Digital Little Music Makers

Designing and Implementing an Innovative Educational Music Proposal Embodying the Concept of "Making"

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Abstract
The evolving landscape of digital technology has transformed music engagement, offering unique opportunities for expression and creative education. In this context, music education is undergoing a significant transformation that challenges traditional teaching models while creating new avenues for creativity, engagement, and learning. This study explores the design and implementation of the "Digital Little Music Makers", a pedagogical music proposal reflecting a constructionist lens that integrates advanced technologies and innovative teaching strategies – music production, maker movement, coding, AI, and immersive technologies (VR/AR) – and examines the teaching and learning impact of a practical intervention conducted over 30 weeks at Pierce, The American College of Greece. The study adopted a qualitative approach, utilizing a Design-Based Research methodology, and data were collected through semi-structured interviews, field observations, informal discussions, and student-created musical artifacts. The ultimate aim was to investigate how these methodologies integrated within a transdisciplinary STEAM-based perspective could improve students' musical creativity and collaborative skills. Findings revealed high levels of student engagement, autonomy, and creativity through diverse technological tools and teaching strategies that enabled participants to compose music, build interactive installations, and design immersive experiences. Emerging and immersive technologies fostered hands-on learning, enhancing problem-solving skills connecting formal and informal music learning beyond the classroom. By positioning students as makers, the intervention appeared to cultivate skills like computational thinking, artistic expression, and peer collaboration skills, which are essential for the 21st century. Overall, the study underscores the transformative potential of STEAM-driven and constructionist perspectives in reimagining and redefining music education through technology-enhanced creativity, challenging traditional teaching methods by emphasizing learning through "making" as a catalyst for an educational paradigm shift.

Keywords and Phrases: Music education, Hands-on learning, Digital music-making, Constructionist learning, Emerging and immersive technologies in Music Education, Creative education.

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1. Introduction

The rapid advancement of digital technology has reshaped the landscape of music engagement, offering unprecedented opportunities for expression, creativity, and education. Children in today's era grow up in a digital musical environment that significantly differs from that of their parents and educators, and from an early age, they experience a seamless blend of technology and music, acquiring digital musical literacies which they expect to see integrated into music lessons (Mygdanis, 2022). In this evolving context, emerging technologies have the potential to transform music learning environments, creating new forms of learning and augmenting traditional teaching methods (Brown, 2015). While music educators must critically assess the integration of digital technologies to adopt transformative pedagogical strategies, it is essential to mention that technology itself cannot be considered a panacea for achieving a paradigm shift in education. On the contrary, pedagogical procedures and strategies are the key, and technology is regarded as a cognitive tool to support and enhance learning (Bell, 2018).

In music lessons, the widespread availability of digital technologies has unlocked new music-making opportunities, primarily through accessible computing and do-it-yourself (DIY) approaches that align with informal music-learning principles, promoting hands-on exploration and autonomy (Bell, 2018; Brown, 2015). Furthermore, integrating STEAM-focused educational scenarios into music classrooms and drawing inspiration from maker movement practices can promote problem-solving skills, computational thinking, and student engagement (Mygdanis, 2022). Such approaches challenge traditional views of musical creativity, fostering exploratory environments where students assume various roles – composers, improvisers, performers, programmers, makers, etc. – and encourage new forms of interaction within musical praxis (Bell, 2018), conceptualizing integration as a "music making/construction" process.

This study investigates the impact of an educational intervention in elementary music education that integrates technologically enhanced musical educational scenarios within a constructionist framework. Emphasizing the concept of music-making, the intervention employs diverse strategies and practices derived from music production, maker culture, music coding, immersive technologies, and artificial intelligence through the principles of "make," providing innovative and enriched forms of music teaching and learning.

2. Steam Approach & Maker Movement in Music Education

Current trends in music education emphasize integrating the transdisciplinary STEAM framework – science, technology, engineering, art, and mathematics – into music educational activities (Mygdanis, 2023; Huang, 2020) to foster in-depth, engaging, and immersive learning experiences by blending diverse cognitive and artistic elements (Psycharis, 2018). Rooted in constructionist theory (Papert, 1980), learning is considered an active process where individuals build knowledge by creating meaningful physical or digital artifacts (Resnick & Robinson, 2017). In these contexts, construction is central to promoting meaningful learning experiences (Kafai & Resnick, 1996; Papert, 1980). Maker culture activities enhance STEAM principles by engaging students in real-world problem-solving through hands-on artifact design and creation (Huang, 2020; Hatch, 2014). Both STEAM and the maker movement align with social constructivist perspectives, emphasizing the importance of social, cultural, and contextual factors in learning while reinforcing the constructionist notion of knowledge acquisition and meaning through creation (Mygdanis, 2023; Papademetri-Kachrimani & Louca, 2022).

The STEAM model emphasizes the importance of hands-on experiences and collaboration in enhancing learning in music education by moving from traditional methods to innovative, experiential practices (Huang, 2020). Research indicates that this approach encourages active participation, enthusiasm, and self-regulation while also fostering creativity, innovation, and the development of musical skills (Mygdanis & Papazachariou-Christoforou, 2023; Papademetri-Kachrimani & Louca, 2022; Abrahams, 2018; Palaigeorgiou & Pouloulis, 2018). These principles can be applied in music lessons through the creative learning spiral (Resnick, 2007), in conjunction with the 4P's framework – projects, passion, peers, and play (Resnick, 2014). Especially in early childhood music education, project-based learning acts as a foundational strategy, encouraging students to utilize practical knowledge in tackling real-world challenges (Charalambidou & Mygdanis, 2024). In a music STEAM-based context, the incorporation of tools such as tactile interfaces and coding practices enhances musical experiences, promotes creativity and inclusivity, and supports the development of authentic, engaging educational music environments (Abrahams, 2018).

3. Current Trends in Music Education

Music education is undergoing a profound transformation driven by emerging approaches that challenge traditional pedagogical frameworks while introducing new opportunities for creativity, engagement, and learning. Key trends such as music production, maker movement, coding practices, immersive technologies (VR/AR), and artificial intelligence can reshape the educational landscape by emphasizing transdisciplinary, hands-on exploration and have the potential to foster meaningful participation in diverse, innovative, and inclusive music-earning environments (Mygdanis, 2023).

Integrating *music production* into music lessons highlights experiential learning, where students actively engage in music creation, mirroring practices used by 21st-century popular artists (Mygdanis & Kokkidou, 2021; Bell, 2018), and encompassing a wide range of DIY activities, including creation, recording, editing, and distribution (Brown, 2015). Tools like Digital Audio Workstations (DAWs) in modern music-making provide functionalities that were previously unimaginable, and by incorporating them into music classes, students nurture creativity, allowing them to create music without needing prior knowledge of composition, music notation or technical skills with an instrument (Bell, 2018; Brown, 2015). In these educational contexts, music production is regarded as “make” that empowers students to take control of their learning (Mygdanis & Kokkidou, 2021) and progress at their own pace (Dammers & LoPresti, 2020), forming an informal and authentic learning environment (Bell, 2018).

The *maker movement* framework fosters hands-on, experiential learning by blending art, science, and technology to create meaningful digital or physical artifacts (Mygdanis & Papazachariou-Christoforou, 2023; Huang, 2020). This approach provided added learning value when combined with STEAM-based scenarios, fostering creativity while increasing engagement, enthusiasm, and motivation and developing musical skills and knowledge (Palaigeorgiou & Pouloulis, 2018). Research highlights the positive effects of tactile interfaces and microprocessors in music lessons, converting conductive and everyday materials into innovative musical instruments or sound installations without requiring expertise in electronic circuits, promoting multimodal learning and a deeper understanding (Sentance et al. 2017).

Music coding practices expand conventional programming methods, emphasizing artistic outcomes and transforming computers into a musical instrument (Aaron et al., 2016). Creative coding combines music with computer science, physics, and mathematics, allowing students to create musical tools and compositions at their own pace, nurturing creativity through an adaptive learning experience (Mygdanis & Papazachariou-Christoforou, 2023). Integrating music coding practices into STEAM scenarios and DIY strategies can enhance collaborative and project-based learning (Psycharis, 2018), reflecting the "learning by making" ethos (Hatch, 2014) throughout all stages of musical engagement – learning, composing, performing, and exploring (Aaron et al., 2016).

Virtual Reality (VR) in education offers immersive learning experiences for experimentation and exploration (Poutiainen & Krzywacki, 2023), promoting student autonomy and enabling self-directed learning engagement (Marougkas et al., 2024). In music education, VR introduces a new dimension for creative immersive expression and abstract musical concept presentation (Stachurska et al., 2024) by constructing virtual musical worlds (Yang, 2024). *Augmented reality (AR)* is another immersive technology combining real and virtual world elements through multimodal exploration and interaction with the physical environment (Azuma, 1997). AR practices can enrich music lessons by fostering motivational engagement and enhancing immersion through intuitive methods while also cultivating 21st-century skills (Leong, 2012). This is more prominent when students create virtual content that interacts with the physical world (Mygdanis, 2023).

Integrating *Artificial Intelligence* (AI) into music teaching practices offers expanded learning experiences through augmented forms of active engagement in musical praxis, providing an in-depth understanding of musical phenomena and developing computational thinking skills (Pan, 2022; Shang, 2019). Beyond virtual assistants, which have demonstrated their pedagogical value (Sanganeria & Gala, 2024), music-making and generative AI applications allow students to explore and experiment with different musical styles and forms of creativity (Pan, 2022). Within STEAM scenarios, AI can provide expanded opportunities for music expression and unique learning experiences that bridge art and science from a data-based music construction perspective (Rohrmeier, 2022).

In summary, integrating the innovative technologies and strategies mentioned above has the potential to redefine music education. By converging transdisciplinary STEAM approaches through constructionist principles, students are empowered to engage in meaningful, hands-on musical activities that promote music-making through exploration, experimentation, and creativity, fostering a new mindset. Overall, embracing these advancements allows music educators to create dynamic and inclusive learning environments that equip students to confront the challenges of the 21st century and establish music education as a powerful medium for technological innovation and artistic expression

4. Aim, Research Questions, Participants and Methodological Design

The aim of this study was the design, development, and implementation of an innovative teaching intervention titled "Digital Little Music Makers" to explore the transformative potential and the added value of integrating advanced digital technologies and creative strategies – music production, maker movement, music coding, AI, and immersive technologies (VR/AR) – in a private Greek elementary school. Grounded in the principles of constructionism and the "learning by making" perspective, the ultimate purpose was to emphasize students' engagement, collaboration, creativity, and active participation through hands-on experiential activities. The research questions were as follows:

- To what extent does integrating music production, maker movement, coding, AI practices, and emerging technologies contribute to enhancing students' creativity and collaboration in primary music education?
- How do constructionist perspectives, especially the lens of artifact creation, influence students' learning processes and their understanding of music as a creative and technological endeavor?
- How do participants assess their engagement and experiences during the teaching intervention, and what insights can be drawn from their reflections about their learning and creative development?

The study involved 23 students from grades 3 to 5 (ages 8 to 11) at Pierce – The American College of Greece who voluntarily participated in the "Digital Little Music Makers" club during the 2023–2024 academic year. The program was conducted over 30 weeks, with nearly equal participation among boys and girls, ensuring gender representation and a diverse range of musical and technological backgrounds.

4.1 Methodology

The study employs a qualitative research approach grounded in the principles of Design-Based Research (Anderson & Shattuck, 2012), establishing a dynamic interaction between research and practice while promoting deeper insights into learning processes within authentic contexts (Barab & Squire, 2016). Multiple data collection methods were employed to gain a deeper understanding of the students' experiences and to comprehensively analyze the qualitative characteristics of the process (Miles et al., 2014), including (a) semi-structured interviews with students conducted by the teacher assistant, (b) detailed observations recorded in a research diary by the teacher-researcher, (c) informal discussions both inside and outside the classroom, and (d) analysis of music-technological creations produced by the students.

To ensure objectivity and research validity, the semi-structured interviews (SI) were conducted by the assistant after the conclusion of the entire intervention and were recorded with the consent of the students and their parents. This process provided insights from students and a deeper understanding of learning experiences that may not have been evident during the intervention (Miles et al., 2014). Observations from field notes (FN) were systematically documented after each session to minimize the risk of data loss. Informal discussions (ID), both inside and outside the classroom, created an open environment for students to express their thoughts and reflections about the procedures, revealing nuances that might not have been captured through other data collection methods (Miles et al., 2014). The students' music-technological creations were organized into individual and collaborative portfolios, offering a structured framework for peer and self-assessment. All collected data were transcribed by the teacher-researcher and analyzed from a triangulation perspective (Miles et al., 2014). The content analysis strategy was implemented following the principles of semantic condensation, which involved identifying, coding, categorizing, and verifying data (Finfgeld-Connett, 2014; Miles et al., 2014).

5. Practical Intervention – "Digital Little Music Makers"

The "Digital Little Music Makers" proposal was developed and implemented as a 30-week extracurricular music club for grades 3-5 students. No prior formal musical training was necessary, and basic computer literacy was preferred but not mandatory. The intervention took place by the teacher-researcher in 45-minute weekly sessions and assisted by another teacher assistant. Reflecting a technology-based music-pedagogical framework and grounded in constructionist principles, the club integrated current education trends, including music production, maker movement, musical coding, AI applications, and immersive technologies, emphasizing cultivating musical creativity, engagement, and collaboration. The teaching scenarios were designed to align with (a) the STEAM framework and (b) informal musical learning (Folkestad, 2006). Multimodal and game-based strategies were integrated to enhance engagement and motivation. Scenarios were introduced as stories that present specific challenges to promote open-ended problem-solving in a student-centered environment (Mygdanis & Papazachariou-Christoforou, 2023). At the end of the program, a "musical concert/presentation" took place as an authentic music experience (Bell, 2018), where students showcased their creations and artifacts, celebrating their achievements with their parents and peers.

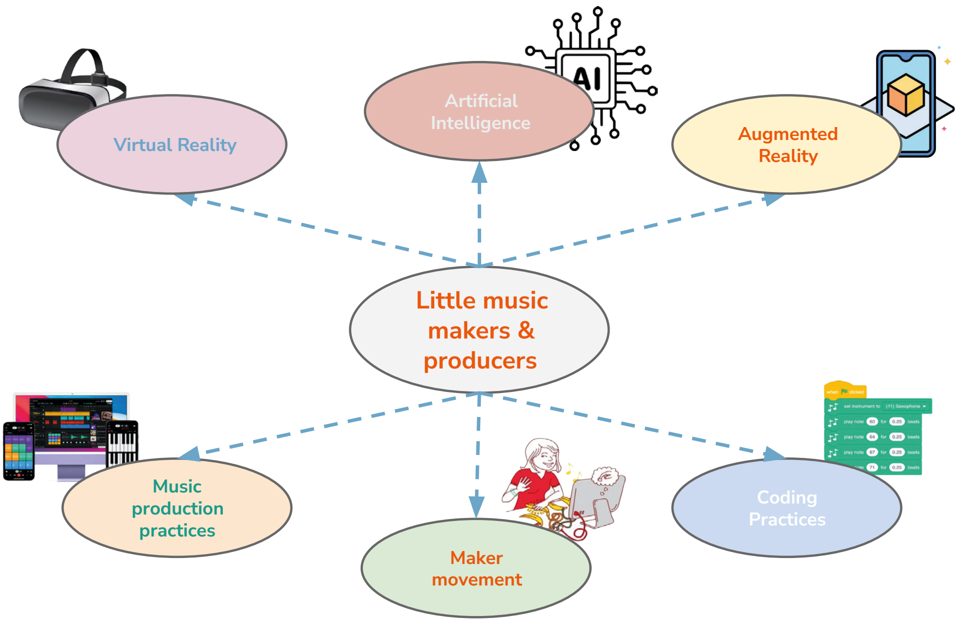

Figure 1: Dimensions of the "Digital Little Music Makers" educational proposal.

In *music production*, students composed music using the online DAW BandLab™ and Chrome MusicLab™. The initial sessions focused on introducing the platform's core features and functionalities through small-scale composition exercises. Gradually, through experimentation using loops, samples, and recordings to compose soundtracks for films and video games, along with original works, students explored various avenues for musical creativity within the framework of "make." In the *maker movement* domain, students designed and built musical instruments and digital artifacts using Makey Makey™ and Micro:bit™ interfaces, along with conductive materials – such as coins, fruits, water, and aluminum foil. Additionally, they utilized crocodile clips and piezo microphones to construct microphones and hydrophones to capture environmental sounds. These recordings were later integrated into sound-based compositions. Through *coding practices*, foundational programming concepts were introduced. Using Scratch™, students developed interactive musical applications like virtual instruments or music-based games and explored creative coding techniques by creating generative music installations. To further augment their virtual projects, they incorporated the aforementioned digital tactile interfaces as input devices, examining the synergy between physical and digital elements in music creation.

In the field of *immersive technologies*, students developed immersive VR environments in CoSpaces™, such as virtual orchestras, where they explored spatial audio and experimented with sound placement in a three-dimensional space. Similarly, AR was utilized to create interactive musical artifacts within Scratch and BlippAR™, where digital objects were designed to represent musical notes that could be activated by hand gestures. On the other hand, various AI-powered tools, such as BandLab SongStarter™ and AIVA™, were used to generate musical ideas. AI was also employed to create original scenarios and soundscape stories, allowing students to develop narratives with ChatGPT™ using imaginative strategies for handling words – keywords, "random" words, and words in sequence – and design covers for their musical projects. Additionally, students assumed the role of journalists by conducting virtual interviews with deceased artists, such as Maria Callas and Freddie Mercury, to gather musical and historical insights. Finally, the most innovative application of AI involved training Google Teachable Machine™ models to recognize Zoltán Kodály's music hand signs and conductors' gestures. These machine-learning models were imported into Scratch block code and used to transform data into creative applications using the computer's webcam and microphone.

Overall, it is essential to note that the intervention encompassed music production, maker movement, coding, AI, and immersive technologies within a holistic STEAM approach. This interdisciplinary method allowed students to explore music by combining artistic and technological processes, thereby enhancing their technical and creative skills.

6. Discussion

The data analysis highlighted the additional educational value of the practical application of the innovative strategies and technologies mentioned above. The intervention fostered an inclusive environment where students demonstrated adaptability, creativity, and collaboration. Their participation underscored the positive impact of these methodologies on their musical and technological growth, nurturing a lifelong appreciation for music and learning. Rooted in constructionist principles (Papert, 1980), participants demonstrated engagement, autonomy, and creative development through hands-on experimentation and collaboration, recognizing that musical creativity extends beyond a sound result. From the beginning, they demonstrated a strong willingness to participate, gradually gaining the confidence to surpass predetermined goals and set their own. These outcomes were apparent in their musical productions and reflections, confirming the effectiveness of experiential learning in music education. It's important to note that throughout the sessions, students frequently experienced "flow" and "aha!" moments (Csikszentmihalyi 2009). Their growing self-regulation enabled them to take ownership of their projects with minimal teacher intervention, cultivating a deeper understanding of the interdisciplinary connection between music and technology.

Collaboration emerged as a cornerstone, with group discussions and peer interactions pivotal in enhancing creativity and learning. The support and encouragement served as a powerful lever to help overcome challenges and build confidence: "At first, I it was hard [...], but my friends were a great help [...] I probably wouldn't have achieved that on my own!" (ID 7). Working collaboratively enabled students to share ideas, refine creations, and learn from one another: "It is fun to make your own song, but it is even better when you work with others [...] the others may have great ideas that you never thought of!" (SI 4) and often draw inspiration: "I didn't think of adding bells to our pattern, but George did, and it sounds amazing!" (FN 30). Activities such as group-constructing artifacts showcased their enthusiasm for teamwork and commitment to achieving shared goals: "Let's combine all our patterns and see what happens!" (FN 39) and "Working in a group helped me understand things faster because someone was always there to explain or show me" (ID 10), fostering a culture of mutual learning, respect, and shared responsibility and exploration.

Figure 2: Snapshots of the practical intervention.

Music production was a central aspect of the intervention, providing students with opportunities to compose, arrange, and remix music. As their confidence grew, they advanced to more complex projects, such as composing original music for video productions and blending pre-recorded samples with acoustic instruments: "It was fun to mix sounds together... I felt like a real music producer!" (ID 11). By the end of the program, they were independently producing music tailored to specific contexts and needs. It is worth mentioning the diversity of students' productions. For example, a grade 3 student, inspired by their favorite cartoon theme, created a rhythmic loop and enthusiastically remarked, "I didn't know I could make something like this!" (SI 5). Grade 4 students composed a background score for a short film they had created, demonstrating their capacity to align music with visual storytelling, while grade 5 focused on remixing popular songs: "We changed the beat because we wanted it to sound more like my style" (FN 21). Participants were generally encouraged to explore music production in a meaningful and personal way, reinforcing their technical skills while nurturing their artistic expression.

From a maker movement perspective, tactile interfaces and conductive materials fostered significant attitudes of creativity in building musical instruments: "Wow, the banana makes a sound when I touch it!" (FN 12). As they grasped the conductivity phenomenon, they designed even more innovative instruments like water drums: "It's like playing music with magical water!" (FN 8). When building hydrophones and microphones to capture environmental sounds, a student noted, "I never thought water could become music... now I hear it differently" (ID 15). These hands-on activities provided the pace for creating meaningful musical artifacts that could be used creatively to produce artistic results and enhance their understanding. The same pattern is present in coding practices. From the beginning, engagement was evident even with simple artifacts: "When I press the spacebar, the drum plays! I made it do that! [...] It's so easy and cool!" (FN 14). As their skills improved, they progressed to more complex projects, including music games: "I made the dragon move faster if the note was higher... it's like an RPG game!" (SI 9). A highlight of the project involved utilizing live coding practices to recreate well-known songs, using loops and conditional statements to capture musical motifs and repetitions: "We needed to determine how to make the notes repeat in the correct sequence... it felt like putting together a puzzle" (ID 18), which enhanced problem-solving skills and computational thinking.

Creativity also flourished through immersive technologies, where students demonstrated high levels of creativity and innovation when creating musical artifacts. Interactive AR musical artifacts like "The Singing Chickens" involved programming elements to assign musical notes to virtual chickens: "When I move my hand, the chicken sings! [...] It's like conducting a funny orchestra" (SI 10). Excitement was prominent in these hands-on explorations, bridging the physical and digital realms, fostering curiosity and deeper engagement: "Wow, it's like the music comes to life when I touch it!" (SI 9). Another notable AR project involved creating an interactive musical poster with embedded QR codes linked to musical notes: "It's cool to play with my QRphone [...] can you scan Imagine Dragons in this? [...] It's cool!" (FN 19). Similarly, VR enabled students to immerse themselves in virtual musical environments that they designed through AI and explored. They used VR tools to create a virtual orchestra where they could "play" different instruments through hand gestures: "It felt like I was inside the music [...] I could see and hear everything around me" (ID 12) and "I made a song that changes depending on where you stand [...] it's like being inside the music" (SI 14).

In the realm of AI practices, the analysis uncovered new pathways for musical creativity and exploration, producing personalized music results: "The AI gave me a melody, and I added my own rhythm [...] now it's my song!" (SI 6) and "I used AI to create a song, but then I added my own twist with two more instruments, and it became my song!" (SI 7), illustrating the balance between AI assistance and personal creative expression. Regarding AI virtual interviews one participant expressed excitement after 'talking' Freddie Mercury, stating, "I asked him the craziest questions, and he answered... it's amazing! Did he really have this in mind when he wrote Bohemian Rhapsody?" (SI 19). To that point, it is worth noting that another questioned AI's reliability, asking, "Can we trust AI to give the right answers? Is it what [the artist] had in mind? What if it makes mistakes?" (ID 13). These reflections emphasize a critical assessment of AI, acknowledging both its potential and its limitations. Reflecting on the machine learning projects and the AI training, the process appeared to enhance students' creativity and engagement while they recognized the fundamentals of AI system training, its capabilities, and their creative perspectives, as seen in the explanation from a fifth-grade girl: "I taught the computer to understand my hand movements [...] I can make a handsign-phone! [...] it's like magic!" (ID 16).

In a general context, the intervention appeared to illustrate the transformative potential of integrating advanced technologies and creative strategies within a constructionist music education framework. Students understood music as a 'making' process and participated in music-educational activities where all outcomes led to musical creations. Concerning the first research question, the study illustrates that integrating music production, maker movement, coding, AI practices, and emerging technologies enhances students' musical creativity as well as problem-solving skills. Students produced music, unique instruments, interactive applications, and various immersive artifacts, demonstrating their ability to explore and express ideas through hands-on experimentation. As for the second research question, the intervention encouraged active exploration, experimentation, and collaboration. Participants cultivated a strong sense of ownership, as shown by their growing autonomy in creating meaningful musical artifacts that combined both artistic and technological elements. The diversity enriched the collaborative processes, as students brought unique perspectives and experiences to their projects, contributing to a more enriched and more inclusive learning experience: "It felt amazing to perform something we made together [...] It wasn't just a project; it was our music!" (SI 8). These moments of pride and ownership demonstrate the effectiveness of the intervention in fostering engagement, collaboration, and a deeper connection to music as both a creative and technological endeavor, directly addressing the second research question.

Regarding the third research question, students' engagement and experiences reveal high levels of enthusiasm. Statements such as "It was like, wow... it was ours, we could have a concert like a real band!" (ID 19) highlight their emotional connection to their creations and the collaborative learning environment. The uniqueness of the artifacts from these collaborations reflects high levels of engagement and shows that creativity holds multiple meanings for each student and team. Furthermore, the intervention illustrated the connection between formal and informal learning, allowing students to broaden their musical exploration classroom. Students' reflections highlighted their intrinsic motivation to continue experimenting with music outside school: "I created patterns at home that I didn't have time for in class" (SI 9), and "I made music for my favorite game at home, and it felt like I was creating something real! [...] I don't know for the others, but for me it was real" (SI 1). Nevertheless, nearly every student participated actively in the process with a significant degree of autonomy. In particular, third-grade children display a higher level of creativity and self-regulation than fifth-graders. At the same time, the latter focus on more complex practices and are less eager to experiment with new types and forms of music or digital media technology.

Overall, by embedding constructionist ideals within a STEAM-based framework, the intervention provided an engaging and inclusive learning experience that fostered creative confidence, collaboration, and a deeper appreciation for music. The findings underscore how collaborative construction and active participation through interdisciplinary approaches can enhance creativity, engagement, and learning, equipping students with the skills needed to navigate the challenges and opportunities of the rapidly evolving digital landscape.

7. Conclusion

The "Digital Little Music Makers" intervention demonstrated the potential of integrating technology and creative strategies for bringing a paradigm shift into music education to engage with music in new and augmented ways. Grounded in constructionist principles, the whole process showed how innovative approaches such as music production, coding, maker movement, AI, and immersive technologies can enhance creativity, collaboration, and engagement among young learners, expanding musical understanding and skills in meaningful ways. The teaching proposal also bridged formal and informal learning, encouraging students to continue their musical explorations beyond the classroom environment and offering exciting possibilities for further enhancing students' experiences. The findings highlight how these methodologies contributed to developing musical and technological knowledge while fostering essential 21st-century skills.

The intervention's outcomes prompt educators to reconsider their teaching methods and develop accessible, inclusive educational approaches that address diverse student backgrounds and learning needs. Moving forward, immediate plans include expanding the integration of emerging technologies such as wearable devices, 3D printing, and blockchain technology, for investigating new opportunities for music interaction and construction in decentralized learning environments that empower students as active agents, creators, and learners. Despite the positive results, it is important to note that the small sample size and limited scope of the intervention do not allow for broad generalization of the findings. A key priority is designing and implementing a similar intervention within general music school education, moving beyond the framework of an extracurricular club within the formal curriculum, and fostering broader student participation. Additionally, plans are underway for a larger-scale research study to examine the long-term impact across different educational settings. Overall, future research and practice can further investigate how emerging digital tools enhance student agency, collaborative learning, and artistic innovation, paving the way for scalable and inclusive educational models and reinforcing the role of music education as a dynamic field.

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