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A Review of Online Learning Pedagogy and Vocal Music Education

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Abstract

This study examined the evolving landscape of online learning in vocal music education. It focused on the interventions introduced in recent years. Recognising the educational significance of music, this study reviewed how online learning pedagogy addressed specific challenges inherent to vocal instruction. Its objectives were to identify dominant trends, key interventions, and derive insights from past studies. The methodology employed a review of past studies published from 2020. This study prioritised past studies that involved online learning on vocal music education. The findings indicated that online learning has enhanced accessibility, flexibility, and engagement in music education through interventions such as virtual reality, artificial intelligence, and multimedia resources. They have facilitated immersive experiences and provided tailored feedback. Thereby, they strengthened students' creative and technical capabilities. Nonetheless, traditional music educators encountered difficulties in adapting to digital platforms. It underscored the necessity for digital literacy and supportive infrastructures. The study suggested that while online learning offers significant advantages, a balanced integration of digital tools with traditional methodologies is essential. Future research should investigate the long-term effects of online learning on skill development and creative growth, as well as explore optimised online platforms for real-time musical collaboration. This study contributed to a deeper understanding of the potential and limitations of online learning in music education, advocating for an approach that harmonises technology with foundational instructional practices.

Keywords: Online Learning Pedagogy, Vocal Music Education, Review

Introduction

Vocal music education is a crucial yet often underappreciated element of the broader educational framework. Beyond developing musical abilities, it fosters critical thinking, emotional resilience and cultural appreciation. Therefore, it is an essential tool for supporting holistic student growth. In an era of rapid technological advancements and shifting pedagogical priorities, the importance of vocal music education transcends artistic expression. Hence, it addresses key educational challenges such as nurturing creativity,

enhancing communication skills and fostering social cohesion in increasingly diverse classrooms. This study reviews how vocal music education can adapt to contemporary demands by incorporating innovative methods and technologies. It emphasises the need not only to preserve the field's rich traditions but also to explore its transformative potential in equipping students for the complexities of a globalised world. By identifying effective strategies, this study seeks to benefit educators, students, and policymakers. Eventually, it provides actionable pathways to integrate meaningful musical experiences into modern education systems.

Nowadays, music plays a significant role in education. The educational value of music warrants emphasis. Following that, vocal music is recognised as one of the most effective means of cultivating musical skills. Next, vocal music education is essential for fostering artistic and academic growth in students. Leading music educators and researchers have long underscored the importance of music education. They mention its extensive educational benefits and its capacity to promote holistic development. It has been widely accepted that every student possesses musical potential. Hence, vocal should serve as the foundation for all music education. It underscores the need for educators to advocate for and demonstrate the significance of vocal music in primary school curricula (Lim et al., 2024). However, student performance in vocal music education often varies considerably.

To address these challenges mentioned above, different strategies have been proposed. They include adopting a more integrated teaching approach that combines vocal training with ideological and psychological education. They optimise content to achieve a balance between Western and Chinese musical traditions. Subsequently, they diversify instructional methods through group lessons and multimedia tools. The strategies aim to render vocal music education more relevant and engaging. Hence, it aligns with the demands of contemporary society (Lagon Rozenbaum & Isaacson, 2024). By prioritising experiential learning and encouraging students to engage in concerts and performances, vocal music education could transition towards a more practical mode. This approach would enable them to apply their skills in real-world. Thereby, it better prepares them for future career opportunities (Xi, 2024).

In the 21st century, technology has profoundly influenced vocal music education. The emergence of technology has introduced new modes of teaching and learning. For instance, online courses, digital resources, and multimedia tools become central components of music education. The COVID-19 pandemic further accelerated the adoption of online learning methods. It reshaped the delivery of music education (Lian & Pan, 2022; Liu et al., 2022). Past studies have shown that online learhing have positively impacted music education outcomes. Hence, they underscored the importance of well-trained educators and supportive institutional frameworks in fully realising the advantages of online music education (Kulal et al., 2024).

The integration of online learning has emerged as a promising solution to several longstanding challenges in music education. Past studies have shown that online learning offers flexibility, accessibility and innovative teaching methods. It can enhance student engagement and learning outcomes. For instance, teacher competence in online instruction

has been found to positively influence perceived learning outcomes when supported by resilience and age-specific strategies (Liu et al., 2022).

To continue, the incorporation of online learning into music education is a relatively recent development. Also, it is propelled by technology and further accelerated by the global COVID-19 pandemic. Traditionally, music education has relied heavily on face-to-face interactions. In this mode, personal instruction and immediate feedback are essential. However, the advent of technology has gradually reshaped this conventional model. The shift towards online music education began in the early 2000s. Initially, online music education was limited to supplementary resources, such as instructional videos, digital sheet music, and interactive tutorials. They provided students with additional tools to support their learning outside the classroom setting.

One of the primary advantages of online learning in music education is its accessibility and flexibility. Online platforms make music education available to a broader audience. It includes students who may lack access to traditional music schools or in-person instructors. They are able to learn at their own pace and according to their own schedules. Thus, they could facilitate a balance between education and other commitments (Lian & Pan, 2022). Additionally, the technology offers an extensive range of learning materials. It includes video tutorials, digital sheet music, and interactive tools. These resources accommodate various learning styles and enable students to reinforce their understanding of musical concepts (Li, 2022).

Moreover, technology facilitate connections between students, instructors, and peers worldwide. Eventually, it enriches the educational experience through exposure to diverse musical traditions and perspectives (Long et al., 2024). Another significant benefit is the ability to record lessons. It allows students to revisit and practise material at their own pace. Furthermore, it supports better retention and mastery. Overall, online learning has transformed music education by offering broader access, a diverse array of resources, and opportunities for global collaboration. Therefore, this study aimed to conduct a literature review with several research objectives:

i) To identify the research purposes in past studies on online music education.
ii) To examine the interventions utilised in these past studies.
iii) To draw insights that emerged from the research findings.

Literature Review

This section presented a literature review of the two major concepts underpinning this study: vocal music education and online learning in music education.

Vocal Music Education

First of all, vocal music education is the structured teaching of singing techniques and vocal performance. Basically, it begins in early childhood and continues through formal education in schools. It aims to develop mental, emotional, and psychomotor skills. Thereby, it could contribute to students' holistic development (Lim et al., 2024). The significance of vocal music education lies in its ability to enhance cognitive and psychomotor skills. Following that, it cultivates artistic appreciation and foster a deeper understanding of musical expression (Darling-Hammond et al., 2020).

Beyond building musical skills, vocal music education plays a vital role in students' broader development. It promotes creativity and facilitates emotional expression. To elaborate, it also boosts self-confidence. Moreover, students gain an appreciation for cultural diversity and often develop a lifelong engagement with the arts (Wang et al., 2022).

The key components of vocal music education include curriculum design, pedagogical strategies, and performance opportunities. The curriculum covers basic music theory, ear training, vocal performance, and piano skills as a supplementary discipline. On the other hand, pedagogical strategies focus on aligning vocal repertoire with students' skill levels, developing vocal and musical skills across age groups, and utilising the surrounding environment as a teaching resource (Li, 2022). Finally, performance opportunities are also integral. They provide practical experience through concerts, competitions, and other stage events (Phillips & Hopkins, 2020). Subsequently, vocal music education emphasises the importance of artistic interpretation, emotional expression and technical proficiency. It ensures that students not only learn the mechanics of singing but also understand and communicate the emotional and cultural contexts of the music they perform (Ngo & Spreadborough, 2022).

Online Learning in Music Education

To initiate, online learning in music education has generated mixed reactions among teachers. Many music teachers express reservations about webinar-based education. It aims to offer information on job acquisition, practical tools, and personal development. However, these webinars often attract only a limited number of international participants. Furthermore, formal performing arts programs in music with qualifications from prestigious institutions such as Guildhall or the University of Southern California have received comparatively little research attention.

Despite these challenges, the potential for technology to complement traditional instructional methods has led to the development of various online learning models in music. The Open University enabled students to complete a music degree entirely online as early as 1982. In the 1990s, online instrument lessons began to emerge. It was benefiting self-motivated adult learners willing to pay for these services. Online platforms have since made music education more accessible and affordable. They created opportunities for individuals in remote locations and expanding perceptions of what musicians can achieve through digital learning. The convenience of online recording tools, such as Zoom and Skype, has also become a competitive advantage in the recruitment of music teachers and institutions.

Past studies highlighted several benefits of online learning. First and foremost, Wang et al (2020), identified three key advantages, namely, independent learning within a collaborative environment, the development of technology and time management skills, and the ability to learn at one's own pace. Next, the National Association for Music Education (Aucouturier & Canonne, 2017), has noted that online learning allows students to explore diverse musical topics and discover new instruments. Eventually, it enhances accountability through regular assessments. Furthermore, online learning provides flexibility. It could allow students to progress at their own pace, prepare for workshops, and review presentations after sessions. Successful online programs have also fostered camaraderie among teachers. Therefore, it adds a positive social dimension to the learning experience.

However, online learning also presents some challenges. Schmidt (2020) observed that distractions in home environments, such as ringing phones or household tasks, can impede effective learning. Also, Guo and Asmawi (2023) pointed out that synchronous online instruction lacks nonverbal cues, such as body language and facial expressions. These are essential for recognising misunderstandings in real time. To add, technical issues, such as platform freezes, can disrupt the flow of learning and require additional time to address. Moreover, designing an effective online curriculum is time-consuming. Besides, synchronous programs may face obstacles like time zone differences. Finally, online learning can also limit students' opportunities for networking and social interaction which are integral aspects of traditional music education.

Methodology

In this study, a review of relevant past studies was conducted. Initially, the researchers employed the keywords "online learning AND vocal music education" to identify relevant past studies. This search on Google Scholar yielded 280,000 publications. To narrow the scope to recent studies, the search was restricted to publications from 2020 onwards. Therefore, it reduced the results to 17,700 publications. To further enhance the manageability, the allintitle technique was applied. At this stage, the keywords were modified to "online learning AND music education". It resulted in 18 past studies.

Following that, the Scopus database was used to locate high-quality past studies. Using the keywords "online AND music education AND vocal," 33 studies were identified. To further refine these results, the researchers modified the keywords to "online learning AND music education AND vocal." Eventually, it yielded the 10 most relevant past studies on Scopus. These 10 past studies were subjected to a quality appraisal process. It ensured that each study met specific criteria such as, they explicitly addressed online learning, focused on music education within an online context, centred on vocal instruction, posed clear research questions, and identified specific online tools used in the educational process.

Findings

In this section, the findings were presented in accordance with the research questions.

Research Question I

The first research questions examined the research purposes of each past study selected. A table was presented below with elaborations.

Table 1
Research Purposes Identified

Research Purpose	Authors and Year
Using neural networks and VR to improve practical music teaching effectiveness	Hu, 2024
Problem-based approach to develop vocal and piano skills online	Liu & Ye, 2024
Lightweight deep learning models for immersive vocal music education	Zhu et al., 2022
Impact of online vocal training on creative thinking abilities	Chang, 2023
AI-driven vocal education with speech recognition integration	Bai, 2022
SWOT analysis of digital teaching for traditionally trained instructors	Liu & Weng, 2023
Student engagement and collaboration in virtual singing/choral learning	Ngobeni, 2024
Impact of online courses on music teachers' professional growth	Biasutti et al., 2019
Internet platforms for broader adoption in vocal music teaching	Tang, 2022
Effectiveness of LoLa (low-latency audiovisual streaming) for online lessons	Redman, 2021

The reviewed past studies offered a range of perspectives on advancing music education through technology and innovative pedagogies. One study focused on enhancing practical music teaching at universities by employing advanced neural networks and virtual reality (henceforth, VR). It illustrated how immersive technologies can transform the educational experience for students in practical music courses (Hu, 2024). Another study explored a problem-based learning approach in online music education. They aimed to improve students' vocal and piano accompaniment skills through structured problem-solving methods (Liu & Ye, 2024). Additionally, the application of lightweight deep learning models was investigated as a tool to enrich vocal music education. They integrated immersive and interactive technology to foster deeper engagement (Zhu et al., 2022).

Beyond technological advancements, some past studies focused on fostering creative thinking skills in students through specialised online vocal training programs. The findings indicated significant improvements in creative metrics (Chang, 2023). Another study developed an artificial intelligence-based vocal system with speech recognition capabilities to facilitate a more interactive and adaptive learning environment (Bai, 2022). Traditional music instructors' experiences with digital vocal teaching were also evaluated. They employed a SWOT analysis of digital teaching methods that underscored the need for digital literacy among instructors transitioning to online platforms (Liu & Weng, 2023).

Following that, student perspectives on virtual learning were examined as well. There were insights into how engagement, collaboration, and motivational factors influenced the online music education experience (Ngobeni, 2024). Another key focus was professional development for music teachers. A collaborative online course was assessed for its impact on teachers' professional skills and teaching practices (Biasutti et al., 2019). Research on the use of internet platforms for vocal music instruction highlighted their potential to broaden access and promote inclusivity in music education (Tang, 2022). Finally, the utility of LoLa, a low-latency audiovisual tool designed for real-time music teaching. It was evaluated across

European conservatoires. Eventually, it underscored its potential to support synchronous interaction and enhance remote learning experiences in music education (Redman, 2021). Overall, these past studies emphasised the transformative role of technology in music education, encouraging a re-evaluation of traditional teaching methods to align with the demands of modern learning environments.

Research Question II

This section presented the findings on the interventions used in the reviewed past studies. A figure is provided below, accompanied by detailed explanations.

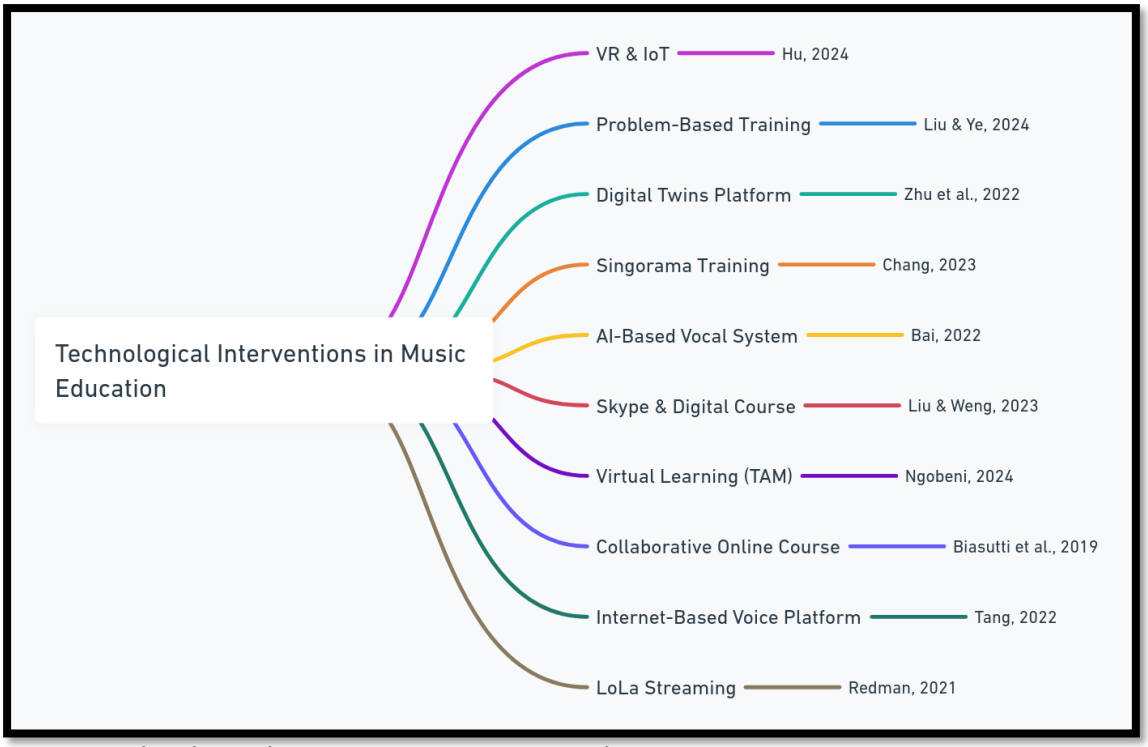

Figure 1. Technological Interventions in Music Education

The past studies reviewed highlighted a diverse range of interventions that were advancing music education. One study employed VR and the Internet of Things (henceforth, IoT) with a multiscale deep bidirectional gated recurrent neural network to create immersive learning environments for music students. It allowed students to be virtually transported to settings such as concert halls and recording studios. Thereby, it enhanced the practical aspects of music teaching (Hu, 2024). Another study focused on a specialised problem-based online training program structured into three modules. It aimed to develop vocal and piano skills by integrating musical and theoretical instruction with practical and artistic growth (Liu & Ye, 2024). Similarly, a Digital Twins platform was implemented. It merged real and virtual teaching spaces to support vocal music education. It utilised big data analytics and neural networks to recognise students' actions and expressions. Hence, it added immersive and interactive dimensions to the learning process (Zhu et al., 2022).

Next, expanding further on online learning resources, the Singorama online vocal training program was assessed for its impact on students' creative thinking. It aimed to enhance musical originality and flexibility through digital practice modules (Chang, 2023).

Another study developed an AI-based vocal system with speech recognition capabilities to facilitate vocal music education through a responsive learning environment accessible on web and mobile platforms (Bai, 2022). In addition, digital tools such as Skype and a customised digital learning course were used to improve the digital skills of traditionally trained vocal instructors. It enabled them to teach effectively online by enhancing their technical competencies (Liu & Weng, 2023).

Next, the Technology Acceptance Model guided the design of a virtual learning environment that explored student experiences in online learning for singing and choral techniques. It provided insights into student engagement and interactivity within virtual settings (Ngobeni, 2024). A collaborative online course based on a socio-constructivist framework was also introduced to support music teachers' professional development. It could blend online and in-person components to enhance teaching practices and curriculum planning (Biasutti et al., 2019). Furthermore, an internet-based voice education platform was evaluated for its potential to expand the accessibility of modern vocal music education. Hence, it promoted student autonomy and contemporary teaching approaches (Tang, 2022). Lastly, LoLa (Low-Latency Audiovisual Streaming) technology was examined for its capacity to enable real-time, high-quality, synchronous interactions in music instruction across conservatoires. It facilitated remote lessons, masterclasses, and live performances with minimal latency (Redman, 2021). In short, these interventions reflected a broader trend towards the integration of digital tools in music education. This trend enhances remote learning capabilities and fosters interactive, immersive educational experiences across diverse learning environments.

Research Question III

This section reported on the insights derived from the findings of the ten past studies reviewed in this study. For greater clarity, these insights were organised into thematic categories. The three primary themes were: i) enhanced interactivity and immersion, ii) skill development and professional growth, and iii) challenges and opportunities in digital transformation.

First and most, under enhanced interactivity and immersion, several studies underscored the benefits of immersive technologies in music education. To begin, VR and the IoT were effectively integrated to create engaging, interactive learning environments. They allowed students to virtually experience concert halls and historical music settings. Hence, it deepened their understanding of music theory and practice (Hu, 2024). Similarly, the Digital Twins platform facilitated real-time interaction between students and instructors by linking virtual and real teaching spaces. It led to dynamic feedback and heightened student engagement (Zhu et al., 2022). Additionally, LoLa technology enabled real-time and synchronous lessons across different conservatoires. It supported collaborative musical performances and masterclasses without geographical constraints (Redman, 2021).

Following that, the second theme focused on skill acquisition through structured online programs. The past study indicated that problem-based learning modules helped music students refine their vocal and instrumental skills, especially in structured online settings (Liu & Ye, 2024). Similarly, the Singorama online vocal training program fostered creative thinking and musical originality. It demonstrated that targeted online resources can enhance artistic

skills in ways that complement traditional methods (Chang, 2023). Moreover, professional development courses for music teachers promoted reflective teaching practices and improved instructional methods. This suggested that online platforms are equally beneficial for instructor development as they are for student learning (Biasutti et al., 2019).

The final theme highlighted both the obstacles and advancements associated with digital integration in music education. Many traditionally trained instructors encountered challenges with digital competencies. However, digital courses, such as those conducted via Skype, significantly improved their skills. Thus, it underscored the need for continuous digital literacy training (Liu & Weng, 2023). The study guided by the Technology Acceptance Model revealed that students often struggled with engagement in virtual settings. It led to recommendations for increased investment in collaboration and support tools to enhance online learning experiences (Ngobeni, 2024). Furthermore, research on internet-based voice education platforms highlighted the potential of networked education as the future of music teaching. Eventually, it provided that issues surrounding student autonomy and system responsiveness are addressed (Tang, 2022). Overall, these insights suggested that while technology introduces valuable immersive and interactive dimensions to music education, it also requires adjustments in teaching methodologies and support systems to fully leverage its potential.

Discussions

This section presented a discussion of the findings in relation to each research question.

Research Question I

The past studies reviewed underscore the potential of technology to profoundly reshape music education. It fostered immersive, interactive, and flexible learning approaches that align with the needs of students in the digital age. In practical terms, interventions such as VR and AI-based vocal systems (Hu, 2024; Bai, 2022) enabled rich, hands-on learning experiences that were previously unattainable in conventional classrooms. For example, VR has transformed educational experiences across diverse fields. It included medical training, architecture, and language learning. Immersive simulations allow learners to practice in realistic environments. In language learning, VR enables students to engage in authentic, situational dialogues in virtual settings. It effectively bridges the gap between theoretical knowledge and practical application (Marougkas et al., 2023). Similarly, VR in music education aim to simulate environments like concert halls or recording studios. It makes technical training more dynamic and directly applicable.

Next, the use of AI and deep learning to enhance skill development is exemplified by lightweight deep learning models applied to vocal music education (Zhu et al., 2022). It reflected a growing trend toward using adaptive technology to personalise learning experiences across educational fields. In language learning, adaptive AI systems have been used to track progress and suggest personalised activities based on learners' performance. It promoted an individualised approach to skill acquisition (Poquet & De Laat, 2021). This parallel suggests that AI can complement traditional education by catering to students' unique learning paces and needs. In music education, AI-based tools provide students with

immediate feedback on their performance. Thus, it fosters self-paced learning and allows for repetitive practice without dependency on an instructor.

However, these benefits also present unique challenges. The study by Liu and Weng (2023), highlighted the digital competency gap among traditional music instructors. They revealed a tension between the demand for advanced teaching methods and instructors' readiness to adopt them. This challenge was similarly observed in language learning. Older educators often struggle to integrate technology-driven methods which require both digital literacy and a shift in pedagogical approach (Li, 2024). This disparity in instructor readiness suggests a broader issue in digital transformation within education. While technology offers significant benefits for students, its potential remains limited without sufficient support for educators.

Moreover, while most studies position technology as a tool to enhance learning, alternative perspectives exist. In fields like physical education, for instance, digital tools are often viewed as supplementary rather than transformative because these subjects inherently depend on physical interaction and real-world practice that cannot be fully replicated in a virtual environment (Dwivedi et al., 2022). This contrast serves as a reminder that the role of technology in education should be tailored to each discipline's specific needs and limitations. While digital resources have considerable potential, they are not a universal substitute for traditional teaching methods, particularly in disciplines where physical presence and tangible interaction are critical.

In short, while the potential for technology to democratise and enhance music education is inspiring, it is important to maintain a balanced approach. As technology becomes increasingly integral to educational contexts, it should complement, rather than replace, the human elements of empathy, mentorship, and hands-on guidance. Moving forward, it is essential to invest in both digital infrastructure and teacher training to ensure that technology serves as an accessible and effective educational tool. By thoughtfully integrating digital tools with traditional methods, music education can become both more inclusive and more responsive to the needs of modern learners.

Research Question II

To initiate, VR and the IoT, combined with neural networks, are noteworthy for their capacity to simulate real-world music settings such as concert halls and recording studios (Hu, 2024). This innovation mirrors the application of VR in fields such as surgical training, where virtual simulations provide controlled environments for practicing high-stakes skills safely and repeatedly (Lawson McLean & Lawson McLean, 2024). Similarly, Digital Twin technology in music education parallels its use in medical training. It allows for practical application and conceptual understanding within a virtual realm. These applications underscore the value of VR and digital twins in creating immersive and risk-free environments for skill development.

Then, problem-based and structured online modules (Liu & Ye, 2024) reflected strategies in STEM education. The structured and problem-based learning promoted active engagement and critical thinking. Just as STEM students benefit from real-world problem-solving learning, music students benefited from a guided and hands-on approach that integrated theory and practice. Similarly, the Singorama program’s impact on creativity and

flexibility aligned with findings in language learning. The structured online resources like interactive vocabulary games and creative writing modules have been shown to enhance originality and adaptability in language use (Hung & Yeh, 2023). These parallels suggested that online learning modules are adaptable and effective in fostering critical thinking and creative capacities.

Moreover, the introduction of AI-based tools and speech recognition systems in music education provided students with real-time and adaptive feedback (Bai, 2022). Similar applications in language learning, such as AI-driven pronunciation apps, tracked students' progress and offered instant feedback. They made these systems instrumental in personalised learning (Shafiee Rad & Roohani, 2024). By delivering adaptive and immediate feedback, AI enables students to learn in real time without waiting for instructor evaluations. However, a significant challenge identified in music education is the digital competency gap among traditionally trained instructors. They often struggle with digital tools and online teaching methods (Li, 2024). This mirrors challenges in other fields, such as language teaching, where senior instructors may find it difficult to adopt interactive language software. Hence, it highlights the need for ongoing digital training programmes (Abuhassna et al., 2020).

Interestingly, while digital tools are transforming many fields, some disciplines still prioritise traditional methods. It occurs fields related to physical and sensory experiences. For instance, in physical education, the effectiveness of digital tools is limited because real-world movement and direct physical interaction are essential for skill development (Lee & Lee, 2021). This contrast reinforces the idea that while technology offers invaluable advancements, it may not be universally applicable or replaceable in all disciplines. Personal perspective on this integration of technology in music education is cautiously optimistic. While these innovations expand possibilities, they also raise questions about the irreplaceable value of human instruction and physical presence, especially in arts education.

To conclude, these studies highlight a promising trend towards integrating digital tools in music education. It echoes similar technological advancements in fields like medicine, STEM, and language learning. To fully harness this potential, however, it is essential to provide both students and instructors with adequate training and resources. As music education continues to evolve, a thoughtful blend of traditional teaching methods and digital innovation can offer a well-rounded, flexible learning experience that honours the discipline's rich, humanistic foundations.

Research Question III

The first theme emphasised the transformative power of immersive technologies like VR and the IoT in the music learning environment. By simulating spaces such as concert halls or historical venues, VR enabled students to experience music in context. It made theoretical concepts more accessible and tangible (Hu, 2024). This mirrors VR applications in history education. Virtual tours of historical sites deepened students' understanding through experiential learning (Asad et al., 2021). Similarly, the use of Digital Twin technology integrated real and virtual spaces to provide interactive feedback. It reflected its application in engineering education. It enhanced design and simulation capabilities to create a more dynamic and hands-on learning experience (Chen et al., 2020). Meanwhile, LoLa facilitated real-time collaboration, akin to real-time language exchanges on language learning platforms.

It enabled spontaneous and cross-border interactions that enriched students' engagement in collaborative, cross-institutional settings (Redman, 2021).

Then, the second theme highlighted the effectiveness of structured online programs in promoting skill acquisition for both students and instructors. The success of the Singorama program in enhancing creative thinking and musical originality parallels findings in language learning. Structured online modules in creative writing promoted originality and self-expression through targeted exercises (Jean-Berluche, 2024). Similarly, problem-based learning modules in music education reflected similar strategies in STEM education. Such modules fostered active and skill-based engagement by allowing students to apply theoretical knowledge in practical and problem-solving scenarios (Liu & Ye, 2024). Notably, online professional development programs also benefited instructors. They fostered reflective teaching practices and strengthening instructional skills (Biasutti et al., 2019). This dual advantage underscored that well-designed digital platforms can enhance teaching methodologies and learning outcomes.

Subsequently, the third theme addressed the barriers traditionally trained instructors face when adopting new technologies. Their difficulties with digital competencies echoed challenges found in other fields. Their limited technical skills and unfamiliarity with digital pedagogy often hinder the transition to online platforms (Li, 2024). The application of the Technology Acceptance Model to music education revealed that student engagement in virtual environments frequently suffers. A concern also observed in corporate training contexts. The lack of interaction in virtual meetings can lead to disengagement and reduced retention (Karl et al., 2022). Additionally, the internet-based voice education platform pointed to the future potential of networked music education but underscored the need to address issues of student autonomy and system responsiveness (Li & Wang, 2-24). In language learning, digital autonomy tools aim to support independent and self-directed learning while maintaining responsiveness. Thus, it reduces dependency on the instructor (Tóthová, & Sedláčková, 2021).

Reflecting on these findings, it becomes clear that while digital tools offer significant benefits for music education. Their full potential depends on thoughtful and discipline-specific integration. Realising the benefits of technology in music education requires investment not only in technological infrastructure but also in training and support for both instructors and students. The researchers of this study believed that while digital tools add valuable dimensions of interactivity and engagement to music education, they should be integrated in ways that complement, rather than replace, the intuitive and empathetic aspects of human-led instruction. This balanced approach ensures that digital transformation serves as an enhancement rather than a constraint, allowing music education to evolve in a way that honours its deeply humanistic foundations.

Conclusion

In conclusion, the reviewed past studies underscored the transformative role of technology in advancing music education through immersive, interactive, and adaptive digital interventions. VR, artificial intelligence, and networked platforms like LoLa exemplified how they opened new pathways for students and educators to explore and engage with music education beyond physical and logistical constraints. By creating virtual concert halls and

simulating realistic teaching environments, the interventions deepened students' connection to musical concepts. It paralleled the use of simulated learning environments in fields such as medical training and engineering (Hadgraft & Kolmos, 2020). The adaptability of AI and data-driven platforms in delivering personalised feedback and structured learning modules further highlighted their capacity to meet diverse learning needs. Also, it extended similar benefits observed in language and STEM education (Bai, 2022; Liu & Ye, 2024).

However, these interventions also present complex challenges. While digital tools hold significant potential for enhancing access, engagement, and skill development, they expose critical areas for improvement in digital literacy and pedagogical adaptation among instructors. Many traditionally trained teachers encounter difficulties in adopting online platforms and digital pedagogies. It is a trend consistent with broader educational challenges in the digital transformation across fields (Li, 2024). Addressing this competency gap is essential, as educators play a crucial role in maximising technology's impact on learning outcomes. Therefore, institutions must prioritise training initiatives, not only to equip instructors with digital skills but also to foster openness to innovative teaching methodologies that can complement traditional music instruction.

For future research and practical application, it is essential to develop frameworks that support personalised, discipline-specific integration of digital tools in music education. Further studies could investigate the long-term effects of these interventions on both student creativity and skill retention. Moreover, future studies could examine how real-time collaborative platforms might be optimised for performance and practice. Additionally, research could consider student perspectives on balancing digital autonomy with instructional guidance, especially as platforms increasingly incorporate features designed to support independent learning. An interdisciplinary approach could also be valuable by drawing lessons from fields like physical education and language learning.

The implications of these findings extend beyond music education. They offer insights into the broader educational landscape as it increasingly integrates digital tools. While technology undeniably enhances accessibility and engagement, a critical perspective is needed to ensure that digital tools serve as complements rather than substitutes for the interpersonal and empathetic aspects of education. Balancing innovation with these foundational elements will be crucial to creating a sustainable and effective model for online music education. In practice, this balanced approach allows music education to preserve its expressive and humanistic core while evolving to meet the demands of a digital age. With thoughtful integration and ongoing research, digital tools have the potential to both democratise and enrich music education, making it accessible to learners from diverse backgrounds.

Finally, these considerations underscore the transformative potential of technology in music education while emphasising the need for nuanced, adaptive approaches. By continuing to investigate and refine these interventions, educators and institutions can help shape a future in which music education is accessible, impactful, and true to its expressive roots.

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