and engaging." Another shared, "When I see how excited students are to use these tools, it motivates me to learn and adapt alongside them."

2) Theme 2: Challenges with technology integration

(1) Hardware issues

Although all students have access to smartphones with internet connectivity, ensuring equal access remains a challenge. The applications or tools used in lessons must be free for all students to download and compatible with diverse device models. One teacher (T2) explained, "While every student has a smartphone, some apps are not free or may not work well on older devices."

(2) Software knowledge update

Teachers had limited knowledge of educational software and often relied on peer recommendations rather than formal training. This reliance resulted in inconsistent use of tools and missed opportunities for effective technology integration. Majority of teacher (T1, T4, T5) explained, "I usually hear about new software from colleagues or students. Sometimes it works well, but other times, I feel like I'm experimenting without proper guidance."

(3) AI adoption

Teachers struggled with adopting AI tools. Students often introduced these tools as playful novelties, but teachers found them challenging to integrate meaningfully into the curriculum. One teacher (T3) explained, "*AI tools are exciting, but I need clearer examples of how to use them effectively. Right now, it feels like I'm trying to tame something I don't fully understand.*"

3) Theme 3: Need for professional development

Teachers expressed a strong need for professional development opportunities to enhance their technological competencies. They emphasized the importance of training programs that are practical, context-specific, and aligned with the curriculum. One teacher (T4) explained, "Workshops that show real-life classroom applications are the most helpful. Theoretical sessions don't help much when I'm faced with a room full of students."

4) Theme 4: Preference for structured lesson plans or textbooks

Teachers prefer ready-to-use materials, such as lesson plans, that clearly outline what the teacher needs to do, what students need to do, which activities to conduct, and how to assess learning. They want resources that allow them to follow a structured progression from simple to more advanced levels. One teacher (T1) emphasized, "*I need lesson plans that tell me exactly what to do at each step, from activities to assessments, so I can guide students through levels of difficulty effectively.*"

3. Mix-methods findings

The challenges faced by music teachers in integrating technology and pedagogy were evaluated

through both quantitative and qualitative approaches. <Table 5> summarizes the findings, highlighting the challenges related to TPACK, TPK, and TCK components. Integrated insights offer practical guidance to address these difficulties, aiming to enhance teaching efficacy in music education.

<Table 5> Joint display of MTPACK challenges: Integrated insights

MTPACK component	Quantitative (PNI)	Qualitative (Interview quotes)	Integrated insights
TPACK	PNI: 0.52 (Highest challenge)	*"Blending traditional music methods or approaches with tech is confusing."*	Teachers need guidance on harmonizing traditional and tech-based instruction.
TPK	PNI: 0.46 (High Challenge)	*"I struggle to design lessons using advanced digital tools."*	Teachers need concrete lesson examples and training for integrating tech and pedagogy.
TCK	PNI: 0.44 (Moderate challenge)	*"I only use apps my students recommend because I lack time to explore others."*	Teachers lack formal exposure to diverse music-specific software.

The table highlights that TPACK presents the greatest challenge, followed by TPK and TCK. Qualitative insights reveal difficulties in blending traditional and technology-based methods, designing lessons, and exploring diverse software. These findings underscore the need for practical training, exposure to various tools, and support in harmonizing teaching approaches.

4. An analysis of software and teaching strategies to address these needs

This analysis underscores the importance of software and teaching strategies in meeting diverse music educators' needs. <Table 6> highlights free music education tools aligned with the TPACK framework, showcasing how each app integrates technological, content, and pedagogical knowledge. The table links apps to specific strategies for developing skills in listening, singing, playing, movement, reading, writing, and composing (Abeles, Hoffer, & Klotman, 1994). Emphasizing free tools reflects insights from interviews showing teachers often start with cost-free options to explore technology in the classroom. Apps are categorized by their focus on music theory and skills, with teaching strategies included to help educators maximize the benefits of the TPACK framework.

<Table 6> Examples of music education software and possibilities of music teaching strategies align with TPACK framework

Applications	What offered by Apps							How music teacher can compliment TPACK model	
	(T) Technological Aspect					(C) Content Aspect		(P) Pedagogical Aspect	
	Platform			Category		Music content	Music skill	Use as a self-learning tool	Use with music teaching strategies
	Mobile	Computer	Web-based	Education	Music				
Tone Ear	/		/	Interactive Lessons	Ear Training	Theory	Listening	Facilitates individualized ear training quiz for mastering chords, scales, and intervals	Encourage self-directed learning by guiding students to develop their own listening strategies for identifying intervals, scales, and chords.
Joox Karaoke	/			Interactive Practice Tool	Karaoke Playback	Literature	Singing	Provides a fun and interactive way to practice vocal techniques and explore repertoire	Provide authentic learning by guiding students to simulate real-world performance settings in the classroom to develop vocal techniques and stage presence.
Soundslice			/	Interactive Practice Tool	Notation and Playback	Literature	Playing	Offers tools to analyze, play along, and annotate sheet music with synced audio and video	Apply problem-based instruction by guiding students to identify performance nuances through analyzing YouTube performances.
Open Saber		/		Game-Based Learning	Rhythm-Based Gaming	Theory	Movement	Engages learners in rhythm-focused movement exercises, improving coordination and timing	Incorporate game-based learning by guiding students to engage in rhythm-focused gaming activities that connect movement to timing and musical concepts.
Teoria			/	Interactive Lessons	Music Theory Tutorials	Theory	Reading	Supports independent learning of music theory, including note reading and interval identification	Facilitate inquiry-based and thinking-based instruction by guiding students to solve theoretical problems and connect them to real-world music practice.
MuseScore	/	/	/	Creative Platform	Music Notation and Editing	Literature	Notation	Enables learners to create, edit, and share music scores, fostering creativity and precision	Implement project-based instruction by guiding students to create, edit, and share music scores with structured teacher and peer feedback.
Chrome Music Lab: Song Maker			/	Creative Platform	Simplified Composition	Theory	Composing	Provides an accessible platform for experimenting with melody, harmony, and rhythm	Apply project-based instruction by guiding students to experiment and explore their creative potential, supported by teacher and peer feedback.
BandLab	/		/	Creative Platform	Professional Composition	Literature	Composing	Encourages self-paced exploration of professional music production and collaboration	Facilitate group process-based instruction by guiding students to create collaborative professional composition projects.
Oxford Music Online			/	Reference Platform	Historical Contexts	History	-	Delivers comprehensive historical resources for independent study of composers, styles, and eras	Utilize inquiry-based instruction by guiding students to explore historical contexts, composers, and stylistic trends.

V. Discussion & Conclusion

This study explored both the quantitative survey data and qualitative interview data in triangulation in order to find the areas of TPACK needs in the order of the priority. Finding confirmed that the more complicated areas of TPACK, which lie in the intersection of two subject areas, were reported as more challenging, and therefore were in priority for individual development and teacher training. The less complicated component of TPACK were reported as less challenging, and therefore were in second priority for individual development or training. The proposed collaboration between what technology had offered and how teachers can achieve higher learning outcomes could suggest the coexistent of technology and human and also reconfirmed the significance of professional training in music education.

When comparing the results of this research with Bauer's (2013), the order of TPACK components is mostly consistent. Both studies highlight the importance of integrated components such as TPACK, TPK, and TCK, while CK and PK rank lower. However, a key difference is the ranking of TK, which is highest in Bauer's study but ranks as the fifth here. This might be the consequence of the timing of the studies. In 2013, technology was less integrated into daily life, whereas in 2024, it is more widespread. This likely makes teachers feel more confident in their basic tech skills. However, as shown in this research, the gap between the current and ideal states highlights an ongoing challenge. Technology evolves rapidly and knowledge can become outdated quickly. Teachers consistently need professional development to keep up with these changes. Notably, It is encouraging to see that the ideal state results for TPACK are significantly higher than the current state, indicating that teachers recognize the importance of technology in music education and are motivated to enhance their competencies and adapt to the demands of modern classrooms.

From the findings, there were significant factors that show Professional development is crucial, and teachers demonstrate a strong willingness to learn. They have high expectations of themselves and are aware of the importance of expanding their technological knowledge. The qualitative findings provide additional nuance. While Partti, Weber, and Rolle (2021) stress the importance of hands-on workshops for professional development, many teachers face practical constraints, such as limited time, that make workshop participation difficult. Instead, qualitative interviews revealed that teachers seek "ready-to-use" lesson plans that provide explicit, step-by-step guidance. These findings align with a broader trend where teachers prioritize practical, time-efficient resources that deliver immediate benefits over longer, more intensive training sessions. This

perspective contrasts with Gall's (2016) assertion that learning to integrate technology into music teaching requires significant time and in-depth knowledge of TPACK domains, particularly TPK and TCK.

From these insights, several key takeaways emerge:

① Focus on Integrated TPACK Domains: Training should emphasize not just TK, PK, and CK but also their intersections, particularly TPK and TCK, to equip teachers for complex pedagogical scenarios and technologies.

② Time-Efficient Training Is Essential: Professional development workshops must be concise and designed to accommodate teachers' limited schedules. While teachers are eager to develop their technological skills, time constraints represent a critical barrier that risks undermining their opportunities for growth.

③ Self-Directed Learning as an Alternative: For those unable to attend workshops, self-guided materials and resources that build technological expertise incrementally can provide a viable solution. This approach can also help fit their limited time more effectively.

This research provides a starting point, offering practical examples for addressing gaps in TPACK knowledge. Teachers can enhance their TK with effort, particularly through structured training and reflective practices (Han, 2023). However, integrating TPACK components ultimately requires teachers' active engagement. No tool can serve as a one-stop solution. It takes sustained effort to blend content, pedagogy, and technology effectively.

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