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A Systematic Review of Metaverse-Based Learning in Music Education

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ABSTRACT

In recent years, the integration of metaverse technologies into educational settings has gained significant attention. This systematic review aims to investigate the application of metaverse-based learning in music education. The review employs clearly defined inclusion and exclusion criteria, spanning literature from 2019 to 2023. The screening process encompasses key concepts, relevance, and alternative keywords to ensure a broad and comprehensive literature retrieval. The study addresses two primary inquiries: firstly, it categorizes Metaverse-Based Learning (MBL) technologies employed in music education, encompassing virtual reality, augmented reality, artificial intelligence, speech recognition, and other pertinent technologies. Secondly, the research provides a comprehensive exploration of MBL applications within diverse music disciplines and skill areas, including but not limited to music theory and fundamentals, performance and improvisation, vocal perception, music composition, instrumental performance, team performance and ensemble. The article also explores limitations in current research and suggests directions and considerations for future studies. This comprehensive review provides a valuable foundation for further research and exploration of MBL applications in music education.

Keywords:
Metaverse-based learning (MBL), music education, literature review, virtual reality (VR), augmented reality (AR), music composition, educational technology

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1. Introduction

In the contemporary landscape of education, the integration of digital technologies and innovative pedagogical approaches has redefined the ways in which students learn and educators teach. With the advent of metaverse technologies, a new horizon has opened up for educational practices [39,40].

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Music education is an essential component of the educational landscape, fostering creativity, cognitive development, and emotional expression [41]. Traditionally, music education has been conducted in physical settings, with students and educators interacting face-to-face. However, with the advent of digital technologies, the educational paradigm is shifting [42]. Virtual and augmented reality technologies, coupled with the development of metaverse platforms, have opened up new possibilities for music education.

The metaverse, as a collective virtual shared space, comprises various interconnected digital environments, with each metaverse platform taking the form of virtual spaces [43]. It is a realm where users can engage, socialize, and cooperate, blending the distinctions between the tangible and virtual realms. These four key components of the metaverse: immersion, advanced computing, socialization, and decentralization [44], are crucial for understanding the nature of the metaverse and its transformative impact on music education. This transformative technology holds significant potential for reshaping the way music education is conducted. Metaverse-based learning can provide immersive, engaging, and interactive experiences, allowing students to explore music in innovative ways.

In the past few years, Metaverse-Based Learning (MBL) has experienced significant growth in research and application in the field of music education. Starting from 2018, many studies began to explore the potential of MBL technology in music learning, reflecting the academic community's interest and exploration in this area. In 2020, the demand for online learning increased globally due to the pandemic [45-47], further accelerating the application of MBL. Subsequently, there has been a gradual increase in the application of MBL, particularly with the development of technologies such as Virtual Reality (VR) and Augmented Reality (AR). By 2023, MBL has become one of the innovative educational methods attracting attention in the field of music education. The technological research and practical application of MBL in music education will be an important trend in both current and future contexts, deserving further investigation.

As the field of metaverse-based learning in music education is relatively new, it is essential to assess its current state and potential benefits critically. Through a comprehensive analysis of existing literature, particularly an in-depth investigation into the development and application of metaverse technologies in music education, we have observed a relative scarcity of practical case studies. The majority of research is predominantly focused on related technological studies. After exploring the types of metaverse technologies and their applications in nurturing music knowledge and skills, this review endeavors to provide valuable insights into the key trends, challenges, and future directions of metaverse-based music education.

As we initiate this systematic review, the discussion will be structured around two primary research questions (RQ1 and RQ2) to steer our investigation into Metaverse-Based Learning in the context of music education.

(a) What are the primary MBL technologies applied in music education?

(b) Which music disciplines and skills are involved in MBL?

These research questions will serve as our compass as we delve into the available literature. They will guide our examination of the current state of Metaverse-Based Learning in music education, the challenges it presents, and the promising directions for future research.

2. Methoodology

This section examines the method shown in Figure 1.

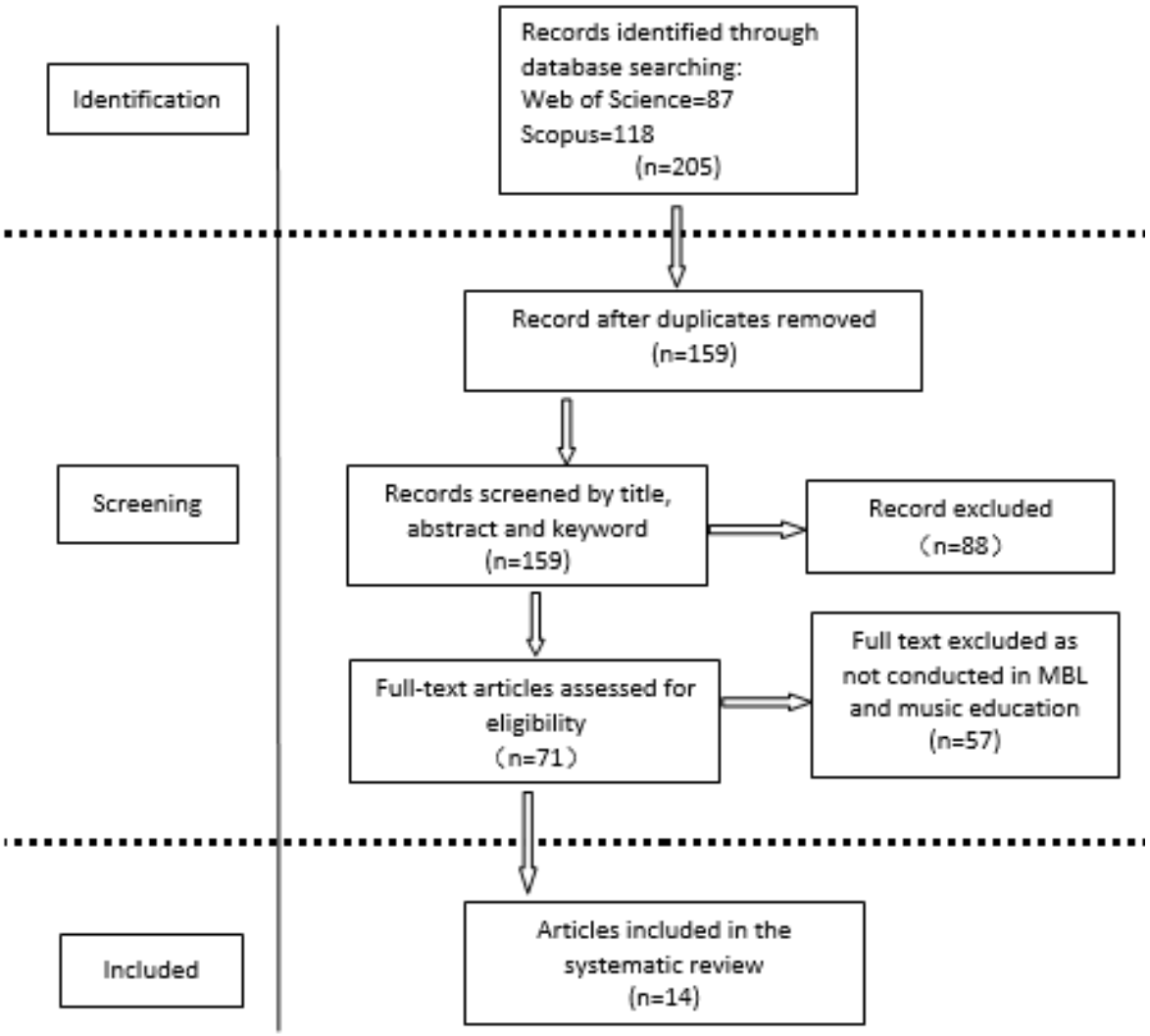

Fig. 1. Flow diagram of the study (PRISMA systematic review)

2.1 Identification

The initial stage in the systematic review is the identification phase [48-51]. The primary databases utilized for literature review include Web of Science (WoS) and Scopus. The search queries involve a combination of keywords and phrases, primarily including terms related to Metaverse-Based Learning (MBL) and music education. Boolean operators such as AND and OR are also utilized in the search process to refine the search and identify relevant articles. Table 1 below presents the search strings used in each of the databases.

Table 1
The search string used for the systematic review process

Database	Search String
Web of Science (WoS)	TS= (("Metaverse-Based Learning" OR "Metaverse-Based teaching" OR "Metaverse-Based platform" OR "digital learning" OR "Virtual Learning" OR "Immersive Learning" OR "Online learning" OR "Online Distance learning" OR "ODL") AND ("Music education" OR "Music courses" OR "music padagogy" OR "music curriculum"))
Scopus	TITLE-ABS-KEY (("Metaverse-Based Learning" OR "Metaverse-Based teaching" OR "Metaverse-Based platform" OR "digital learning" OR "Virtual Learning" OR "Immersive Learning" OR "Online learning" OR "Online Distance learning" OR "ODL") AND ("Music education" OR "Music courses" OR "music padagogy" OR "music curriculum"))

2.2 Screening

The articles included in this systematic review must meet specific inclusion criteria, including articles published between 2019 and 2023 to ensure the capture of the most recent research in the field. The main emphasis of these articles should center on Metaverse-Based Learning within the realm of music education. Exclusions will apply to articles not in English, as this review will be conducted in English. Furthermore, articles with no full text available, such as abstracts or conference posters, will be excluded. Articles unrelated to the research questions posed in the introduction, and articles that do not provide sufficient information regarding the methodology or results, will also be excluded. Table 2 below show the inclusion and exclusion criteria.

Table 2
Inclusion and exclusion criteria

Criterion	Eligibility	Exclusion
Timeline	Between 2019 and 2023	<2019
Literature type	Articles from journals	Conference proceedings, review articles, book chapters, reports, retracted publication
Language	English	Non-English
Scope	Related to Metaverse-Based Learning (MBL) and Music Education	Not related to Metaverse-Based Learning (MBL) and Music Education

In the search results, initially, articles belonging to the field of music education and explicitly containing "metaverse-based learning" or related terms were retained. Among the considered articles, a further step involved reading the full text and excluding those that only discussed online video-based learning without mentioning interactivity or learners' participation within a virtual environment. "Metaverse-based learning" is typically defined by emphasizing student interaction and engagement, as well as the use of virtual environments, rather than passive video content consumption. Such articles were filtered out. The selected articles, even though some did not explicitly mention this specific term, explored topics related to virtual environments, virtual reality, augmented reality, online learning, and their relevance to the definition, scope, and features of metaverse-based learning, and were included in this study. The retained literature employs some alternative terms that encompass concepts similar to metaverse-based learning. Here is the correlation of these terms in Table 3.

Table 3
Conceptual relevance

Concepts	Correlations
Virtual Learning/Environment	Metaverse-based learning typically involves learning in virtual worlds, and the term "virtual learning/environment" is commonly used to describe this concept. In certain articles, scholars may prefer to use "virtual" because it more broadly encompasses virtual concepts related to the metaverse.
Online Distance Learning (ODL)	While ODL primarily refers to online distance learning, in some instances, it can be considered a form of metaverse-based learning, especially when the online learning environment provides a more immersive and interactive experience.
Immersive Learning	Metaverse-based learning often includes immersive learning experiences, and "immersive learning" is used to describe this alternative term that emphasizes interactive and experiential learning approaches.
Digital Learning (space)	Describes the learning process conducted through digital media and technology, aligning with the characteristics of Metaverse-Based Learning. Metaverse-based learning typically occurs in digital environments, and "digital learning spaces" emphasizes the virtual or digitized spaces where learning takes place.
Metaverse-Based Teaching	This term emphasizes the instructional aspect within the metaverse, focusing on the role of educators and instructional strategies in a virtual environment.
Metaverse-Based Platforms	Refers to the technological infrastructure or digital spaces where metaverse-based learning occurs, highlighting the role of platforms in facilitating immersive educational experiences.

In the retained literature, these alternative terms are used to more broadly cover related concepts, describe specific learning experiences, or because these terms are more commonly used in certain contexts. Researchers choose these alternative keywords based on the specific direction and goals of their research.

2.3 Included

The search results in the chosen databases revealed that, based on the Table 4 above selected from WoS and Scopus for the third stage, known as Included.

Table 4
Summary of the selected studies

Study	Database	Aim	Methodology	Participants	Findings
Bai J. (0)	WoS	Build a vocal music education system, it can be applied in college teaching and learning.	Leverage J2EE, UML, JAVA, and web programming to implement music education activities aligned with current needs and music theory preparation.	Students learning vocal music.	The intelligent system can enhance the standards of vocal music education management, teaching organizational proficiency, and proficiency in operating the teaching platform.
Beirnes S. & Randles C. (0)	WoS, Scopus	To explore the experiences of a music teacher who had to adapt to blended learning during the COVID-19 pandemic. The focus is on how technology, specifically metaverse-based learning and other digital tools, affected music education and student learning.	An autoethnographic study where the teacher reflects on their experiences during the pandemic and discusses the impact of technology on music education.	The music teacher (A1) who shares their experiences.	Embracing metaverse-based learning is vital in pandemic music education, fostering student creativity through online tools and DAWs. Teachers should prioritize flexibility, student-centered approaches, and technology for relevance, promoting engagement through curiosity and autonomy in blended learning.
Cao Y. (0)	Scopus	To implement online piano learning, ensure the assessment of academic performance, and evaluate the motivation of the respondents.	To assess through experimental research methods and compare the differences between online learning and traditional face-to-face education.	40 students from 19 to 25 years	The effectiveness of the online learning strategy was comparable to face-to-face training and exhibited superior parameters. In practical terms, this technique can be applied in schools and universities that prioritize musical curricular activities.
Espigares-Pinazo M. J., Bautista-Vallejo J.	Scopus	To showcase the effectiveness of automated analysis processes within Moodle, particularly for assessing educational	A quantitative approach processes students' test responses in real time using an algorithm for data analysis. This enables the creation of a statistical model that	Thirty Secondary Schools in the autonomous community of Andalusia (Spain)	Automated procedures prove valuable for examining educational musical data. Technology enables monitoring, exploration, and prediction.

M.& García-Carmona M. (0)		musical data concerning cultural and artistic competences.	organizes information based on educational and didactic criteria.	were invited to participate (n=30).1327 students of the first grade of 'ESO' (Obligatory Secondary Education) between the ages of 12 and 13.	
Ismail M. J., Anuar A. F. & Loo F. C. (0)	WoS, Scopus	To identify the effectiveness of music ODL on gifted students' motivation.	The study employed a survey research method, utilizing questionnaires to measure the opinions of music gifted students in Malaysia about Metaverse-based learning.	81 secondary gifted students, aged 13 years, from 13 states in Malaysia.	An Open and Distance Learning (ODL) strategy in music courses markedly improves motivation domains like empowerment, usefulness, success, interest, and caring for gifted students.
Liu P., Cao Y. & Wang L. (0)	Scopus	A user-centric personalized learning approach is suggested through the analysis of online education data, leading to the development of a music online education system	Diverse methods, including multimodal knowledge mapping, extraction, integration, retrieval, and personalized recommendation, were employed to construct an online music education knowledge graph.	University student users	The suggested model effectively predicts multiple benchmark metrics, surpassing other algorithms in recommendation accuracy.
MacGlone U. M. (0)	WoS	Female students' comprehension of their learning environment in an online unrestricted improvisation module and the potential for inventive and musical activities accessible to them.	Uses a case study approach.	Four female students who participated in a higher education online improvisation course.	In Metaverse-Based Learning, students personalize online experiences with filters and background changes. Understanding female perspectives guides teachers in fostering an inclusive space for improvisational learning.
Merrick B. & Joseph D. (0)	WoS, Scopus	Examine Australian music teachers' views on confidence, preference, and use of music technologies, including ICT, in COVID-19 teaching, and assess the	Employing a mixed methodology, incorporating both qualitative and quantitative approaches.	Music educators who are members of peak Australian music organizations.	Teachers adapted confidently amidst uncertainty, utilizing diverse technologies and software essential for online teaching. ICT and metaverse-based learning effectively engage students in music education activities.

		impact of ICT and music technology on music education during the pandemic.			
Tang, M. M. (0)	Scopus	Examines the advantages and challenges of an internet-based voice education approach, offering solutions to encourage vocal music teachers to embrace modern teaching methods and enhance music education in regular schools.	Designs, tests, and analyzes an internet-based platform for vocal music teaching in college.	4,000 college student and teacher users.	The integration of Internet-based education platforms and traditional vocal music teaching methods enhances students' independence
Thomas M. A., Norgaard M., Stambaugh L. A., Atkins R. L., Kumar A. B. & Farley A. L. P. (0)	Scopus	To investigate the impact of the abrupt transition from conventional face-to-face teaching, co-teaching, and mentorship on the engagement of music PSTs and their CT mentors in a specific region of the United States.	A survey-based research method	Thirty-seven participants responded, representing about 32% of all PSTs in Georgia during that period.	Face-to-face interactions are crucial for both PST and P-12 students. Some PSTs lack knowledge in planning and implementing online music instruction. Teacher preparation programs should integrate technology for more flexible teaching approaches.
Ward F. (0)	Scopus	Records the efforts of the AIM to reproduce the communal music-making aspects of the Irish music tradition by recounting the virtual learning experiences of those who engaged with the AIM website.	Ethnographic enquiry	Conducted ethnographic interviews regarding general transmission practices with several IT musicians and educators, among whom was Michelle Mulcahy, a celebrated multi-	OAIM utilizes virtual pedagogies such as Virtual Classrooms, Sessions, Jam Sessions, and Virtual Reality Sessions, revealing their potential and limitations in online music education.

				instrumentalist performer and IT instructor from Co. Limerick, Ireland.	
Wieser M. & Müller F. H. (0)	Scopus	Applying self-determination theory, this research examines the motivation and satisfaction levels of music students' psychological needs during instrumental lessons before and after the transition to online teaching prompted by COVID-19.	Comparative survey research of two independent samples.	Comparing two independent sample groups of music students in an Austrian state, the first group comprised 856 students, aged 7 to 68 years, and the second group included 640 students, aged 7 to 77 years.	In online learning, intrinsic motivation decreased, and controlled motivation increased compared to pre-enforced distance learning. Satisfaction of basic autonomy, competence, and relatedness needs, crucial for autonomous motivation, was lower online.
Wu Y. H. & Tao T. T. (0)	WoS	Effectiveness of learning music using virtual reality tools.	The primary research method employed was a questionnaire survey to assess students' attitudes, motivation, and their awareness of virtual reality.	342 second-year students (59% of girls and 41% of boys), with the mean age of 19.02±0.48.	Using Ehlers' method, student motivation levels were higher among those utilizing virtual reality, contrasting with lower motivation levels observed among participants using traditional learning tools.
Yang, P. & Liu, X. (0)	Scopus	Examines the comprehensive services of an online learning platform using an online music education platform as a case study.	Applies a comprehensive weighting method, hierarchical model, and rough set-neural network evaluation model to assess the services of online learning platforms, using an online music education platform as an illustrative example.	Colledge tudents and teachers who use the online music education platform.	By constructing an evaluation indicator system and model, it is possible to effectively assess the service quality of online learning platforms, demonstrating high accuracy in predicting the comprehensive service quality of online teaching platforms in simulations.

2.4 Data Synthesis

Data synthesis will involve a narrative approach. We will analyze the selected articles to identify trends, common themes, and variations in the application of Metaverse-Based Learning in music education. The results will be presented in a coherent manner, addressing the research questions posed in the introduction.

All relevant articles on metaverse-based learning applications in music education have been systematically collected and organized using citation management software, EndNote. Following the completion of the collection process, thematic analysis was conducted to address the following research questions:

(a) What are the primary MBL technologies applied in music education?

(b) Which music disciplines and skills are involved in MBL?

The review employed an interpretive analysis of the selected articles, aiming to categorize themes relevant to the specified research questions. The themes identified for the first research question were categorized according to the metaverse technologies discussed in the literature review. The second research question involved the classification of music disciplines and skills implicated in metaverse learning.

3. Results

RQ1: What are the primary MBL technologies applied in music education?

In this systematic review, MBL employs various technologies, broadly classified into (1) Virtual Reality (VR) and Augmented Reality (AR), (2) Artificial Intelligence (AI) and Speech Recognition, (3) Online Learning Platforms, (4) Digital Audio Workstations (DAW), (5) Audio Analysis and Processing, (6) Neural Networks and Deep Learning, (7) Knowledge Graph Technologies, (8) Data assessment, (9) Autonomous Project Support, and (10) Interdisciplinary Interaction. These classifications are based on the articles listed in Table 4 and showcase the diverse technologies utilized by MBL in music education, each enriching the experience of music learning in different ways. The table 5 illustrates the categorized types of articles used in this study.

Table 5
Application types of MBL technology in music education

Concepts	Correlations
Virtual Reality (VR) and Augmented Reality (AR)	Ward (0); Wu & Tao (0); Tang (0); Cao (0)
Artificial Intelligence (AI) and Speech Recognition	Cao (0); Liu et al. (0); Yang & Liu (0)
Online Learning Platforms	Merrick B. & Joseph D. (0); Espigares-Pinazo et al. (0); Wieser & Müller (0); Thomas et al. (0)
Digital Audio Workstations (DAW)	Beirnes & Randles (0)
Audio Analysis and Processing	Tang (0)
Neural Networks and Deep Learning	Liu et al. (0) Yang & Liu (0)
Knowledge Graph Technologies	Liu et al. (0)
Data assessment	Espigares-Pinazo et al. (0)
Autonomous Project Support	Wieser & Müller (0)
Interdisciplinary Interaction	Beirnes & Randles (0)

As shown in the table, four articles [52-55] demonstrate the extensive application of Virtual Reality and Augmented Reality technologies in music education. Wu and Tao [53] introduce the application of Virtual Reality technology in teaching Chinese music composition, emphasizing students' positive responses to digital learning experiences, illustrating the successful integration of VR into music education. Ward [52] discusses the application of virtual environments and immersive technologies in an Irish Traditional Music Academy, providing music education through online platforms and VR 360 Sessions. The comprehensive integration of Virtual Reality (VR), Augmented Reality (AR), and audio analysis technologies allows students to experience music performances in virtual environments, enhancing the learning experience through AR. This technological diversity provides a richer dimension to music learning [54]. Modern applications of AR and VR in piano teaching, specifically in online piano instruction, have proven to be effective, with results indicating no significant differences compared to traditional face-to-face teaching [55]. These studies consistently demonstrate that the application of VR and AR technologies in music education provides students with immersive and captivating learning experiences, enriching the forms and content of music teaching.

Artificial Intelligence (AI) and Speech Recognition Technology: Three articles [55-57]. MBL systems utilizing multimodal music knowledge graphs integrate online course data, micro-videos, audio, and course exercises. The construction of knowledge graphs and their propagation enhances the efficiency of online music education [56]. Yang and Liu [57] use a BP neural network to evaluate comprehensive services on online music education platforms, highlighting the role of AI and neural networks in music education assessment. Cao [55] suggests that there are no significant differences between online piano teaching utilizing AI and traditional face-to-face instruction, offering guidance for future studies on Metaverse-Based Learning. AI and speech recognition technologies innovate assessment and learning methods in music education, expanding the educational scope of the music discipline.

Neural Networks and Deep Learning: Two articles [57,56]. Yang and Liu [57] comprehensively assess online learning platforms using a neural network model, emphasizing the role of neural networks in teaching communication and interaction. Liu *et al.,* [56] utilize knowledge graph technology to construct multimodal music knowledge graphs, integrating diverse information sources, including online course data, micro-videos, audio, and course exercises. Neural networks and deep learning technologies are employed to provide personalized learning support within MBL, indicating opportunities for innovative practices.

The study by Espigares-Pinazo *et al.,* [58] focuses on the Moodle platform, conducting a detailed assessment of students' musical proficiency levels through data assessment technology. Data assessment technology, categorized as an independent technology in MBL, is utilized to quantify and analyze students' performance in music education.

Online learning platforms and autonomous project support are integral to MBL technology. These platforms provide various digital tools and software that facilitate interactive and flexible music education [46,58-60]. They allow students to access learning materials, collaborate with peers, receive real-time feedback from instructors, and fostering a creative learning atmosphere. These factors are considered crucial for enhancing students' motivation and sustained engagement in music subjects. By meeting students' basic psychological needs in online or blended learning environments, autonomous project support in MBL promotes student initiative and increases subject motivation.

Literature on interdisciplinary interaction technology explores project-based courses where students engage in music exploration using various technologies, including creating drum beats and using music composition applications [61]. Adopting this interactive learning approach, students can

participate in diverse music experiences. Project-based learning promotes students' comprehensive development in music education, enhancing the fun and engagement of learning.

RQ2: Which music disciplines and skills are involved in MBL?

According to the literatures, the music disciplines and skills involved in Metaverse-Based Learning (MBL) can be categorized into the following main groups (Table 6).

Table 6
Categories of music disciplines and skills involved in MBL

Category	Summary	Related Studies
Music Theory and Fundamentals	Acquiring and applying music theory, harmony, rhythm, and fundamental skills, employing Virtual Reality (VR) and Augmented Reality (AR) technologies to foster intuitive comprehension.	Beirnes & Randles (0)
Performance and Improvisation	Engaging in performance within virtual environments, simulating performance scenarios to enhance practical experience. Providing opportunities for improvisation, supporting practical music composition.	Ward (0); MacGlone (0)
Vocal perception	Through virtual technology, support vocal learners in perceiving sound, provide real-time feedback and guidance, and promote vocal skills.	Bai (0)
Music Composition	Allowing students to compose music within virtual environments using online Digital Audio Workstations (DAWs) or other digital tools.	Beirnes & Randles (0); Ismail et al. (0)
Instrumental performance	Performing instrumental music in a virtual environment, simulating performance scenarios, enhancing practical performance experience, and cultivating actual playing skills.	Wu & Tao (0); Cao (0); Ismail et al. (0); Yang & Liu (0)
Team Performance and Ensemble	Providing opportunities for virtual orchestral and ensemble performances, supporting collaboration and performance within a team environment.	Ward (0)

Music Theory and Fundamentals Through Virtual Reality (VR) and Augmented Reality (AR) technologies, students can learn and apply music theory. These technologies provide an intuitive understanding and application of the fundamental elements of music. [61] demonstrated students' engagement in music theory using online Digital Audio Workstations (DAWs) and other music composition tools. This interactive learning environment fosters creativity and curiosity, providing students with new ways to understand music theory.

Performance and Improvisation MBL provides students with opportunities to perform and improvise in virtual environments [62]. By simulating scenarios, students can play virtual instruments and engage in virtual singing, simultaneously learning and developing performance skills. This helps enhance students' practical performance experience. [63] developed a vocal education system utilizing speech recognition simulation technology. This system enables students to engage with the emotional aspects and aesthetics embedded in vocal works, grasp singing techniques, and enhance their abilities in perception and expression.

Music Composition a significant aspect of MBL is its support for students' development in music composition. MBL supports practical music composition by providing opportunities for improvisation in a virtual environment [62]. By using online DAWs or other digital tools, students can compose music in virtual environments. Students might create a drum beat in an app or make a song in a

music-creation app [61]. Experiencing richer experiences through virtual reality and augmented reality technology in the composition process helps stimulate creativity and interest.

Instrumental Performance Virtual reality in music improves the quality of sound through visual immersive experiences, tactile sensations, and interactivity [53]. [57] note that online music education, especially for musical instruments, emphasizes practice, skill mastery, practical tutoring, and error correction. The MBL platform they use focuses on recognizing and analyzing interactive modes between teachers and students. The piano simulator application for online learning has enabled most participants to achieve a basic level of piano skills, improving rhythm and speed skills [55]. High-performance skills were demonstrated in improvisation.

Ensemble and Collaboration Some studies indicate that MBL supports students in collaborating and performing in a team environment through opportunities for virtual orchestras and ensemble playing. [52] elaborates on how the Online Academy of Irish Music (OAIM) utilizes MBL, specifically Virtual Reality Sessions, to promote online musical collaboration. AIM learners aim for connections through virtual communications in the Virtual Classroom, participating in the Virtual Session, and eventually engaging in face-to-face performances and interactions with others. This interactive form fosters students' collaboration and teamwork, providing them with opportunities to create music together in a virtual environment. Learners can create music together in a virtual environment, even collaborating with virtual musicians, helping cultivate musical collaboration and coordination skills.

4. Discussion

The comprehensive synthesis of the selected articles reveals a rich landscape of Metaverse-Based Learning (MBL) technologies and their applications in music education. The discussion below aims to delve into key themes, draw connections across studies, and explore the broader implications of MBL in the context of music learning.

The analysis demonstrates the diverse array of MBL technologies applied in music education. Immersive experiences are provided by Virtual Reality (VR) and Augmented Reality (AR) technologies [52-55]. These technologies not only simulate real-world performance scenarios but also enrich the learning experience by providing intuitive and engaging platforms. Artificial Intelligence (AI) and Speech Recognition technologies, as highlighted by studies like [55-57] play a pivotal role in personalizing music education, offering innovative assessment methods, and contributing to efficient learning processes. The integration of Data Assessment and Autonomous Project Support technologies in MBL showcases its multifaceted nature, employing data-driven insights and enabling autonomous learning experiences.

MBL extends its influence across various music disciplines and skills. Music Theory and Fundamentals are approached innovatively through VR and AR technologies, providing students with a unique and intuitive understanding of foundational elements [61]. Performance and Improvisation benefit from the simulation of virtual environments, enabling students to enhance practical experience and explore diverse musical styles [62]. Vocal Perception, as demonstrated by [63] showcases how MBL leverages speech recognition simulation technology to enhance singing techniques and emotional expression. Music Composition experiences a paradigm shift with MBL, enabling students to compose in virtual environments using online DAWs [61]. Instrumental Performance sees a boost, with studies like [53] and [57] highlighting improvements in skills such as rhythm and speed through MBL platforms.

An exciting dimension of MBL is its facilitation of collaborative learning and ensemble performance. Studies like [52] and [61] emphasize the potential of MBL in fostering teamwork and collaborative music creation. The utilization of VR Sessions and virtual environments allows learners

to connect, communicate, and perform together, transcending geographical boundaries. This collaborative aspect of MBL holds promise for breaking down barriers in music education and creating inclusive learning environments.

While the literature demonstrates the potential of MBL in music education, it also reveals certain gaps. The scarcity of practical case studies underscores the need for more empirical research and in-depth examinations of MBL applications in diverse musical contexts. Future research should focus on addressing these gaps, exploring the nuanced effects of MBL in different stages and domains of music education, and assessing the effectiveness of specific technologies in enhancing learning outcomes.

The limitations of this review are attributed to the scarcity of literature, preventing a more comprehensive coverage of a broader spectrum of technologies and skills within Metaverse-Based Learning (MBL). The diversity of MBL technologies introduces challenges in directly comparing them due to their unique advantages and limitations. Furthermore, there is a potential imbalance in the literature regarding the exploration of different music disciplines and skills. Some disciplines and skills may receive more attention, while others may be relatively underrepresented. This imbalance could impact the overall understanding of MBL across various domains.

5. Conclusion

This review ensures the focus and relevance of the review within the field of music education by systematically examining recent research on Metaverse-Based Learning (MBL). The time frame covers from 2019 to 2023, capturing the latest developments in the field.

Addressing the research questions, the articles extensively discuss the wide-ranging applications of MBL technologies in music education. Virtual Reality (VR) and Augmented Reality (AR) technologies facilitate immersive learning experiences, complemented by Artificial Intelligence (AI) and Speech Recognition technologies supporting personalization and innovative assessment in music education. Technologies such as data assessment and autonomous project support also play crucial roles in MBL, underscoring the importance of data-driven insights and autonomous learning experiences. Furthermore, the applications of MBL are categorized into different music disciplines and skill areas, including music theory, performance, vocal perception, music composition, instrumental performance, and teamwork and ensemble playing. These discussions reveal the extensive potential of MBL across various music domains, providing students with innovative and enriching learning experiences.

Some limitations and shortcomings of the current research are highlighted, including the imbalance in the literature and the lack of empirical studies. Suggestions for future research are made, urging a focus on these aspects, in-depth exploration of the impact of MBL in different musical contexts and stages of education, and assessment of the effectiveness of specific technologies in improving learning outcomes.

In summary, MBL demonstrates profound potential for comprehensive application in music education, offering valuable guidance for future research and practice. The integration of diverse technologies and music disciplines positions MBL as a crucial tool for teaching innovation and enhancing the learning experience.

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