In-Service and Pre-Service Teacher Perceptions of Music Technology Education: An Empirical Explortion of Divergences

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Abstract

This article seeks to contribute to the body of knowledge on effective music technology integration in teacher education. In this paper, we use literature to evaluate the impact of technology on music education and explore the disparities and commonalities between the views of pre-service and in-service music educators through an empirical study. Our two-part qualitative study explores the experiences and perceptions of educators regarding the integration of technology in music education. The study data demonstrated clear divergences between beliefs, perspective, and experience. Pre-service educators were found to have a more favorable perception of the effectiveness of technology in music education and appeared more confident in their preparedness to integrate technology into their teaching practices. Our discussion of the data and literature highlights potential curricular shifts towards integrating Technological Pedagogical Content Knowledge (TPACK) principles into teacher education programs, as well as a need for educators to adopt an adaptive mindset if we are to success-

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fully integrate technology into music education today. The results also demonstrate a need to target professional development opportunities for in-service teachers, regardless of their career stage. Our findings call for music teacher education programs to not only integrate technological skills training but also to embed these skills within a pedagogical framework that reflects modern educational philosophies. Armed with this knowledge, we hope that music educators today can be better prepared to leverage technology in their classrooms.

Keywords: music teacher education, TPACK framework, music technology

Introduction

The domain of music education is continually evolving, reflecting the dynamic interplay between traditional pedagogical methods and the integration of advanced technological tools. Within this evolving landscape, the preparation of future music educators, particularly in the realm of music technology, has garnered significant attention. Research has illuminated a tendency toward overly generalized and teacher-centered approaches within music technology instruction for pre-service music teachers, suggesting a potential misalignment with the nuanced demands of contemporary classroom teaching (Bauer, 2012; Haning, 2016). This has raised concerns regarding the efficacy of current educational practices in adequately preparing future music educators to leverage technology in enhancing student learning experiences.

In response to these challenges, the theoretical framework of Technological Pedagogical Content Knowledge (TPACK) has emerged as a pivotal lens for examining and enhancing the preparation of music educators. Originally articulated by Mishra and Koehler (2006), the TPACK framework underscores the complex interdependencies between technological knowledge, pedagogical knowledge, and content knowledge, advocating for an integrated approach to teacher education. This framework has been further explored and supported by subsequent scholars, including Bauer (2012), Ndongfack (2015), and Mroziak & Bowman (2016), who have underscored its potential to refine the focus of music teacher education towards more effective integration of technology in pedagogical practices.

This article aims to extend the discourse on music technology education for pre-service and in-service music teachers by exploring the divergences in their perceptions of the role and implementation of music technology in educational settings. Building on the foundational work of Mishra and Koehler (2006) and drawing upon the insights of Bauer (2012), Ndongfack (2015), and Mroziak & Bowman (2016), we advocate for the application of the TPACK framework as a means to

enhance the andragogical and vocational outcomes of music teacher education. By juxtaposing the perspectives of in-service teachers, who are immersed in the practicalities of classroom teaching, with those of pre-service teachers, who are currently navigating their educational pathways, this paper seeks to uncover insights into how music technology education can be re-envisioned to better serve the needs of both educators and students alike.

Through a comprehensive review of literature and empirical investigation, this study endeavors to contribute to the body of knowledge on effective music technology integration in teacher education. By identifying the gaps and convergences between in-service and pre-service teachers' perceptions, the paper aims to propose actionable strategies for music teacher educators to foster a more impactful and relevant approach to teaching music technology. In doing so, it aspires to support the development of future music educators who are not only proficient in their use of technology but are also adept at creating engaging, innovative, and pedagogically sound music learning experiences for their students.

Given the well-documented gaps in music teacher education regarding technological integration (Bauer, 2012; Haning, 2016; Mishra & Koehler, 2006), this study seeks to investigate whether significant differences exist between pre-service and in-service music educators in their perceptions of technology's role and effectiveness in teaching music. Specifically, this study hypothesizes that pre-service music educators will report higher confidence in their preparedness to integrate technology into their teaching, alongside a more favorable perception of technology's role in music education, compared to their in-service counterparts. This hypothesis aligns with prior research suggesting that exposure to contemporary pedagogical frameworks, such as Technological Pedagogical Content Knowledge (TPACK), may influence pre-service educators' outlooks more strongly than those of in-service teachers, whose views are often shaped by established practices and past professional development experiences. By exploring this hypothesis through qualitative and quantitative analyses, this study aims to contribute to a deeper understanding of how technology-related pedagogical beliefs evolve over time and how teacher education programs might bridge these gaps.

Literature

The integration of technology in music education represents a critical juncture at which pedagogical philosophies and practical method-

ologies intersect, signaling a transformative phase in the way music is taught and learned. This evolution necessitates a comprehensive understanding of how music educators, both in-service and pre-service, perceive and incorporate technology into their teaching practices. As the educational landscape becomes increasingly digital, these perceptions play a pivotal role in shaping the future direction of music education. The scholarly exploration of these perspectives is not only timely but essential in navigating the challenges and opportunities presented by the integration of technology in educational settings.

A fundamental framework for understanding how educators integrate technology into their instruction is Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006). The TPACK framework asserts that effective teaching with technology requires the seamless integration of three core domains: technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). Unlike early models of technology adoption in education, which often treated digital tools as isolated add-ons, TPACK underscores the need for technology to be woven into the pedagogical and content-based fabric of instruction. In music education, this means that educators must not only be proficient in various music technologies (TK) but also understand how to integrate these tools into effective teaching strategies (PK) while maintaining a strong grounding in music-specific disciplinary knowledge (CK). The intersection of these three areas—technological pedagogical content knowledge—is where meaningful, contextually relevant technology integration occurs.

Despite the growing recognition of TPACK's value in teacher preparation, research suggests that music educators experience varying degrees of success in implementing this framework in practice. Pre-service music educators, who are increasingly trained within TPACK-informed curricula, tend to express greater confidence in their ability to integrate technology into instruction (Bauer, 2012; Haning, 2016). However, this confidence does not always translate into meaningful long-term implementation, as many in-service educators—trained before the widespread adoption of TPACK—report challenges in aligning technology with their pedagogical philosophies and content delivery. This divide underscores the need for structured professional development that supports in-service educators in continuously refining their TPACK competencies, ensuring that their technology use remains relevant and pedagogically sound.

Coles and Gunther (2024) further explore these complexities by examining the intersections of technology, philosophy, and pedagogical practice in music education. Their work highlights how educators' phil-

osophical orientations toward teaching and learning often influence whether they perceive technology as a transformative tool or a disruptive force. For instance, music teachers who adhere to constructivist, student-centered pedagogies are more likely to embrace technology as a vehicle for creative exploration and engagement, whereas educators who prioritize traditional, notation-based instruction may view digital tools as a superficial or inauthentic addition to their teaching. The TPACK framework provides a valuable lens for bridging these ideological differences, as it encourages educators to think beyond the simple adoption of technology and instead focus on how digital tools can be meaningfully integrated into diverse teaching philosophies.

Literature on music education technology has predominantly focused on the potential benefits and applications of digital tools in enhancing learning outcomes. However, a nuanced examination of educator perceptions reveals a complex interplay of factors that influence the adoption and implementation of technology in music education. Divergences between in-service and pre-service music teachers in their perceptions and philosophies toward music technology education are particularly telling, reflecting broader themes of change, resistance, and adaptation within the profession.

This literature review aims to establish comprehensive groundwork for the empirical exploration of data sets depicting these divergences. It will delve into the existing body of research to uncover the multifaceted dimensions of educational music technology, including theoretical frameworks such as TPACK and its implications for music education. By examining studies that have investigated the perceptions of both in-service and pre-service music teachers, this review will highlight the disparities and commonalities in their views, thereby offering insights into the current state and future directions of music technology in education. Furthermore, this review will contextualize the significance of understanding these divergent perspectives within the broader discourse on teacher education and professional development. It will consider the impact of these perceptions on pedagogical strategies, curriculum development, and ultimately, student learning experiences. Through a critical synthesis of the literature, this review will identify gaps in the current understanding and suggest areas for further research, setting the stage for an empirical investigation into the data set at hand.

Music Technology in the Classroom

The integration of music technology into classroom settings represents a pivotal area of exploration within the field of music education.

This literature review draws upon seminal works by Michałko, Campo, Nijs, Lo, Leman, & Van Dyck (2022), Dammers (2012), and Bauer (2020) to frame the current study's investigation into the effective use of music technology in educational environments. Each of these sources not only informs the theoretical underpinning of our research but also plays a crucial role in the development of the research instruments designed to evaluate the impact of technology on music learning.

Michałko et al. (2022) provide an in-depth analysis of teachers' perspectives on the use of technology in instrumental music education. Their research, focusing on the concept of *meaningful technology*, emphasizes the necessity of aligning technological tools with pedagogical objectives to ensure that technology integration enhances the learning experience rather than detracts from it. The insights gleaned from this study have informed the creation of survey items within our research instruments that assess educators' attitudes towards technology, their perceived efficacy in using technology to achieve educational goals, and the challenges they face in integrating technology into their teaching practices. Similarly, Dammers (2012) explores the landscape of technology-based music classes in high schools across the United States, providing a comprehensive overview of how technology is currently being utilized in music education. Dammers' findings on the diversity of technology applications and the associated challenges have directly influenced the design of our study, addressing the types of technologies employed, the pedagogical strategies that accompany their use, and the barriers to effective technology integration.

Bauer (2020) extends the discourse on music technology in the classroom by emphasizing the multifaceted role of digital pedagogy in shaping modern music instruction. In *Music Learning Today: Digital Pedagogy for Creating, Performing, and Responding to Music*, Bauer articulates a framework that positions technology not as an auxiliary tool but as an integral part of contemporary music pedagogy. He argues that effective technology integration should support and enhance three core dimensions of music learning: creative production (composition and improvisation), performance (both individual and ensemble-based), and critical engagement (listening, analyzing, and responding to music). These dimensions directly inform our study's conceptual framework by aligning with the Technological Pedagogical Content Knowledge (TPACK) model (Mishra & Koehler, 2006). Bauer's framework expands on TPACK by providing a music-specific application of technological, pedagogical, and content intersections, offering a structured approach to evaluating how educators balance technology with traditional music teaching methodologies. His work underscores the need for purposeful technology inte-

gration that extends beyond basic digital literacy and actively engages students in music-making processes.

In our research, Bauer's model has been instrumental in developing observational checklists designed to assess technology-mediated pedagogical practices. These checklists aim to capture how educators implement digital tools across compositional, performance, and analytical tasks, thereby reflecting the broader TPACK-driven conceptual foundation of our study. By embedding Bauer's digital pedagogy principles within our observational framework, we seek to evaluate not just whether technology is being used in music classrooms, but how effectively it is shaping students' musical engagement and understanding.

The integration of insights from Michałko et al. (2022), Dammers (2012), and Bauer (2020) into the development of our research instruments ensures a comprehensive approach to investigating music technology in the classroom. By grounding our instruments in existing literature, we aim to capture the multifaceted nature of technology integration in music education and its implications for teaching and learning. This approach not only enhances the validity and reliability of our research findings but also contributes to the ongoing dialogue on how best to leverage technology in the service of music education.

Music Education Philosophy and Technology

The integration of technology in music education is not merely a matter of tool adoption; it is deeply intertwined with educators' philosophical orientations and pedagogical beliefs (Elliott, 2012; Prestridge, 2017). As music education philosophies evolve, so too do the frameworks that guide technology use, shaping the ways in which educators perceive, implement, and resist technological advancements in their teaching. Research suggests that educators' pedagogical beliefs strongly influence their willingness to integrate technology, often determining whether digital tools are viewed as enablers of student-centered learning or as disruptions to traditional instruction (Jääskelä et al., 2017; Tondeur et al., 2017). These philosophical perspectives are not static but are shaped by teacher preparation experiences, professional development opportunities, and institutional expectations (Ottenbreit-Leftwich et al., 2018).

A fundamental divide exists between constructivist-oriented educators, who see technology as a tool for exploration, creativity, and student agency, and more traditional educators, who may view it as an enhancement to—but not a replacement for—established instructional methods (Prestridge, 2017). In music education, this manifests as a

spectrum of approaches ranging from digital composition and music production, which encourage learner autonomy, to more rigid, notation-based instruction where technology is often used in a supplementary, rather than transformative, capacity (Elliott, 2012).

Jääskelä et al. (2017) highlight that educators who view learning as an active, student-driven process are more likely to incorporate technology as a means of fostering engagement and deeper musical understanding. In contrast, teachers with more content-focused philosophies may prioritize traditional instructional approaches, using technology primarily for administrative efficiency rather than instructional innovation. Tondeur et al. (2017) extend this discussion by demonstrating how teacher beliefs about pedagogy and technology are shaped not only by personal teaching philosophies but also by systemic factors, such as curriculum mandates and institutional support structures. This suggests that the integration of technology in music education is as much an ideological consideration as it is a logistical one.

The development of educators' technological beliefs is particularly crucial in understanding the divergence between pre-service and in-service teachers' attitudes toward technology (Funkhouser & Mouza, 2013). Pre-service teachers, who are often introduced to technology in structured, forward-thinking teacher preparation programs, tend to demonstrate optimism about technology's potential in music education. However, these initial beliefs often shift when they transition into professional practice, where they encounter real-world constraints such as limited resources, institutional resistance, and competing curricular demands (Ottenbreit-Leftwich et al., 2018).

This discrepancy between pre-service optimism and in-service reality suggests a need for more continuous, career-long engagement with technology training to ensure that music educators remain adaptive in their instructional approaches. Funkhouser & Mouza (2013) argue that without sustained reflection and professional development, even educators trained in technology-rich environments may struggle to sustain meaningful integration over time. Their work underscores the importance of creating reflective spaces within teacher education and professional learning communities where music educators can critically examine their evolving beliefs about technology and its role in the classroom.

The overarching challenge in integrating technology into music education is not simply equipping educators with digital tools but ensuring alignment between their pedagogical beliefs and technology use (Prestridge, 2017). This requires institutional support, ongoing training, and professional discourse that acknowledges both the philosophical and practical barriers to adoption. The research reviewed here sug-

gests that teacher preparation programs must go beyond exposure to digital tools and actively engage educators in discussions about how technology aligns (or conflicts) with their teaching philosophies (Elliott, 2012; Ottenbreit-Leftwich et al., 2018). By framing technology not just as an instructional tool but as an extension of pedagogical identity, educators may develop a more cohesive, adaptable approach to integrating digital resources into music instruction.

Music Technology Education and Music Teachers

In music education, the application of TPACK (Mishra & Koehler, 2006) has illuminated key challenges related to educator preparedness, professional development, and evolving pedagogical philosophies (Bauer, 2012; Haning, 2016; Ndongfack, 2015). One significant concern is the disparity in technology confidence and competence between pre-service and in-service music educators. Research suggests that pre-service teachers, who receive formal training in technology integration within structured coursework, often report higher confidence in their ability to use digital tools. However, this confidence does not always translate into sustained practice, as many in-service teachers—especially those trained before widespread digital adoption—face barriers such as insufficient professional development, institutional resistance, and a lack of direct experience implementing technology in real-world classrooms (Han et al., 2017).

The importance of professional learning structures for technology adoption is widely acknowledged in research (Ndongfack, 2015; Mroziak & Bowman, 2016; Tejada & Morel, 2019). Studies emphasize that ongoing, context-driven training opportunities are critical for in-service educators to remain adaptable in their instructional practices. Project-based learning and hands-on implementation strategies have been identified as particularly effective approaches for developing teachers' ability to integrate technology within authentic classroom settings (Gall, 2017; Tejada & Morel, 2019). These models align closely with TPACK's emphasis on the intersection of technology, pedagogy, and content, ensuring that digital tools are not merely add-ons to instruction but instead fully embedded within a pedagogically sound framework.

Despite the benefits of TPACK-aligned professional development, barriers to implementation persist. Dorfman (2015, 2016) highlights a gap between the perceived importance of technology in music education and the actual readiness of educators to integrate it effectively. This discrepancy is particularly evident in cases where teachers lack structured training in applying digital tools to music-specific learning

objectives or where institutional infrastructure does not support consistent technology use. Furthermore, research by Bannerman & O'Leary (2021) challenges assumptions about digital native educators, arguing that pre-service music teachers often lack practical, hands-on experience with music technology. While they may have been exposed to technology in their personal or academic lives, this exposure does not necessarily equate to pedagogical competence, reinforcing the need for intentional, skill-based instruction in music teacher education programs.

Taken together, these studies and scholarship outlined in this literature review underscore the need for a more comprehensive approach to technology integration in music teacher education. The TPACK framework provides a theoretical lens for addressing gaps in training and professional development, but its success depends on creating sustained, meaningful learning opportunities that support educators throughout their careers. As music education continues to evolve in the digital age, bridging the divide between theoretical knowledge and practical application remains a critical challenge—one that must be addressed through curriculum design, professional development initiatives, and institutional support structures that align with the realities of classroom teaching.

Method

This study employed a mixed methodological approach, utilizing a surve`n-ended items. A total of 85 participants initiated this survey, with 58 completing it, for a completion rate of 68.2%, indicating a strong interest and engagement with the subject matter. Pre-service music teachers represented 34.5% of participants (n=20) and in-service music teachers represented 65.5% of participants (n=38), representing 25 U.S. states and one Canadian province. Participants self-reported gender as 71.1% female (n=27), 26.3% male (n=10) and 2.6% non-binary/third gender (n=3). An overwhelming majority of participants self-reported as White (79%, n=30) and small numbers of participants self-reported as Hispanic or Latino (7.9%, n=3), Black or African American (5.3%, n=2), Native Hawaiian or Other Pacific Islander (2.63%, n=1) or Asian (2.63%, n=1). One participant chose not to disclose race. To guide this study's investigation into the divergences between pre-service and in-service music educators' perceptions of technology integration, the following research questions were considered:

1. How do pre-service and in-service music educators perceive the role of technology in music education, and what factors influence these perceptions?

2. To what extent do pre-service and in-service educators feel prepared to integrate technology into their teaching practices, and what barriers do they identify?

3. What differences exist in the types of music technology tools that pre-service and in-service teachers report using or planning to use in their instruction?

4. How do educators' pedagogical beliefs shape their approaches to technology integration, and in what ways do these beliefs differ between pre-service and in-service teachers?

These questions provide a framework for analyzing the qualitative and quantitative data collected, ensuring that the study captures both the perceived efficacy and challenges of technology use in music education from the perspectives of educators at different career stages.

Results

The results of this study illuminate significant distinctions in perceptions and educational philosophies between pre-service and in-service music educators in relation to the integration and effectiveness of technology in music education. Pre-service teachers reported a more favorable perception of the effectiveness of technology use during their K-12 music education compared to in-service teachers (see Table 1). This observation may reflect the temporal proximity of pre-service teachers to their K-12 experiences, potentially exposing them to more recent advancements and integrations of technology in education. The study did not explore the underlying reasons for these perceptions, leaving room for further investigation into the evolving landscape of technology in music education.

Regarding the effectiveness of technology use in their college or university music education, pre-service teachers largely agreed that technology was used effectively, indicating a positive reception towards

Table 1
"Technology was used effectively in my K-12 music education"

	Strongly Agree	*Agree*	*Somewhat Agree*	*Neither Agree nor Disagree*	*Somewhat Disagree*	*Disagree*	*Strongly Disagree*
Pre-Service (n = 20)	0%	25%	30%	10%	35%	0%	0%
In-Service (n = 38)	2.6%	0%	31.6%	5.3%	7.9%	28.9%	23.7%

the integration of technology in higher education music programs (see Table 2). In contrast, in-service teachers displayed mixed responses, suggesting variability in the perceived effectiveness of technology use during their tertiary education. This divergence points to possible changes over time in the incorporation and application of technology within music education programs at the tertiary level.

Responses to the statement about learning to use technology effectively for teaching music during college/university education further highlighted differences between the two groups. Pre-service teachers tended towards agreement, albeit not strongly, suggesting a moderate confidence in their preparedness to integrate technology into teaching. Conversely, in-service teachers leaned towards disagreement, indicating a perception of inadequate preparation in effectively using technology for teaching music during their tertiary education.

Participants were asked to indicate their views on a continuum between two polarized statements (see Figure 1). When examining educational philosophies, in-service teachers demonstrated centrist views on their roles as educators and the importance of curriculum content versus sense-making in instruction. They balanced between viewing their role as facilitators for student discovery and as structured de-

Table 2
"Technology was used effectively in my college/university music education"

	Strongly Agree	*Agree*	*Somewhat Agree*	*Neither Agree nor Disagree*	*Somewhat Disagree*	*Disagree*	*Strongly Disagree*
Pre-Service (n = 20)	20%	60%	20%	0%	0%	0%	0%
In-Service (n = 38)	7.9%	15.8%	21%	13.2%	15.8%	15.8%	10.53%

Table 3
"I learned how to effectively use technology to teach music during my college/university education"

	Strongly Agree	*Agree*	*Somewhat Agree*	*Neither Agree nor Disagree*	*Somewhat Disagree*	*Disagree*	*Strongly Disagree*
Pre-Service (n = 20)	10%	45%	25%	5%	10%	5%	0%
In-Service (n = 38)	5.3%	7.9%	21%	2.6%	7.9%	31.6%	23.7%

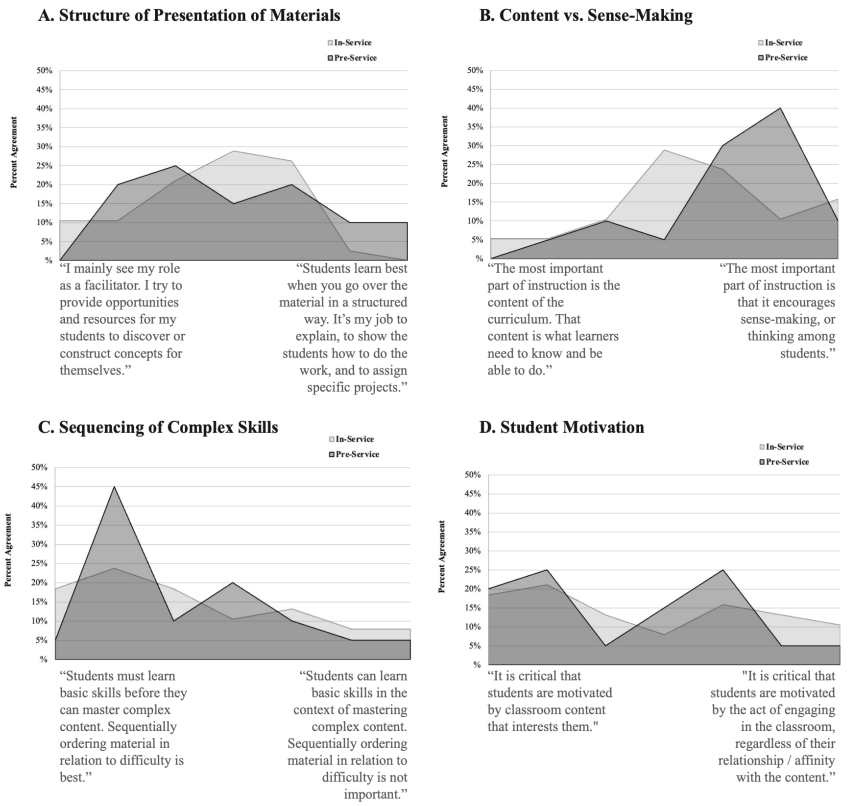
liverers of material. Similarly, their views oscillated between valuing the content of the curriculum and fostering sense-making or thinking among students. On the other hand, pre-service teachers showed a propensity towards facilitating roles and emphasized the importance of encouraging sense-making and thinking, indicating a preference for more progressive educational philosophies.

Both pre-service and in-service teachers acknowledged the importance of learning basic skills before mastering complex content, with a notable inclination towards sequentially ordering material based on difficulty. However, the pre-service population exhibited a stronger preference for sequential and scaffolded instruction, suggesting differing approaches to curriculum design and implementation.

In terms of technology used in teaching, significant divergence between pre-service and in-service teachers was observed in the utiliza-

Figure 1

Area Graphs Depicting Participant Philosophical Views on Teaching and Learning Roles



tion, or planned utilization, of Aural Skills/Music Theory Software, Assessment Tools, and MIDI Controllers. This variance underscores the diverse adoption and application of specific technological tools among music educators, reflecting their unique teaching contexts and pedagogical strategies (see Table 4).

Overall, the results indicate nuanced differences in the experiences, perceptions, and pedagogical philosophies of pre-service and in-service music educators regarding technology integration in music education. While pre-service educators reported greater confidence in their technological preparedness and a stronger belief in technology's role as a transformative tool for teaching and learning, in-service educators expressed more skepticism and identified significant barriers to implementation, including limited access to professional development, institutional constraints, and a lack of direct training in technology integration during their teacher education. These findings suggest that technological disparities in music education are not solely generational but are also deeply tied to teacher training structures, access to resources, and evolving pedagogical priorities. Moreover, the results of this study highlights differences in technology adoption patterns, with pre-service teachers favoring contemporary digital tools such as laptops, cloud-based storage, and DAWs, while in-service teachers ex-

Table 4
"Which of the following technologies do you or will you use actively while teaching?"

Technology	*Pre-Service (n = 20)*	*In-Service (n = 38)*	*Difference*
Aural Skills/Music Theory Software	31.6%	75.0%	43.4%
Assessment Tools	34.2%	60.0%	25.8%
MIDI Controllers	34.2%	55.0%	20.8%
Laptops	81.6%	65.0%	16.6%
Learning Management Systems	76.3%	60.0%	16.3%
Video Editing Software	31.6%	45.0%	13.4%
Tablets or Phones	52.6%	65.0%	12.4%
Improvisational Playback Tools	10.5%	0.0%	10.5%
Western Notation Software	60.5%	70.0%	9.5%
CloudStorage	84.2%	75.0%	9.2%
Audio Mixers	21.1%	15.0%	6.1%
Coding Programs	10.5%	5.0%	5.5%
Microphones	55.3%	60.0%	4.7%
Administrative Software	81.6%	85.0%	3.4%
Digital Audio Workstations	63.2%	65.0%	1.8%
Video Projectors	73.7%	75.0%	1.3%
Video Streaming Sites	89.5%	90.0%	0.5%

hibited greater reliance on assessment tools, aural skills software, and more traditional digital resources. These discrepancies suggest that music technology implementation is shaped by not only educators' levels of exposure but also by the practical demands of their teaching environments. Additionally, the findings underscore how philosophical orientations toward teaching—whether student-centered or content-driven—play a significant role in determining educators' approaches to technology use.

Discussion

The findings of this study, revealing nuanced differences in perceptions and pedagogical philosophies between pre-service and in-service music educators concerning technology integration, resonate with and extend the existing literature on music education and technology. The differential experiences and expectations concerning technology use in education, as reported by pre-service and in-service teachers, underscore the evolving landscape of technology in music education, a theme echoing the works of Bauer (2012), Haning (2016), and Dorfman (2015, 2016).

The findings of this study provide substantive insights into the research questions posed earlier. Regarding the role of technology in music education (RQ1), pre-service teachers generally held more favorable perceptions of its effectiveness, aligning with recent advancements in teacher preparation curricula that emphasize digital integration. In-service teachers, by contrast, exhibited more skepticism, often citing lack of institutional support and professional development gaps as barriers to meaningful implementation.

The perceived preparedness to integrate technology (RQ2) also varied significantly. While pre-service educators expressed moderate to high confidence in their training, in-service teachers frequently reported a lack of formalized instruction in technology integration during their own teacher education. This disparity underscores the need for structured, ongoing professional development opportunities to ensure that in-service teachers can adapt to evolving technological landscapes. Analysis of technology usage patterns (RQ3) revealed clear distinctions in the tools favored by each group. Pre-service educators demonstrated a stronger inclination toward laptops, cloud storage, and digital audio workstations (DAWs), whereas in-service educators reported greater reliance on aural skills/music theory software and assessment tools. These findings suggest that technology preferences are not just generational but also shaped by the realities of teaching contexts and institutional expectations.

Finally, educators' pedagogical beliefs (RQ4) emerged as a key determinant of technology adoption. Pre-service teachers gravitated toward facilitative, student-centered philosophies that align with constructivist approaches to digital learning, while in-service educators were more likely to balance traditional content delivery with technological integration. These differences indicate a need for teacher preparation programs to explicitly address philosophical orientations toward technology use to ensure that new educators enter the profession with adaptable, context-sensitive approaches.

Bauer's (2012) exploration of the acquisition of musical technological pedagogical and content knowledge (TPACK) provides a theoretical underpinning for understanding the variance in technology integration reported by our study's participants. The emphasis on TPACK in music teacher education, as outlined by Bauer, suggests that the pre-service teachers' more positive perceptions of technology use may stem from recent curricular shifts towards integrating TPACK principles in teacher education programs, a notion supported by Haning (2016). These shifts aim to equip new teachers with the competencies required to effectively integrate technology into their teaching practices, potentially explaining the observed differences in perceptions between pre-service and in-service educators.

Furthermore, the work of Han, Shin, and Ko (2017) on the impact of student teaching experiences and teacher beliefs on pre-service teachers' self-efficacy and intentions to use technology offers insights into the moderate confidence among pre-service teachers in their preparedness to use technology. Our findings align with these ideas, suggesting that while exposure to technology integration principles through TPACK-based education is beneficial, the translation of this knowledge into self-efficacy remains complex and is influenced by a variety of factors, including hands-on teaching experience and underlying pedagogical beliefs.

The centrist views of in-service teachers, as compared to the more progressive stances of pre-service teachers on educational philosophies, may reflect broader shifts in educational paradigms. Dorfman (2016) and Tejada and Morel (2019) highlight the ongoing evolution of music teacher preparation programs to incorporate technology, suggesting that newer entrants to the profession are being trained under pedagogical philosophies that emphasize student-centered learning and the facilitative role of the teacher. This evolution is consistent with the observed preference among pre-service teachers for roles as facilitators and for educational approaches that prioritize sense-making and thinking, as highlighted by Mroziak and Bowman (2016).

The lack of uniformity in the adoption of specific music technological tools—including Aural Skills/Music Theory Software, Assessment Tools, and MIDI Controllers—underscores the need for specialized professional development for in-service teachers. This necessity is highlighted in the work of Ndongfack (2015) and Gall (2017), who advocate for tailored training programs. Furthermore, Bannerman and O'Leary (2021) contest the notion that pre-service educators, often referred to as "digital natives," naturally have the requisite skills for effective technology integration. Their findings emphasize the critical importance of ongoing education and adaptability among music educators at all stages of their careers (Bannerman & O'Leary, 2021).

The TPACK framework, as conceptualized by Mishra and Koehler (2006), remains central to understanding and addressing the gaps and opportunities in music teacher education concerning technology. The framework's emphasis on the interplay between technological, pedagogical, and content knowledge offers a lens through which to examine the findings of this study, suggesting that both pre-service and in-service music educators benefit from ongoing professional development that is responsive to the rapidly changing technological landscape in education.

In summary, the results of this study provide empirical support for the hypothesis that pre-service music educators demonstrate higher confidence in their technological preparedness and hold more favorable perceptions of technology's role in music education than their in-service counterparts. The survey data indicate that pre-service teachers were more likely to report that technology was effectively used in their own K-12 and university music education experiences and that they felt adequately trained to use technology in their future teaching. In contrast, in-service teachers expressed more skepticism, with many indicating that their professional preparation lacked sufficient focus on meaningful technology integration. These findings align with prior research on TPACK-based curriculum reforms (Bauer, 2012; Haning, 2016), suggesting that recent shifts in music teacher education may be influencing the confidence levels of pre-service teachers. However, this divergence also underscores the pressing need for professional development opportunities that provide in-service educators with updated frameworks and tools for integrating technology effectively. Addressing these disparities will be essential for fostering a more cohesive and adaptive approach to music technology education across career stages.

Conclusion

The findings from this study provide a compelling narrative on the current state and challenges of technology integration in music education, bridging the gap between pre-service and in-service educators' experiences and expectations. By continuing to examine the nuances in perceptions, pedagogical philosophies, and self-reported preparedness in utilizing technology, this research underscores the multifaceted nature of educational technology adoption within the domain of music education. The study highlights the differential experiences and outlooks of pre-service and in-service music teachers and brings to the fore the critical need for dynamic evolution within music teacher education programs.

The evident discrepancies in perceptions of technology use effectiveness, as reported by pre-service and in-service educators, reflect broader trends in educational technology's evolving landscape. These differences emphasize the impact of rapidly advancing technological tools and methodologies on teaching and learning in music, suggesting that recent entrants to the teaching profession may be better positioned to navigate this changing landscape, given their more recent exposure to integrated technology in education. However, the mixed responses from in-service teachers regarding their preparedness to use technology effectively indicate a significant gap that needs addressing through targeted professional development and continuous learning opportunities.

Furthermore, the divergent educational philosophies and pedagogical approaches reported by participants in this study suggest a shifting paradigm in music education. The inclination of pre-service teachers towards facilitating roles and emphasizing sense-making in learning aligns with contemporary educational theories that advocate for student-centered, inquiry-based learning environments. These findings call for music teacher education programs to not only integrate technological skills training but also to embed these skills within a pedagogical framework that reflects these progressive educational philosophies.

The application of the TPACK framework emerges as a pivotal consideration in this context, offering a structured approach to understanding and developing the competencies required for effective technology integration in music education (Mishra and Koehler, 2006). By emphasizing the intersection of technological, pedagogical, and content knowledge, TPACK provides a valuable lens through which teacher education programs can design curricula that address the complex

nature of teaching music in the digital age. This study's findings reinforce the necessity of embedding TPACK principles deeply within music teacher education to prepare educators who are not only technologically proficient but also pedagogically adaptable. To address the divergences in perceptions of technology integration between pre-service and in-service music educators, this study suggest the need for targeted, research-informed strategies to enhance music technology education. First, music teacher education programs should more intentionally embed TPACK-based training within their curricula, ensuring that technological, pedagogical, and content knowledge are taught in an integrated, practice-oriented manner. This could be achieved through project-based learning experiences where pre-service teachers engage in hands-on technology use in instructional settings before entering the workforce.

Second, structured professional development opportunities for in-service educators must be expanded to bridge the preparedness gap identified in this study. These opportunities should not merely focus on software proficiency but should also align with pedagogical best practices, helping educators develop a nuanced understanding of how technology can be used to support student learning. Institutions and professional organizations should offer workshops, mentorship programs, and ongoing coaching that enable in-service teachers to refine their technological skills in a way that aligns with contemporary educational philosophies.

Finally, collaborative initiatives between pre-service and in-service educators should be fostered, enabling knowledge-sharing between recent graduates and experienced teachers. Such partnerships could take the form of structured peer-mentorship programs, technology integration case studies, or intergenerational professional learning communities. By facilitating these exchanges, music education programs can support a more continuous and reflective approach to professional growth in music technology pedagogy.

By implementing these strategies, music teacher education programs can better equip educators at all career stages with the skills and confidence needed to integrate technology meaningfully into their teaching. These recommendations aim to address the disparities observed in this study while ensuring that technology serves as a transformative tool in music education rather than a point of divergence between generations of teachers. In light of these considerations and along with the aforementioned suggestions, it becomes evident that fostering an adaptive mindset among music educators is crucial for the successful integration of technology in music education. This en-

tails not only equipping them with the latest technological tools and strategies but also nurturing an ongoing commitment to professional growth and adaptation to new pedagogical challenges. As this study illustrates, the journey toward effective technology integration in music education is continuous and multifaceted, requiring concerted efforts from educators, teacher educators, and policymakers alike.

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