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Conceptualization, literature review, translation, and writing

Abstract

Today's world is undergoing a significant transformation due to revolutionary developments in technology, and this process necessitates a re-evaluation of the traditional pedagogical structure of education. This study aims to conduct an in-depth examination of the digital transformation in music education, analyzing the opportunities it presents, the challenges it poses, and potential future development pathways, by synthesizing the local and international literature in the field through a comparative approach. Prepared using a descriptive literature review approach, this article analyzes new pedagogical models such as Technological Pedagogical Content Knowledge (TPACK), which defines teacher competencies, new pedagogical models such as Virtual Reality (VR), Augmented Reality (AR), and Gamification, modern assessment approaches such as digital portfolios, and internationally successful applications such as the Finnish model are analyzed. The findings show that despite the potential of technology to enrich music learning processes, the fundamental challenges in Turkey and on a global scale (teacher competencies, infrastructure, curriculum alignment) overlap significantly, and that socio-economic barriers such as the "digital divide" stand in the way of this potential. The discussion section examines the philosophical contradictions regarding whether technology is a "tool" or an "end" and the systemic contradictions in the context of equal opportunities in education. In conclusion, the success of this transformation depends not only on the provision of technological tools but also on the restructuring of teacher education based on the TPACK model, the internalization of digital culture in curricula, and comprehensive policies that ensure the application of technology in accordance with the principles of social justice and equality.

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Review Article

Technological Transformation in Music Education: Opportunities, Challenges, and Future Perspectives *

Ali DELİKARA [1]

Abstract

Today's world is undergoing a significant transformation due to revolutionary developments in technology, and this process necessitates a re-evaluation of the traditional pedagogical structure of education. This study aims to conduct an in-depth examination of the digital transformation in music education, analyzing the opportunities it presents, the challenges it poses, and potential future development pathways, by synthesizing the local and international literature in the field through a comparative approach. Prepared using a descriptive literature review approach, this article analyzes new pedagogical models such as Technological Pedagogical Content Knowledge (TPACK), which defines teacher competencies, new pedagogical models such as Virtual Reality (VR), Augmented Reality (AR), and Gamification, modern assessment approaches such as digital portfolios, and internationally successful applications such as the Finnish model are analyzed. The findings show that despite the potential of technology to enrich music learning processes, the fundamental challenges in Turkey and on a global scale (teacher competencies, infrastructure, curriculum alignment) overlap significantly, and that socio-economic barriers such as the "digital divide" stand in the way of this potential. The discussion section examines the philosophical contradictions regarding whether technology is a "tool" or an "end" and the systemic contradictions in the context of equal opportunities in education. In conclusion, the success of this transformation depends not only on the provision of technological tools but also on the restructuring of teacher education based on the TPACK model, the internalization of digital culture in curricula, and comprehensive policies that ensure the application of technology in accordance with the principles of social justice and equality.

Keywords: Music education, music technology, educational technologies, digital transformation

1. INTRODUCTION

Today's world is undergoing a critical transformation due to revolutionary advances in technology, where information is rapidly produced, disseminated, and accessed through diverse channels. This change not only profoundly impacts social structure but also inevitably transforms education, a system intertwined with society. As the digital revolution permeates every aspect of life, music education is at a critical juncture where traditional frameworks are being challenged by the need to integrate digital technologies. This integration represents a comprehensive transformation that includes not only the use of new tools but also the redefinition of pedagogical approaches, learning processes, and teacher roles (Akšamija & Ploskić, 2023; Asztalos, 2021; Calderón-Garrido et al., 2020; Çetinkaya & Kaya, 2023).

Since the 1990s, higher education music institutions have begun investing in modern technologies to supplement traditional educational methods (Aras & Göksel, 2024). Particularly with the Covid-19 pandemic, the use of digital technologies in music education has increased significantly, further highlighting the importance of digital learning environments and accelerating the search for technological solutions (Akšamija & Ploskić, 2023; Asztalos, 2021; Ayhan & Aydınlı Gürler, 2023).

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During this process, music educators have collaborated with their colleagues to ensure the continuity of lessons, sharing knowledge and experience, and developing unique solution methods.

This article aims to examine the digital transformation in music education in depth, exploring the current status, challenges, and potential future development paths. In line with this overall objective, the study seeks answers to the following fundamental research questions:

1. According to the current literature in music education, what are the key opportunities and challenges presented by digital technologies?

2. How is the role of the music teacher being redefined in the digital transformation process, and what competencies does this role shift require?

3. What are the pedagogical, infrastructural, and curricular barriers to the effective integration of technology into music education?

1.1. Literature Review

The integration of digital technologies in music education is a multilayered research area that has received increasing attention over the past two decades. The literature in this area focuses on three main axes: the opportunities and challenges presented by digital transformation, theoretical frameworks defining teacher competencies, and barriers to technology integration. The literature is unanimous that the digital revolution has fundamentally changed all processes of music, including music production, distribution, consumption, and education. New digital technologies have offered new perspectives and opportunities, such as the democratization of access to learning resources. The internet provides students and teachers with virtually unlimited resources for researching sound and repertoire, exploring various musical styles and genres, and accessing online course materials. While previously only possible in professional studios, recording, editing, and composing audio using computers, tablets, and smartphones has now become accessible to every student. The COVID-19 pandemic, in particular, has served as a catalyst for this digital transformation, forcing music educators to find creative technological solutions for remote rehearsals and performances (Akšamija & Ploskić, 2023; Asztalos, 2021). In this process, findings have emerged that lessons with interactive digital materials increase student achievement and can be more effective than traditional methods (Akyıldız et al., 2023).

Despite these opportunities offered by digitalization, the most fundamental challenge highlighted in the literature is the "digital divide" between students and the education system. This often stems from a mismatch between students' technological fluency, often born into a digital culture, and the infrastructure, financial resources, and technological competencies of teachers offered by schools (Cuervo et al., 2019). Research shows that infrastructural problems such as inadequate internet connection, lack of up-to-date hardware, and access to software are the most tangible obstacles to technology integration in many schools. In studies conducted in Türkiye, music teachers frequently mention a lack of materials and inadequate internet infrastructure (Ayhan & Aydınlı Gürler, 2023). This situation further exacerbates socioeconomic inequalities in access to technology, causing technology, while an opportunity for some students, to become a source of disadvantage for others (Hargittai, 2002).

Beyond these technological and socio-economic barriers, the literature highlights that the key to successful integration of technology is the competencies and evolving role of the teacher. The teacher's role is evolving from a model of knowledge transfer to a "facilitator" who guides students (Cuervo et al., 2019; Köksal, 2019). The most frequently used theoretical framework to make sense of this new role is the Technological Pedagogical Content Knowledge (TPACK) model. The TPACK model argues that for effective integration, teachers must masterfully combine technology, pedagogy, and content knowledge (Mishra & Koehler, 2006). However, studies report that teachers and prospective teachers often lack this integrated knowledge; they are resistant to new technologies and

do not know how to use existing knowledge pedagogically (Akšamija & Ploskić, 2023; Ayhan & Aydınlı Gürler, 2023). For example, although music teacher candidates' general digital literacy levels are high, their recognition and use of field-specific software have been found to be low (Babacan, 2022; Köksal, 2019). This suggests that technology education in teacher training programs is often addressed separately from pedagogy, creating a "theory-practice gap" (Brown & Warschauer, 2006).

These reviews of the existing literature reveal a significant research gap in the field. Most studies examine the impact of a specific technology on educational processes or explain teachers' general trends in technology use. However, there are very few studies that examine this digital transformation process, including its opportunities, challenges, pedagogical approaches, and theoretical frameworks, while also presenting a comprehensive overview of local and international literature. This study aims to address this gap by systematically compiling various sources in the field and providing a comprehensive overview of the digital transformation in music education. It also aims to create a comprehensive resource that combines the field's fundamental dynamics, current debates, and future potential, comparing the situation in Türkiye with international developments.

2. METHOD

This study was structured using a descriptive literature review method to thoroughly examine the current status, challenges, and potential of digital transformation and technology use in music education. This approach aims to systematically examine existing scientific publications, reports, and other academic resources on a specific topic, thereby providing a general picture of the field and creating a holistic synthesis (Okoli & Schabram, 2010).

The data collection process for the research was based on a comprehensive literature review strategy. This process involved searching international databases such as Google Scholar, Web of Science, and Scopus, as well as national databases such as ULAKBİM TR Index, YÖK Thesis Center, and DergiPark. The search was conducted using keywords such as "music education," "educational technologies," "digital transformation," "TPACK," "teacher competencies," "music education," "educational technology," and "digital transformation," focusing specifically on the last twenty years due to the relevance of the topic. Peer-reviewed journal articles, postgraduate theses, conference proceedings and basic theoretical texts in the field obtained as a result of the scans were included in the scope of the study.

A thematic approach was adopted in the analysis and synthesis of data. Data obtained from the reviewed sources were coded according to recurring and prominent themes and grouped under main themes such as "opportunities and challenges," "teacher competencies," "pedagogical, infrastructural, and curriculum-based barriers," and "new pedagogical models." Tables 1 and 3 presented in the article were created by categorizing the recurring findings from this thematic analysis. Table 2 was structured for the comparative analysis at the heart of the study. This table aims to compare domestic studies reflecting the situation in Türkiye with findings from international literature within the framework of common criteria such as:

- Technology use trends,
- Perceptions of technological competence,
- Main challenges encountered, and
- Recommended areas for development.

This approach aims to provide both a local assessment of the digital transformation in music education and a more comprehensive perspective by placing this assessment within a global framework.

Research Limitations

While this study provides a comprehensive framework, it does have some limitations. The research was designed as a descriptive synthesis of existing local and international literature and,

therefore, did not involve the collection of new empirical data. The conclusions reached and the inferences drawn are limited to the information and findings provided by the sources reviewed, which were limited to the databases and keywords specified in the Methods section. Grey literature (reports, unpublished documents, etc.) other than peer-reviewed publications were excluded from the scope of this study.

3. FINDINGS

The findings obtained from the literature review are detailed in line with the research questions presented in the introduction.

3.1. Opportunities and Challenges Created by Digital Technologies

Research in this area demonstrates that digital technologies offer significant opportunities for music education. New technologies are considered essential tools for teachers to make their pedagogical-musical strategies and content more dynamic and engaging (Cuervo et al., 2019). The internet plays a critical role in researching and analyzing instrument/voice repertoire, establishing network connections, accessing resources on music theory and practice, participating in online courses, and accessing detailed references. Mobile devices, in particular, have proven extremely beneficial for music practice thanks to their portability and connectivity.

Computers and mobile devices have made recording, editing, and composing easier to access. Interactive digital course materials have been shown to increase student achievement and to be more effective than traditional methods of delivering music education through digital materials (Akyıldız et al., 2023). International studies also support this finding. For example, a group using digital learning objects reported a significant improvement in academic achievement, students working with a commercial CD-ROM program showed significantly improved reading and rhythmic skills (Calderón-Garrido et al., 2020), and piano students' improvisational capacities improved more in technology-enhanced lessons than in traditional lessons (Cuervo et al., 2019). These tools span a wide range of topics, as seen in Table 1.

Table 1. Technological tools and platforms used in music education specified in the literature

Tool/Platform Category	Examples	Purposes of Use
Musical Note Software	Sibelius, Finale, Mus2, MuseScore	Musical note writing, arranging, preparing scores, teaching basic harmony and theory
Audio Recording and Editing (DAW)	Cubase, Logic Pro, GarageBand, FL Studio	Multitrack recording, audio editing, mixing, digital composing, podcasting.
Online Platforms	Moodle, Skype, Zoom	Distance learning, material sharing, online collaboration, virtual classrooms
Hardware	Smart Board, Computer, Tablet, Smartphone, Sound System	Video/audio playback, karaoke, interactive presentations, mobile applications, performance recording
Special Education Software	SAMI, iSCORE (e-portfolio)	Early childhood music learning, tracking student progress, digital portfolio

However, this transformation also brings with it significant challenges. The most fundamental challenge is the mismatch between students' fluency in digital culture and the material and institutional constraints within schools, such as infrastructure, connectivity, and teacher training (Cuervo et al., 2019). While students acknowledge the advantages of digital materials, such as convenience and the ability to work at their own pace, they also highlighted negative aspects such as difficulties in asking teachers questions and the materials' sometimes boring nature (Akyıldız et al., 2023). Many students emphasized that face-to-face instruction at school was more efficient and emphasized the importance

of interaction with the teacher (Akyıldız et al., 2023). Teachers' resistance to new technologies or their feelings of inadequacy in this regard prevent them from fully utilizing these tools in pedagogical practices (Akšamija & Ploskić, 2023; Çetinkaya & Kaya, 2023; Ayhan & Aydınlı Gürler, 2023).

3.2. The Transforming Teacher Role and Required Competencies

With digital transformation, the role of the music teacher and the competencies required for this role are also being redefined. Domestic and international studies reveal similarities and differences in the technology competencies of music teachers and prospective teachers (See Table 2).

Table 2. Comparative findings regarding the technological competencies of music teachers and candidates

Research Conducted Abroad	**Key Findings**
Cuervo et al. (2019) (Brazil)	While students learn technology intuitively, teachers face infrastructural and curricular barriers to technology integration.
Thayer-Morel et al. (2018) (Chile)	Although half of the music teacher candidates feel competent in using technology, they see the lack of technological content in undergraduate programs as a fundamental problem.
Akšamija & Ploskić (2023) (Bosnia-Herzegovina)	Although the pandemic increased the general use of digital tools, it also revealed a shortage of field-specific music software and an intense demand for training in this area (95%).
Calderón-Garrido et al. (2019) (Literature Review)	Digital portfolio and online learning models are on the rise, and technology has been proven to have a positive impact on personal and professional development.
Davidova (2019) (Northern Cyprus)	Technology courses in undergraduate programs are insufficient, and seminars and workshops are needed to improve teacher competencies.
Gorgoretti (2019) (General Review)	Low budget and lack of financial support are the main reasons for the inadequacy of technological infrastructure in schools, which hinders pedagogical innovations.
Domestic research	**Key Findings to Consider**
Babacan (2022)	Although the general digital literacy level of music teacher candidates is "good" (3.67/5.00), other studies show that this general competence is not reflected in pedagogical practices.
Arıcı (2016)	41% of music teacher candidates find the duration of the notation software training insufficient.
Köksal (2019)	While 93% of music teacher candidates see technological competence as a necessity, 41% do not use any music software; this shows the contradiction between the need and the current situation.
Çetinkaya & Kaya (2023)	Prospective music teachers have positive attitudes towards technology, but their frequency of using field-specific software is low and they request additional training in this regard.
Ayhan & Aydınlı Gürler (2023)	Incumbent teachers use smart boards the most (42%), but the rate of using new generation tools such as Web 2.0 is very low (80% do not use).

The comparative findings presented in Table 2 point to a global trend: Despite acknowledging the necessity and potential of technology, music teachers and prospective teachers struggle to translate their general digital literacy into field-specific pedagogical skills (Babacan, 2022; Cuervo et al., 2019). Studies specific to Turkey indicate that prospective teachers frequently request additional training and find their current undergraduate education inadequate (Arıcı, 2016; Köksal, 2019), while international literature highlights infrastructural deficiencies and the need for curriculum updates as universal problems (Gorgoretti, 2019; Thayer-Morel et al., 2018). This underscores the need for teacher preparation programs to restructure technology integration from theory to practice.

There is a shift from the traditional "knowledge transmitter" role to a "facilitator" or "learning manager" role, one that designs and guides students' learning processes (Cuervo et al., 2019; Köksal, 2019). This new role requires the integrated use of technology, pedagogy, and content knowledge, as outlined in the TPACK model. However, studies indicate that teachers lack the ability to achieve this ideal integration. This competency gap is consistently demonstrated in both local and international research.

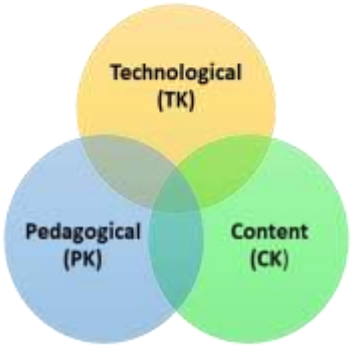

Figure 1. Technological pedagogical content knowledge (TPACK) model

Although the general digital literacy levels of music teacher candidates were found to be above average (3.67/5.00) in a study conducted in Turkey (Babacan, 2022), other studies found that the frequency of recognition and use of field-specific music/hearing education software was below average and a significant portion of the candidates did not use these software at all (Köksal, 2019; Çetinkaya & Kaya, 2023). Similarly, although preservice teachers in Bosnia and Herzegovina were experienced with general internet and Office programs, their experience using specialized software such as music notation platforms was found to be quite low before the pandemic (Akšamija & Ploskić, 2023). A study conducted in Chile found that approximately half of preservice teachers felt competent in using music technology (Thayer-Morel et al., 2018). This situation shows that although prospective teachers have a general aptitude for technology, there is a global difficulty in integrating this skill into their own fields with pedagogical mastery.

Paradoxically, 93.3% of prospective teachers in Turkey believe that a music educator must professionally use at least one music software program and are calling for more technology-focused courses in undergraduate education (Köksal, 2019). This clearly reveals the significant gap between prospective teachers' perceived need and their current training. More specifically, while prospective teachers' propensity for technology use is above average, their familiarity with and use of specialized software, such as music/auditory training, remains below average (Köksal, 2019).

3.3. Pedagogical, Infrastructure and Curriculum-Based Obstacles to Effective Integration

There are three main groups of interrelated and mutually reinforcing obstacles to the full integration of technology into music education.

- **Infrastructure and Financial Barriers:** As observed in many schools, especially in developing countries like Brazil, problems such as inconsistent connection quality and limited access to technological resources in classrooms exist (Cuervo et al., 2019). In studies conducted in Turkey, music teachers also cite the lack of materials and equipment, inadequate internet infrastructure, and limited financial resources of schools as the biggest challenges (Ayhan & Aydınlı Gürler, 2023).
- **Curriculum-Based Obstacles:** Educational curricula are often slow to adapt to technological advancements. Technology is often viewed as an "add-on" added to lessons rather than an integral part of the curriculum. Wise et al. (2011) emphasize that moving technology from this "add-on" status to one "embedded" in the curriculum is the most challenging yet crucial step. This problem is universal; preservice teachers in Chile also cited the lack of technological content and the weak

integration of Information and Communication Technologies (ICT) across subjects as among the biggest problems in the curriculum (Thayer-Morel et al., 2018). An examination of the middle school music curriculum in Türkiye reveals that the absence of any direct or indirect objectives related to critical thinking and problem solving, two of the 21st-century skills, is an indicator of how unprepared the curricula are for this transformation (Pektaş & Ekşioğlu, 2023).

- **Pedagogical Barriers:** The most critical barrier lies in pedagogical approaches. Traditional, teacher-centered teaching models are likely to present challenges in using technology effectively. In teacher training programs, technology education is often taught solely as a "tool-using" skill, separate from pedagogical practices, exacerbating the "theory-practice gap" graduates face in the classroom. One of the primary sources of this problem is students' inadequate exposure to the pedagogical aspects and integration of information and communication technologies during the pre-service period (Brown & Warschauer, 2006). These barriers are summarized in Table 3.

Table 3. Main obstacles to technology integration in music education

Obstacle Category	Explanation
Teacher Competencies and Resistance	Teachers' resistance to technology, lack of sufficient digital competence and pedagogical knowledge. A "digital divide" between students and teachers.
Infrastructure and Financial Constraints	Inadequate internet connection in schools, lack of up-to-date equipment, and insufficient financial resources to access technology.
Pedagogical Integration Issues	Technology is used as an "add-on" that merely reinforces traditional methods, rather than being "embedded" in the curriculum with a pedagogical purpose. The gap between theory and practice.
Lack of Curriculum and Institutional Support	Curricula are slow and inadequate in adapting to technological developments and teachers are not provided with sufficient support at the institutional level (in-service training, etc.).

3.4. New Technologies and Pedagogical Models: VR, AR and Gamification

Beyond traditional digital tools, the literature shows a growing interest in new technologies and pedagogical models that have the potential to radically change the learning experience.

- **Gamification:** By definition, gamification is the integration of game mechanics into a non-game context to increase motivation and engagement (Deterding et al., 2011). In music education, this aims to make the learning process more engaging through elements such as earning points, leveling up, badges, and leaderboards. This approach encourages student engagement by preventing boredom, particularly in repetitive instrument practice or abstract theory. Apps like Yousician and Simply Piano are popular examples of this model.
- **Virtual Reality (VR) and Augmented Reality (AR):** These technologies create immersive learning environments that place the student at the center of the experience, rather than being a passive spectator. With VR, a student can conduct a virtual orchestra and gain the ability to follow scores for different instrument groups simultaneously. With AR, a student can point their smartphone camera at a piano and see the correct notes and finger positions appear on the keys in real time. These technologies offer revolutionary potential, particularly in overcoming space, space, and resource constraints and in concretizing abstract musical concepts (Gürer & Sonsel, 2025).

3.5. Technology-Supported Measurement and Evaluation: Digital Portfolios

Technological transformation is impacting not only teaching methods but also approaches to measuring and evaluating student achievement. Traditional, summative exams are being replaced by more holistic, formative methods. Digital Portfolios (E-Portfolios): The most notable innovation in this field is digital portfolios. Allowing students to collect their recordings, compositions, research

papers, and performance videos throughout the semester on a single digital platform, e-portfolios are a rich assessment tool that demonstrates not only the student's final results but also their entire developmental process. Platforms like iScore allow students to upload their own work, write reflections on it, and receive feedback from teachers or peers (Brook & Upitis, 2015). This method transforms assessment from a grading process into a pedagogical process where students take responsibility for their own learning and develop reflection and self-assessment skills.

3.6. The Finnish Example as an International Success Model

Despite the challenges faced in integrating technology, the Finnish education system is frequently cited as a model of success internationally. Key factors underlying this model's success include the extensive autonomy afforded to teachers, high-quality teacher training at the master's level, and the concept of technology as an integrated tool that fosters creativity rather than a separate subject (Sahlberg, 2021).

3.7. Socio-Economic Factors and the Digital Divide

One of the biggest obstacles to the widespread adoption of technology-enabled opportunities is socioeconomic factors and the resulting "digital divide." This concept refers to the inequality between those who have access to technology and those who don't. Differences in access to hardware, software, and high-speed internet access disadvantage students, particularly those from low-income families, and undermine equal educational opportunities. This is not only related to physical access but also to differences in "digital capital," which refers to the ability to effectively use technology (Hargittai, 2002).

4. DISCUSSION and CONCLUSION

Research findings reveal that the digital transformation in music education is not merely a process of technological adaptation, but rather a complex paradigm shift involving pedagogical, philosophical, and socioeconomic tensions. While technology holds the potential to democratize and enrich music education, it also serves as a catalyst, exacerbating existing inequalities and creating new problem areas. This section, guided by the findings, will explore these fundamental elements along three main axes: human factors, pedagogical objectives, and systemic contradictions.

4.1. The Human Factor: Changing Teacher and Student Roles in the Digital Age

The findings point to differences in skills and expectations between "digital native" students, who are natural members of a digitalized culture and use technology instinctively, and "digital immigrant" teachers, who have had to adapt to this culture later. This can be seen as a contemporary reflection of Pierre Bourdieu's concept of "cultural capital"; Technology fluency has become a new type of "digital capital," and students often come to class with more of this capital than their teachers (Akšamija & Ploskić, 2023; Cuervo et al., 2019; Çetinkaya & Kaya, 2023). The problem isn't simply a lack of technical knowledge. The real issue lies in how teachers transform this digital knowledge into pedagogical competence. As the literature highlights, even if teachers possess a basic level of digital literacy, there's a significant "theory-practice gap" when it comes to integrating this skill into their own field-specific pedagogical strategies. As Table 3 demonstrates, this competency gap observed in Turkey is a universal problem recurring in contexts as diverse as Chile and Bosnia-Herzegovina. It is at this point that the TPACK theoretical framework takes center stage. TPACK argues that an effective educator must not only possess knowledge of technology, pedagogy, and content knowledge, but also possess an integrated wisdom at the intersection of these three (Mishra & Koehler, 2006). Findings indicate that teacher preparation programs often teach technology as a "tool skill" isolated from pedagogy and content knowledge, ignoring this integration, the essence of TPACK. Therefore, what needs to be done is to provide teachers with the pedagogical vision that will teach them "how to design an effective music lesson with technology."

4.2. The Pedagogical Paradox: Means or Ends?

Technology integration also reveals a profound dilemma at the core of educational philosophy: Should technology in music education be a goal or merely a tool? This question can be examined within the framework of Gert Biesta's classification of educational goals. According to Biesta, education has three fundamental goals: equipping students with specific abilities (competence), integrating them into existing social norms and traditions (socialization), and supporting their development as independent and unique individuals (subjectification).

From this perspective, a "tool-oriented" approach to technology risks reducing it to a mere "competence" tool. For example, simply teaching a student how to use a notation software (Sibelius, Finale, etc.) may qualify them in some ways for a future profession. However, this is the shallowest layer of education. Gamification findings also carry this risk; If implemented incorrectly, students may be motivated only to earn points and badges rather than to enjoy the music itself (Deterding et al., 2011).

However, the true transformative power of technology emerges when it serves the process of "subjectification." When a student uses a DAW (Cubase, FL Studio, etc.) to compose their own original compositions and express their own feelings and ideas through music, it not only enables them to acquire a skill but also to find their own voice as a "subject" in the world. Therefore, an effective music educator should use technology not merely as a productivity tool, but as a "pedagogical playground" where students can explore their creativity and individuality.

The process by which technology has become a part of musical expression can be supported by historical examples. Askerøi (2020) notes that initially, soft vocal styles like crooning, made possible by the use of microphones, or effects like slapback echo, a product of multi-track recording, were perceived by listeners as "unnatural" or "dishonest." However, over time, these "technological cues" faded, and these techniques became aesthetic conventions that defined specific musical genres. As Askerøi (2020) notes, the "gated reverb" drum effect that defined 1980s music also originated as a studio technique but quickly became the sound of an era. This demonstrates that digital production techniques, currently viewed as "tools," have the potential to transform into the musical "purpose" and aesthetic of the future. Therefore, these tools in education should be approached not merely as technical skills but as potential forms of artistic expression.

4.3. Systemic Contradiction: Equality of Opportunity or Consolidation of Privileges?

The final and most critical dimension of the debate is the contradiction that emerges at the systemic level. While technology is theoretically presented as a democratizing force that provides equal learning opportunities for all, in practice it risks reinforcing existing socioeconomic inequalities and creating a new "digital caste system" (Hargittai, 2002). Findings indicate that access to hardware, software, and high-speed internet is directly related to a family's socioeconomic status. This "digital divide" fundamentally undermines the principle of equal opportunity in music education. The findings in Table 3 demonstrate that infrastructural and financial inadequacies are among the most fundamental obstacles to technology integration in both Turkey and countries like Brazil.

The Finnish model provides an illuminating counterexample on this point. Finland's success stems not only from its investment in technological infrastructure, but primarily from its investment in "people." The importance placed on teacher training, the extensive pedagogical autonomy granted to teachers, and the egalitarian nature of the system create buffer mechanisms that prevent technology from becoming a tool of privilege (Sahlberg, 2021). Thanks to this autonomy, teachers have the flexibility to creatively utilize the resources at their disposal, even if they don't possess the most expensive technology, in line with the needs of their classroom.

This situation offers an important lesson for other countries: Simply distributing tablets and equipping schools with smart boards won't ensure digital transformation. If these technological advances aren't supported by holistic social policies that empower teachers, expand curricula, and

ensure access for disadvantaged students, technology will be an ineffective investment at best and a tool that exacerbates social injustice at worst. Furthermore, this integration isn't just a matter of social justice; it's also an economic necessity. In developed economies, the music and gaming industries create significant employment. For example, in Sweden, the music industry employs over ten thousand people, while the gaming industry employs over five thousand, and these sectors are reported to be experiencing significant economic growth (Eiksund et al., 2020). This demonstrates that equipping students with digital music production skills is a critical investment for their future employment prospects. Therefore, technology integration in music education is not only a matter of educational policy but also a matter of social justice.

4.4. Recommendations

This study demonstrates that digital transformation in music education is an inevitable and multifaceted process. While this transformation provides students with access to a wide range of information and opportunities for creativity, it also presents significant challenges, including teacher competencies, infrastructure deficiencies, and pedagogical integration issues. For this process to be successful, a holistic reassessment of technology, aligned with educational philosophy and objectives, is necessary, rather than treating it solely as a technical tool. In light of these findings and discussions, the following recommendations are presented:

- **Mandatory and Practical Training:** The findings of this study suggest that, given the intense demand for technology among prospective teachers, mandatory and practical courses based on TPACK should be added to undergraduate music teaching programs. These courses should focus not only on the use of tools but also on the pedagogical integration of technology.
- **Continuous Professional Development:** It is vital that current educators adapt to the requirements of the digital age. To this end, the Ministry of National Education should organize regular, hands-on in-service training, seminars, and workshops that keep up with current developments in the field. The findings of this study confirm that this need is valid both locally and internationally.
- **Embedded Integration into the Curriculum:** Digital technologies should be transformed from an add-on into music curricula to a fully integrated learning objectives and outcomes. This doesn't mean simply repeating existing subjects with technology. The curriculum must be updated and enriched to include new forms of musical expression and professional fields, such as digital music production, electronic music composition, and sound design.
- **Student-Centered and Project-Based Approaches:** Constructivist pedagogies that foster student active participation, collaboration, and critical thinking skills should be encouraged over traditional, teacher-centered approaches. Project-Based Learning (PBL), in particular, offers a highly suitable framework for technology integration. Students creating their own music projects (video clips, cover recordings, podcasts, etc.) using technological tools will allow them to develop both their technological and musical skills within a meaningful context.
- **Financial Investments and Equal Opportunity:** Central and local governments should invest in technology to fix school infrastructure. These investments should consider the risk of a "digital divide," which could worsen inequality. Policies should prioritize disadvantaged areas and ensure equal opportunity. Social justice requires fair access to technology for all students.
- **Intersectoral Collaboration:** Strategic collaborations among educational institutions, technology companies, the music industry, and civil society organizations should be encouraged. In particular, government-supported projects developed with domestic software companies in Türkiye will both increase production and ensure that current technology reaches schools more affordably. Such collaborations can also provide students with concrete career opportunities, such as internships and mentorships.

Ethics Committee Decision

Due to the scope and method of the study, ethics committee permission was not required.

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