DESIGNING AND APPLYING EDUCATIONAL SCENARIOS USING SYNTH4KIDS MUSICAL EDUCATIONAL SOFTWARE IN PRESCHOOL EDUCATION

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ABSTRACT

The rapid technological advancement of recent years has transformed how people interact with music. In a world where digital transformation is accelerating, the role of technology in music education has become increasingly crucial. In particular, digital platforms and tools are reshaping the way music is taught, especially for younger generations. Children in the digital age are exposed to various musical experiences and preferences. This has led to the development of digital learning environments and software for preschool children, creating a fundamentally new educational framework. However, music pedagogy often relies on traditional teaching models that do not incorporate digital technologies. This article discusses findings from an educational intervention using the Synth4kids software in early childhood music education. Synth4kids offers new avenues for educators to incorporate technology into early childhood education, encouraging creativity, collaboration, and engagement. The study highlights how combining technology and music pedagogy can enrich the learning experience for young children. The results highlight a new techno-centric learning environment where children engage actively and enthusiastically in authentic music teaching and learning situations, transforming their experiences and developing new musical and technological skills. Additionally, the study shows the importance of designing child-friendly software that balances educational goals with playful engagement.

KEYWORDS

Music education, Technological music-educational scenarios, Synth4kids software, Digital learning environments, Early childhood creativity, ***Music technology integration***

1. INTRODUCTION

Technology's rapid advancement has significantly transformed how people interact with music [3], creating novel avenues for musical expression, creation, and education [17], [25]. With the advent of smart devices and intuitive software interfaces, children as young as preschool age can now interact with music more directly and more immersively. Children are exposed to digital media from birth, which shapes their musical worlds in diverse ways [29]. As digital natives [19], they encounter musical stimuli distinct from those of their "pre-digital" parents and teachers [29]. Consequently, they engage with music through digital and multimodal forms [17], expecting to be involved in future music lessons [9].

These shifts raise important questions about the role of traditional music education methods in a world where digital tools are omnipresent. In many cases, educators face a challenge: how to merge established, proven educational techniques with the dynamic, ever-changing landscape of

digital tools. This article explores the outcomes of a teaching intervention involving technological music pedagogical activities with the educational software Synth4kids for four preschool children. The primary goal was to investigate emerging technologies' integration into preschool music education to nurture creativity and collaboration. Through this integration, the research also seeks to understand how technology can enable deeper cognitive and emotional engagement with music at a very young age. The findings revealed that children were eager to participate and adapted to the new technological-musical teaching and learning context that facilitated the acquisition of diverse musical and technological experiences.

2. CURRENT TECHNOLOGIES IN PRESCHOOL MUSIC TEACHING-LEARNING

Incorporating current technologies into music education presents exciting possibilities and unique challenges [27]. Digital tools offer an interactive element that allows children to experiment with sound in ways that traditional instruments often do not. Digital tools, like synthesizers and virtual instruments, can offer endless possibilities for sound manipulation, helping children develop not only musical skills but also a broader understanding of cause and effect, patterns, and experimentation. Research has shown that digital media in the music classroom can have positive outcomes [17], [25], [28], even at the preschool level [26], allowing for new multimodal music experiences, encouraging creativity, and enhancing understanding of musical concepts [13].

However, integrating technology into preschool music education appears to be limited [13], [26]. While the effectiveness of technology in kindergarten settings has caught research interest for over two decades [12], there is a general hesitancy towards digital media [18], which seems to be augmented within music education contexts [14]. Many educators remain uncertain about digital technologies' role, often fearing that they may disrupt traditional teaching models. This reluctance is often linked to concerns about young children's screen time, the technical complexity of the tools, and the perceived disconnect between digital and tactile musical experiences. The traditional music educational methods still used today –Dalcroze Eurhythmics, Orff Schulwerk, Kodály Method– were designed decades ago and do not account for the emerging music-technological environments [13], emphasizing specific genres and musical instruments that may not be relevant in the current digital world [27]. Thus, there is a pressing need to re-examine these methods in light of technological advancements. By integrating technology with these well-established pedagogical approaches, educators can bridge the gap between tradition and modernity, ensuring that children gain the benefits of both worlds.

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4. SYNTH4KIDS MUSICAL EDUCATIONAL SOFTWARE

The emergence of virtual instruments and digital music games profoundly impacts music education [23], offering a wide range of interactive musical experiences and visual feedback, introducing new possibilities for musical practices such as listening, performing, creating, and arranging [14], [10]. Software like Synth4kids, specifically designed for young children, makes complex musical concepts accessible and fun. Aligning with traditional teaching methods, they can enhance music learning by offering opportunities that would be impossible without technology [7]. Through these tools, young children can explore the world of sound more dynamically and flexibly, adapting to their unique learning styles and preferences. Indicative examples are sensors, tangible interfaces, smart devices, and augmented reality [24].

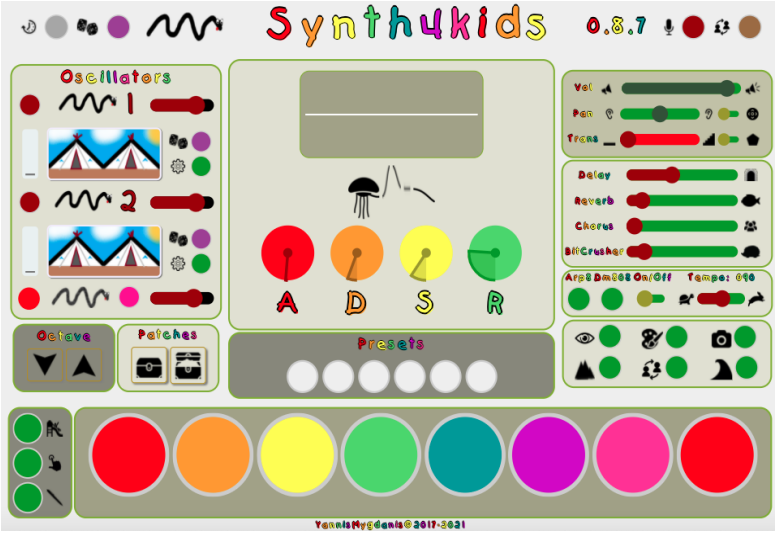

Figure 1. Synth4kids musical educational software

Synth4kids musical educational software was developed according to the above notion to enable students to explore new musical possibilities and engage in innovative forms of musical interaction, creation, and learning. Synth4kids incorporates various interactive elements, such as touch-based controls, visual feedback, and auditory stimuli, which help captivate children's attention and facilitate intuitive learning. As a web-based educational music software, it consists of a virtual analog monophonic synthesizer designed to facilitate music education [13] and integrate into STEAM educational scenarios [14]. In addition, its emphasis on chromesthesia—associating sounds with colors—makes it especially appealing to young learners, as they can 'see' the music they are creating. It incorporates elements from the traditional music pedagogical methods emphasizing chromesthesia, pentatonic scales, moveable-do, and kinesthetic experiences. Additionally, it leverages emerging technologies like augmented reality, tangible

interface connection, eye-tracking and face-tracking for music performance, QR codes, and online collaborative music practices through WebRTC [15]. Synth4kids' versatility allows educators to design lessons tailored to individual or group settings, encouraging both independent exploration and collaborative music-making.

5. STEAM EDUCATION & CREATIVE LEARNING IN MUSIC LESSONS

Music education seems to have shifted from traditional methods, embracing practices such as the transdisciplinary STEAM model –Science, Technology, Engineering, Arts, and Mathematics [16]. The STEAM philosophy draws from Papert's constructionism (1980). It considers learning an active process where individuals construct knowledge by creating meaningful artifacts [22] through hands-on experience and collaborative efforts [6]. This approach encourages students to not only learn by doing but also to see the connections between music and other disciplines, fostering a more holistic understanding of the world around them. Integrating music into STEAM education highlights the arts' role in enhancing creative thinking and problem-solving skills, as well as making abstract scientific concepts more accessible to young learners.

Figure 2. The creative learning spiral

The principles of creative learning are rooted in the STEAM and constructionist philosophy [20]. In this notion, designing instructional scenarios draws from early childhood adopting the spiral creative learning model (see Figure 2) and the 4P's framework: projects, passion, peers, and play [21]. These principles place the child at the center of the learning process, emphasizing the importance of personal engagement and social interaction. When children are given opportunities to explore musical ideas through hands-on projects, they develop a sense of ownership over their learning, which can be deeply motivating. Project-based learning is crucial, as it challenges children to apply practical knowledge to solve real-world problems (projects). To foster motivation and engagement, the content should be connected to children's experiences and interests (passion). Collaboration with peers is also fundamental, encouraging experimentation, risk-taking, and discovery (play) [22]. By integrating play into these projects, children are encouraged to view learning as enjoyable, reducing potential frustration and fostering curiosity.

6. RATIONALE, AIM, RESEARCH QUESTIONS, AND PARTICIPANTS

The rationale addresses a research gap concerning the limited research interest in integrating digital media in preschool music education. While studies have explored digital media in other educational contexts, preschool music education remains under-researched, especially when it comes to practical applications. Given the increasing role of digital technologies in children's lives, it is critical to understand how these tools can be integrated into educational frameworks that are developmentally appropriate for young learners. This study delves into the experiences of four and six-year-olds by implementing music pedagogical activities using the Synth4kids tool in the education setting of "Baby Maestro Cyprus." Research questions for this study are:

1. Did the educational scenarios with Synth4kids contribute to developing their creativity and improving collaborative skills, and in what ways?
2. What knowledge and skills have the children acquired throughout the educational intervention?

The study group comprises four male children between the ages of four and six who are currently enrolled in the group music curriculum for preschool at Baby Maestro Cyprus. Two participants have been attending this program for three years. Two children reported having no computer experience, while the other two had basic skills. This diversity in the children's backgrounds provided a unique opportunity to observe how the software could be adapted to different levels of experience and familiarity with technology. The variation in prior knowledge among participants also allowed researchers to investigate whether technology can act as an equalizer, helping those with less experience catch up with their peers.

7. METHODOLOGY

Researchers can delve deeper into specific aspects of their subjects by utilizing various methodological tools for data collection to understand their qualitative characteristics [5], [11]. In this study, four tools were employed: (a) group semi-structured interviews with the children, (b) diary-format observations by the researcher, (c) informal discussions with the children, and (d) musical and technological creations. These methods ensured a comprehensive understanding of both the children's learning processes and their personal experiences during the intervention. Combining qualitative data (observations, interviews) with tangible outputs (musical creations) provided rich insights into how children interacted with Synth4kids and the educational activities. The semi-structured interviews were conducted with the consent of the children and their parents following the completion and recording of the sessions. Interviews aimed to provide an overall evaluation, addressing aspects that could not be extensively explored during the sessions. In the analysis, they are mentioned as SI. Observations were recorded in a diary format after each session and were organized by keys to identify areas in behaviors and capture unexpected reactions. They refer to FN in the analysis. Informal discussions within and outside the sessions were recorded with the participant's consent and are mentioned as ID in the study. Finally, the creations were organized in portfolios, which served as subjects for group discussions, peer evaluation, and self-assessment.

The data collected through interviews, observations, and informal discussions was transcribed into text format. A triangulation perspective was adopted to ensure accuracy [11]. By applying triangulation, the study ensured that data was validated from multiple perspectives, providing a more robust analysis. The triangulation process was particularly important for identifying patterns in how different children responded to similar tasks, ensuring that the findings were not limited to isolated cases. Data was analyzed applying the content analysis method, reflecting the

principles of semantic condensation [8], following the steps of identification, coding, frequency thematic area counting, and data verification (see [2]).

8. DESIGN AND APPLICATION OF THE PRACTICAL INTERVENTION

Activities were developed following a project-based perspective, emphasizing creativity development through active participation in authentic scenarios. Each activity was designed with clear educational objectives, aligning with both musical and technological skills development. They were designed to align with the principles of the creative learning spiral model [20]. Additionally, given the prevalence of digital media in informal learning contexts [17], they were crafted to be adaptable both within and outside the classroom, reflecting formal and informal learning environments [9]. The instructional scenarios presented real-world problems the children needed to solve, such as creating a musical soundtrack for a film or constructing musical artifacts for a concert. Each activity was designed to foster collaboration, with the researcher-educator acting as a facilitator. At the end of each session, a reflective phase was held, which served as a source of new ideas for future meetings. The reflective phase was crucial for allowing the children to review their work, make adjustments, and take ownership of their learning process. Activities are designed to develop musical skills such as active music listening, percussion and melodic instrument performance, improvisation, and composition of rhythmic and melodic phrases, as well as to cultivate an understanding of musical terms and concepts. Including improvisation as a core component of the activities allowed the children to experiment freely, giving them space to discover their own voices.

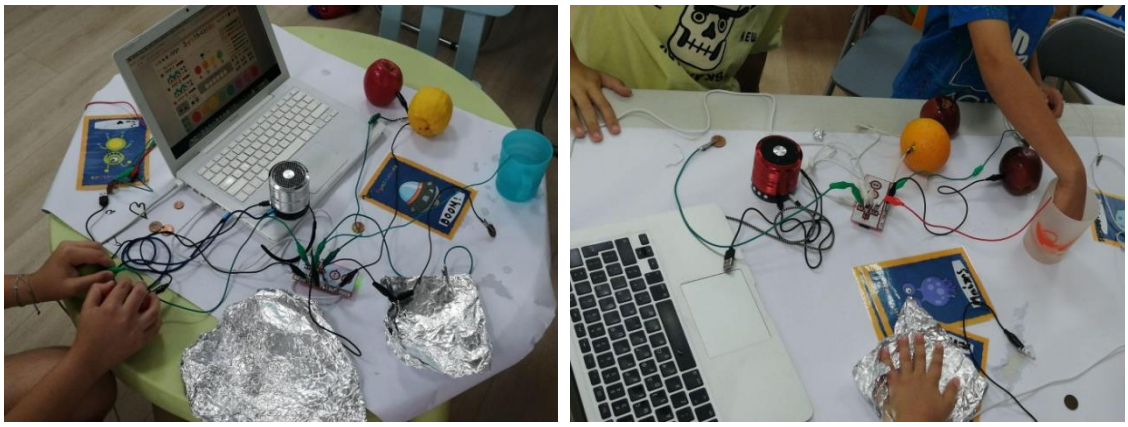

Figure 3. Snapshots from the educational intervention

The practical application took twelve 45-minute weekly lessons. In the first three meetings, the children came in touch with the fundamental functions of the Synth4kids software for creating musical tones, rhythmic patterns, and melodic shapes. These activities were crucial for familiarizing the children with computer operation and software handling. Over the subsequent three sessions, the children were encouraged to utilize their acquired skills to compose music for a film. The seventh and eighth meetings built upon their previous activities by introducing instruments from the Orff orchestra. The following two sessions focused on designing sound effects, allowing the children to experiment with the functions of impact, sound generators, and waveforms to produce a range of timbres. During the eleventh and twelfth meetings, the scenarios were aligned with STEAM, which involved creating musical artifacts using conductive materials and connecting them to the Synth4kids (Figure 3). This allowed for making an augmented music orchestra, incorporating augmented reality principles [24].

9. RESULTS AND DISCUSSION

The practical implementation yielded encouraging results, indicating that the pedagogical activities provided a valuable avenue for the children's musical and technological development. One of the most striking findings was the children's enthusiasm for using technology as part of their creative processes. This enthusiasm was particularly notable among children who initially lacked computer experience, suggesting that well-designed educational software can overcome barriers to engagement. The remarkable levels of participation observed suggest that the children were actively engaged in the processes. They quickly became proficient in operating the Synth4kids and effectively utilizing it. Additionally, they demonstrated a deep understanding of various techniques and strategies for creative extensions. Throughout the sessions, many instances of flow and "aha!" moments [4] were observed, where the children were fully immersed in a joyful discovery of musical-technological possibilities. These moments of deep engagement are crucial indicators of the software's ability to facilitate 'flow states,' where children lose track of time and become fully absorbed in the creative process. Upon analyzing the data, four key themes emerged: creativity development, musical and technological skills enhancement, collaborative skills cultivation, and participation in authentic teaching-learning experiences.

9.1. Creativity development

The intervention focused on creative activities where children could experiment and engage in music-making, understanding that creativity extends beyond sound. From the early sessions, they expressed a desire to participate in the activities, gradually gaining confidence to work without guidance, deviating from the predefined goals, and setting their own. This process of gaining progressively independence in their creative decisions was a key indicator of their growing self-confidence and artistic expression. The shift from teacher-led to child-led learning was one of the most important outcomes of the study, as it demonstrated how children can take ownership of their creative processes when given the right tools. Statements such as "Is it really that simple to create a rhythm?" (FN 7) and "It's nice, but I want to create another [rhythmic pattern] for the video... it will be better!" (FN 19), reflect their growing enthusiasm in the creative process. When it comes to the construction of musical artifacts, the levels of creativity were remarkably high. They actively engaged in musical experimentation with their constructions, exploring the potential of various conductive materials and expressing their uniqueness: “All these things [i.e., conductive materials] can make a sound... let's create music with everything!" (FN 22).

Throughout the intervention, participants could independently incorporate technology to varying degrees, often alongside acoustic instruments, without educator intervention. They exhibited autonomy and self-regulation, gaining mastery over the creative processes. This autonomy is particularly important in early childhood education, as it allows children to explore their creative potential without fear of making mistakes. The availability of options and the visual feedback provided by Synth4kids proved fundamental, allowing them to perceive their musical experiences and make decisions while utilizing the software, especially in later sessions when they created the augmented orchestra. Indicative examples of excerpts are:

Yay! I just loved how everything I did turned out super fantastic! I could tap-tap-tap on the keyboard, and a new rhythm would magically appear. Then I could mix and match the colorful fruits, add a dash of sparkle, and voila! It was ready to play! (SI 3).

Wow, the water drum was so cool! It was different from everything we made, and I liked it! Next time, I want to make something even more awesome and use lots and lots of aluminum foil! (SI

6). These excerpts highlight how the children not only engaged with the tasks but also took creative risks, exploring unconventional materials and methods to achieve their goals.

9.2. Musical and technological skills enhancement

The participants developed musical and technological skills and knowledge, effectively utilized through creative extensions based on their specific preferences. Their skills gradually developed gradually, as children moved from basic sound exploration to more complex music-making tasks involving sequencing, pattern recognition, and rhythm creation. Regarding music, the acquired knowledge mainly revolved around rhythm and melody, facilitating a deep understanding of abstract musical elements –pitch, duration, musical interval, and melodic patterns. These foundational elements were crucial for the children's later engagement with more complex musical tasks, such as composing their own pieces. Also, children demonstrated expanded thinking and a growing musical vocabulary. Initially, their expressions were vague, "this boom [i.e., rhythmic instrument]" (FN 9), or general, like "it is good" (FN 10). As the intervention progressed, their statements became more targeted: "I do not want claps in my pattern... I prefer bells!" (FN 32). Their expanded thinking is evident in the feedback comments during the creative process: "I don't like the beat we made [i.e., the group], can we change it?" (FN 36), "Nice pattern... let's add two C's and two G's and see what happens" (FN 39).

Regarding technological skills, children acquired knowledge in computer operation, specifically in utilizing Synth4kids: "It is easy to make music on the computer" (ID 5), "It is very simple... you put the notes you want [in order], and ta-da! It turns into a song!" (ID 24). The simplicity of the interface played a critical role in fostering confidence among the children, allowing them to focus on creativity rather than the technicalities of the software. Apart from technology and music, the participants gained knowledge from various domains of the STEAM model due to the nature of the scenarios. From science, they understood conductivity and grasped the basic principles of electricity: "It's like the light in my room [i.e., switch], the black wire [when connected] makes it play" (ID 16). They also gained construction skills from engineering, utilizing interfaces, cables, and conductive objects. These transdisciplinary learnings underscored the importance of STEAM education, as children were able to make connections between musical concepts and other areas of knowledge, such as physics and engineering. From mathematics, they utilized the analogies between musical and technological phenomena, such as pattern recognition, both in their creations and musical compositions.

9.3. Collaborative skills cultivation

Throughout the sessions, the children exhibited high levels of participation in collaborative practices and group experimentation. Collaborative learning was not only encouraged but became a central part of the intervention, as children were prompted to share their discoveries and work together to solve creative challenges. They drew inspiration from their peers' creations, showcasing their willingness to cooperate towards a common goal. The collaborative nature of the activities helped foster a sense of community within the group, where each child felt valued and included in the creative process. Their statements, such as "It's great to create your own instrument, but it's even better when you do it with a group... it can become perfect!" (SI 2) and "Let's combine all of our rhythmic and melodic patterns and see what happens!" (FN 39), demonstrate their enthusiasm for contributing to the development of group creations and their dedication to collaborative efforts. A notable shift in attitudes toward collaborative practices was observed as children were inspired by music production. Creating a collaborative atmosphere facilitated the development of group designs, where each child contributed without restricting the choices of others. This approach deviated significantly from conventional music methods and is aligned with popular music artists' informal digital media practices [1].

The creation of artifacts proved to be an effective means of enhancing collaborative abilities. These endeavors encouraged extensive interaction and reciprocal learning. Notably, those with greater technological proficiency assumed the role of mentors, providing support. Additionally, reflective discussions were encouraged to validate group decisions, resulting in meaningful dialogue and expressing personal preferences. The reflection process, combined with peer feedback, helped the children recognize the importance of collaboration in achieving their artistic goals. Finally, opportunities for mutual learning and decision-making instilled a sense of ownership and engagement in the creative process, further cultivating the children's collaborative skills. This collaboration process is particularly important in early childhood education, as it helps children develop social skills and emotional intelligence, preparing them for future group-based learning experiences.

9.4. Participation in authentic music teaching-learning

Creating educational activities based on real-life problems is a goal for creative learning [20] and STEAM scenario development [16]. Authentic learning situations, where the tasks reflect real-world problems or scenarios, provide children with a meaningful context for their learning and allow them to apply their skills practically. The participants were excited about the activities and strongly desired to continue using the tools and practices beyond the learning framework. Their statements, such as "I learned to play music" (SI 4) and "It's different from the other instruments [referring to Orff instruments]" (SI 3), demonstrate that they found value and meaning in the activities.

Their enthusiasm to continue was evident in statements like "I liked it a lot... I would like to do it again next time" (FN 33), "But our time is up? Can we continue a bit longer?" (FN 36), and "Can we play with this [referring to Synth4kids] next time?" (ID 15). This ongoing enthusiasm suggests that the children viewed the activities not as isolated learning experiences but as part of a broader journey of musical discovery. The highest levels of participation were observed in the hybrid orchestra, where children perceived technology as an integral part of the musical praxis and expressed a desire to engage in authentic situations, such as organizing a concert [14]. This experience fostered a sense of ownership and excitement, as expressed by one participant: "It was like, wow... it was ours [orchestra], we could have a concert like a real band!" (ID 19). Furthermore, the engagement with the Synth4kids application and its meaningful experiences served as a stimulus for further engagement outside the classroom during the intervention period. As one participant expressed, "I liked what we did, and I wanted to play at home... I created my own patterns that I didn't have time for [during the session]" (SI 9).

When the appropriate learning environment is established to leverage digital tools in music education, implemented practices inherently reflect informal music teaching-learning processes [17]. This notion is reinforced by the children's desire to transfer their experiences to their homes (see [9]). Two participants reported using the software at home, showcasing their intrinsic motivation and the transferability of their experiences, fostering a more profound connection beyond the structured learning environment. This transferability highlights the importance of creating flexible educational tools seamlessly integrating into formal and informal learning contexts. An illustrative example was creating music for a video, where one participant decided to compose music for his favorite game. The transformation is evident in the following excerpt:
"Wow, it was so much fun! I loved the project! I learned how to make better music. Before, I didn't know anything, but now I can make a song for Minecraft! Every day, there was something new and interesting to learn, like notes and musical instruments. It was amazing!!" (SI 1).

10. CONCLUSION

In conclusion, the practical implementation of this program has yielded positive outcomes for the participants' learning experiences. The combination of digital tools and traditional music education methods provided a robust platform for creativity, collaboration, and skill development. The findings of this study underscore the potential of digital technologies to enhance not only the musical skills of young learners but also their overall cognitive, social, and emotional development. Children's engagement has been enhanced by creating a new educational environment, leading to transformative musical and technological experiences and helping foster their creativity and collaboration skills. It was found that the combination of problem-solving and playful elements played a crucial role in the music teaching-learning process. Children were exposed to music in various digital formats, meaningful to them through Synth4kids integration in peer-learning and authentic environments, which deepened their understanding of musical concepts, resulting in the acquisition of musical and technological knowledge and skills.

To sum up, it is essential to acknowledge that this educational intervention's limited sample size may restrict the findings' generalization. Nonetheless, the outcomes are auspicious, offering a preliminary glimpse into how technological tools can be integrated into preschool music education. Future studies should delve deeper into the development of digital music education environments and their alignment with established music education methodologies. In addition, future research should consider broader participant demographics, particularly concerning gender, to provide a more comprehensive understanding of how different groups interact with music technology. Moreover, it is crucial to consider the gender balance of the participants since this study only included boys. Ultimately, the objective is to understand how different environments can interact and complement each other to foster a well-rounded digital and physical musical world for children. Combining traditional pedagogical approaches with innovative digital tools seems to represent a crucial part of the future of music education, where creativity, collaboration, and critical thinking are fostered through technology integration.

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