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Integrating ubiquitous music ecologies into STEAM scenarios in music teaching-learning processes

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Abstract

Technological progress over the course of the past few decades has transformed how children interact with sound and music, offering new and extended ways of expression, creation, and learning. This digital environment can provide opportunities for constructing a framework of sound perception, musical praxis, and creativity enhancement, the emergence of cross-platforms and a growing variety of hardware and software serving to support these developments through an emerging context of ubiquitous acoustic ecologies. The aim of this research was to involve educational scenarios in music lessons following such ecological perspectives through a pilot study for children aged 7 to 9 in a conservatoire setting in Greece. Actions for the current practical intervention have been designed following a STEAM project-based learning approach, which offers students cooperative activities, transdisciplinarity, game-based, augmented reality, playful learning, and authentic problem-solving experiences. Analysis revealed four distinct, emerging thematic categories that drew on the development of auditory perceptual ability, creativity development, computational thinking cultivation, and the shaping of digital and physical musical worlds. The results of the educational intervention underlined the fundamental role of ubiquitous music ecologies in planned actions, which served to widen students' musical horizons.

Key words

ubiquitous music ecologies, STEAM education, creative and computational thinking development, conservatoire setting, music teaching and learning

Introduction

Technological progress over the course of the past few decades has offered new and extended ways of expression, creation, and learning, transforming the way children interact and communicate with sound and music (Mygdanis & Kokkidou, 2021). Based on a ubiquitous computing perspective, this digital environment can provide opportunities for constructing a framework of sound perception, musical praxis, and creativity enhancement (Etmektsoglou, 2019). The development of digital cross-platforms and the growing variety of hardware and software have arisen in an emerging context of ubiquitous acoustic ecologies (Keller, 2020). Ubiquitous computing technologies cover a wide range of Do-It-Yourself (DIY) practices using browser-based platforms, mobile computing, interconnected distributed resources, the Internet of Things (IoT), low-cost hardware interfaces, microcontrollers, open-source software platforms, and programming languages (Lazzarini et al., 2020). These tools and procedures emphasize the social-cultural environment for collaborative creative processes through everyday life and objects (Dionysiou, 2019).

This research aimed to incorporate ubiquitous music ecology perspectives into music lessons through a pilot study for children aged 7 to 9 in a conservatoire setting in Greece. The focus was on examining students' learning processes and exploring their perceptions of musical acquisition. Actions for the current practical intervention were designed following a STEAM project-based learning approach, which offered students cooperative activities, transdisciplinarity, game-based, augmented reality, playful learning, and authentic problem-solving experiences. The methodology was based on qualitative educational research (content analysis). For data collection, multiple methods were utilized, including observations and field notes during the lessons, semi-structured interviews with the children, informal discussions inside and outside the classroom, and ubiquitous musical artifacts.

Acoustic music ecologies and sound-based pedagogy

Sound is everywhere and defines our relationship with the environment. Educational actions focusing on sound can provide additional value in music education by forming multiple meanings for students (Paynter & Aston, 1970; Schafer, 1977) and strengthening their environmental and cultural awareness (Etmektsoglou, 2019; Truax, 1996). In recent decades, there has been a strong interest in the shift from organized sound and music aesthetics to the soundscape in the musical educational process (Dionysiou, 2019).

Active listening is fundamental in sound-oriented learning environments (Westerkamp, 2011), connecting the listener with the environment and his musical-sound world (Dionysiou, 2019). Integrating active listening into activities with sounds enables children to improve their auditory perception, understanding, reflection, and creative and critical participation in the soundscape in which they live (Dionysiou, 2019; Truax, 1996; Schafer, 1977). In these activities, sound is perceived as movement, a means of creation, and an interface with the environment and culture (Etmektsoglou, 2014; Truax, 1999).

Sound pedagogy involves all students in teaching-learning processes, regardless of their musical background (see Etmektsoglou, 2019; Dionysiou, 2019), including various practices – improvisation, composition, recording, editing, mixing, listening, playing, evaluation, graphic scores, etc. – through an inquiry approach (Kokkidou, 2015). Using multimodal and multisensory perception, students can produce musical compositions and graphic scores through music-making with sounds from conventional or improvised musical instruments, even with daily objects (Tinkle, 2015). To that extent, soundscape-based activities emphasize listening and recording sounds, such as soundwalks (the exploration of the relationship of the ear with the environment (Westerkamp, 2011)), and soundmaps (rendering graphic representations of the soundscape (Schafer, 1977)), as well as sound libraries (the creation of repositories of sounds (Nicolaidou et al., 2018)).

Ubiquitous music ecologies and digital media

Nowadays, technology is integrated into everyday life, forming an inseparable unity. Within this context, pervasive and ubiquitous computing (see Weiser, 1991) provides expanded means of expression, creation, and learning (Mygdanis, 2021). We have access to music anytime, anywhere, and from anyone, at the push of a button and a click (Pimenta et al., 2014). As a result, mobile devices (smartphones, tablets, etc.), the internet, and ways of interacting with sound and the soundscape shape a new context of sound perception (Lazzarini et al., 2020). In this way, the conventional concepts of the distribution, production, recording, and reproduction of sounds acquire new meanings in the modern environment, creating conditions for pervasive or, to put it another way, ubiquitous music (Lazzarini et al., 2020).

Extending Schafer's (1977) viewpoint that the world's soundscape is changing and that the auditory environment is becoming radically different from what it used to be, this phenomenon has witnessed an augmentation in today's society whereby new digital and multimodal literacies are developing. As we move from desktop personal computers to a multi-platform environment with mobile devices that enable connection and interaction between users, a growing variety of hardware and software has been exploited in the contemporary literature on ubiquitous acoustic ecologies. The recent introduction of components from different scientific fields has enhanced the application of knowledge from other fields in an interdisciplinary approach while, simultaneously, the forms of interaction are expanding (de Lima et al., 2012). As a result, ubiquitous music perception is emerging, and requires technical knowledge from many fields, including, among others, technology, linguistics, physics, mathematics, sociology, philosophy, psychology, and music (de Lima et al., 2020), depending on the cultural and social context of these changes (Lazzarini et al., 2020).

Within this framework, we no longer refer to the use of tools but to ubiquitous music ecologies (Keller & Lazzarini, 2017) as an expanded musical-technological mindset. These technological means are divided into three major categories: a) do-it-yourself (DIY) practices; b) online platforms (browser-based platforms); and c) interconnected distributed resources (Lazzarini et al., 2020). Specifically, they include low-cost hardware (Keller et al., 2014), open-source software platforms and programming languages, electronic DIY constructions, microcontrollers and interfaces (Nikoladze, 2020), mobile computing, and the Internet of Things (Turchet et al., 2020). The integration of the above tools takes place based on the social context, which is a central factor in creative processes (Keller & Capasso, 2006). In particular, materials and resources from everyday life are ideal for collaborative artistic practices, enhancing motivation for inquiry learning and strengthening ecological consciousness (de Lima et al., 2020). Unlike conventional musical instruments strongly connected with Western music notation and requiring specific virtuoso practices, ubiquitous acoustic ecology perspective artifacts instead adapt to the social and cultural context of the individual (Keller, 2020).

STEAM approach, maker culture, and computational thinking in music education

Current trends in music education focus on the transdisciplinary STEAM model – Science, Technology, Engineering, Arts, and Mathematics – for the design of music-pedagogical activities (Gold et al., 2022). Based on the STEM framework's epistemology, STEAM incorporates the field of Arts and emphasizes the computational experiment methodology, an authentic problem-solving approach involving inquiry and experiential learning (Kalovrektis et al., 2021).

Educational scenarios designed using the STEAM approach are based on Seymour Papert's constructionism, in which learning is effective when students experiment and construct an artifact that is meaningful to them (Demetriadis, 2015). Focusing on the concept of "making," the maker culture is grounded in the mindset of STEAM (Huang, 2020), invoking the principles of inquiry, examination, iteration, designing, testing, and problem-solving in order to achieve creative, aesthetic, and self-expressive goals (Gold et al., 2022). In music education, STEAM and maker movement activities can lead to students' cultivation of computational thinking, an in-depth understanding of musical, technological, and scientific concepts, and the development of technological and musical skills, as well as a more in-depth understanding of the digital and physical world (Abrahams, 2018; Palaigeorgiou & Pouloulis, 2018).

The utilization of ubiquitous computing is intertwined with the development of computational thinking, associated with problem-solving and understanding human behaviors through various tools derived from computer science (Kalovrektis et al., 2021). Although there is no clear definition of computational thinking, researchers emphasize specific thematic areas, including abstraction, decomposition, algorithmic thinking, and pattern recognition (Psyharis et al., 2020).

In music education, computational thinking can expand existing horizons and open new doors. Although it primarily refers to computer science practices, such as coding techniques, it creates a new viewpoint where musical phenomena are perceived as computational data (Greher & Heines, 2014). The cultivation of computational-musical thinking creates conditions for new sonic, visual, audio-visual, and tactile approaches to sound, as well as hybrid forms that comprise rich, multimodal musical experiences (Mesz et al., 2012). Research activity demonstrates the added value of computer science by engaging children in authentic teaching-learning situations and connecting with the real world (Kalovrektis et al., 2021). Through maker culture activities (artifact construction), students develop the self-confidence necessary to solve complex problems with collaborative processes, acquire a positive attitude towards open-ended challenges, and cultivate their creative skills (Selby & Woollard, 2013). However, computational thinking has not been widely adopted as a strategy in music-pedagogical activities (Keller, 2020).

Rationale, participants, aim, and research questions

The rationale of the current study is based on the research gap between the incorporation of technologies and digital media in sound pedagogy activities. It focuses on designing and applying a teaching approach drawing on the current literature review about ubiquitous music ecologies following the appropriate steps and methods. The activities function as an innovative perspective and extension of existing teaching strategies in sound pedagogy, and include digital tools, block-based languages, microprocessors, and interfaces.

The educational intervention was designed and implemented in the fall of 2021 within conservatoire education in Greece after a period of quarantine brought about by the COVID-19 pandemic. Five children aged 7 to 9, who did not know each other and with no previous learning experience in a conservatory setting, participated. The primary purpose was the involvement of the children in shaping their physical and digital world through active participation in creative actions (e.g., soundscape composition) and digital storytelling with gamification elements.

The aim of the present research was to study the types of digital media integration that have been applied and implemented through the processes of ubiquitous music ecologies within the pedagogy of sound educational actions with correspondingly positive learning outcomes. At the same time, participants' perception skills, ability, and computational thinking were cultivated during their engagement in creative activities and digital storytelling. Three research questions guided the study, as follows:

1. How can ubiquitous music ecologies enrich traditional sound-based activities from a STEAM model perspective and lead to new forms of creativity?

2. How can the use of digital media contribute to the development of auditory perception and enhance students' computational thinking?
3. How can ubiquitous music ecologies form a learning environment for children to understand and shape their musical worlds?

Methodological Tools

Different methodological data collection tools were applied to increase the reliability of specific aspects of the objects being studied and lead to a more in-depth understanding of their qualitative characteristics (Denzin & Lincoln, 1994; Miles & Huberman, 1994). Data collection tools were: (a) semi-structured interviews with the participating children; (b) data from observations in diaries by the teacher-researchers; and (c) informal discussions with the children during the music creation phase. For ethical reasons, parents were required to agree to let their children participate in the research, and the participants' anonymity was ensured throughout. They were also informed about the research aims and the data collection tools.

The semi-structured interviews took place at the end of each lesson. During the interviews, the children had the opportunity to express their opinions about topics they could not mention in the activities. The diaries and forms were transcribed at the end of each lesson, minimizing the possibility of missing significant information (Denzin & Lincoln, 1994). When needed, data were recorded during the process in a coded way so as not to interrupt the whole procedure. Observation keys were used to organize the data, both to identify the areas within the patterns of behavior and to record unexpected reactions (Denzin & Lincoln, 1994), and included maintaining the children's interest, interactions with each other, self-regulation, active participation, and involvement in creative activities. These data are mentioned in this paper as field notes (FN).

The recorded material from the interviews, observations, and discussions was transcribed a second time into text, the data analysis following a triangulation perspective (Miles & Huberman, 1994). Content analysis was used, drawn from the principles of semantic condensation (Finfgeld-Connett, 2014), through a series of distinct steps that included identification, coding, and counting the frequency of the occurrence of phrases, as well as the rechecking of data (Miles & Huberman, 1994).

Designing and implementing the educational STEAM proposal based on acoustic music ecologies

The teaching intervention was implemented over a period of 14 weeks (one 60 minute lesson per week), following a STEAM approach. Teaching scenarios emphasized the involvement in creative activities (e.g., compositions of soundscapes) and digital storytelling from the perspective of ubiquitous music ecologies. The selected tools were open-sourcing online applications, such as 'SoundBlocks', 'Sampler', the block-based programming language 'Scratch', and the 'Makey-Makey' interface. Although all the steps were prepared beforehand, there was a continuous process of reflection and re-design of the content so that it could be adapted to new conditions as they arose.

Specifically, the first two lessons were an introduction to the description of the phenomenon of sound, emphasizing sound production and its characteristics – timbre, pitch, duration, and dynamics – and its transferability through the practical application of experimentations with simple materials. The actions focused on connecting the audio and the visual stimulus. Gamification elements, such as visual examples of waveforms using flashcards (when children tried to match the sound they heard or suggested their own ways of representation), also played a fundamental role.

In the following two lessons, the children's involvement with soundwalk activities allowed them to get in touch with the concept of the soundscape. In accordance with the restrictions brought about by the spread of COVID-19, the soundwalks took place inside the conservatory area before the children recorded sounds in familiar areas such as homes, neighborhoods, and playgrounds. In the second part of this unit, discussions were held about the kinds of sounds they could or could not hear in a certain environment, and then they created (in groups) artificial soundscapes with the 'SoundBlocks' app. Each group presented their composition, and the rest of the children drew an "imaginary" space for the soundscape they heard (see Figure 1). Finally, the activity was connected to the previous unit and the multiple ways of representing sounds. Discussions and concerns about various issues and the sounds of the environment were essential elements of the process and helped the children to create in a reflective manner.

Figure 1 *Drawing "imaginary" spaces based on other children's soundscapes*

The next unit focused on targeted environments from pupils' everyday lives. The children recalled sounds from their daily routines (e.g., waking up in the morning, the sound of their alarm) that could create feelings and reactions. Having recorded five to nine such sounds, they then created a digital soundmap with these sounds using the 'Sampler' app and connected conductive materials in the 'Makey-Makey' (see Figure 2). The digital map was a DIY construction using interfaces as a prototype digital musical instrument. Following this, the children exchanged sounds and collaboratively created digital maps with "imaginary" soundscapes, enriching the action with storytelling elements and utilizing digital soundmaps to accompany the narrative. In this way, the children effectively created their own sound stories by improvising and composing soundscapes. Finally, the stories were recorded, presented, and reflected upon.

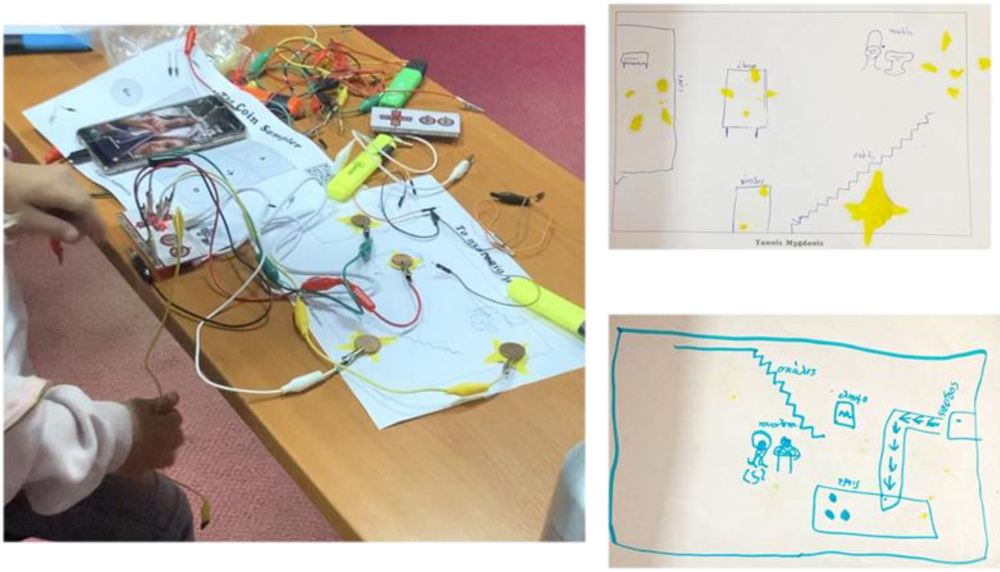

Figure 2 *Creating a digital soundmap based on prerecorded sounds*

After introducing the children to the creation of sound stories, the next unit focused on developing digital storytelling in ‘Scratch’. The children invented sounds based on an environment (e.g., school, playground) and imitated them using their bodies or various sound-producing objects. These sounds were recorded in ‘Scratch’, after which they created the story’s characters and adapted the recorded sounds to the movements. When the digital storytelling was completed, the children narrated their stories in groups while the other groups tried to draw them. The groups’ role were then interchanged.

In the next stage, the pupils worked on their creations by deepening the use of technological tools based on previous activities. Using ‘Scratch’, they experimented further with the sound processing functions / commands (pitch, volume, stereo image) and discussed their characteristics, which led to new creative extensions. In addition, the use of 'Scratch' was expanded by interfacing the digital soundmap with 'Makey-Makey' and using sound processing and block commands to generate random selections (with parameters set by the children). A key element in this unit was the degree to which digital media was incorporated into the children's creations. As a result, pupils made unique tactile DIY artifacts, and groups chose their favorite processing commands in 'Scratch'. That process positively widened their sound compositions' creative perspectives and horizons (see Figure 3).

Figure 3 *Using 'Scratch' to create tactile DIY artifacts and enhance their sound compositions*

At the end of the implementation phase, the pupils were introduced to augmented reality elements by drawing on the "real" objects and "virtual" soundscapes and integrating the web camera of their devices (tablets, laptops) in 'Scratch'. Based on their previous sound stories, the children developed another story with themselves as the main characters. The designed block code was similarly based on their previous actions, forming an extension of the digital soundmap. By moving their hands, the children could “touch” the objects and cause an acoustic result based on the sounds they had previously recorded and imported.

Results and Discussion

The results of the educational intervention suggest that the planned actions opened children’s minds to understanding the sound-musical world. Together with acquiring new terms related to sound and soundscape, they understood various ways and creative techniques they could apply in their sound-musical creations. Flow experiences and “aha!” moments were often observed (see Csikszentmihalyi, 2009), especially when they successfully applied a technique or discovered new creative possibilities. Through data analysis, the following thematic categories emerged: auditory perception development, creativity enhancement, computational thinking cultivation, and digital and physical world interaction.

Auditory perception development

Auditory perception development and active listening are fundamental goals in music-sound teaching-learning activities (Dionysiou, 2019). Starting from the first lessons, sound was associated by the children with kinesthetic movement and the environment (see Etmektsoglou, 2014), which contributed to improving their auditory perception, understanding, evaluation, and critical participation in the soundscape where they lived (see Truax, 1996). At first, the sound descriptions were quite general. Gradually, pupils expressed themselves more purposefully using the appropriate terminology, such as volume and pitch, which contributed to their thoughts and opinions of both their own and others' creations.

Technological means also contributed to the cultivation of the children's levels of auditory perception. From the construction of "virtual" soundscapes through online applications, as well as the creation of digital artifacts with physical objects, topic discussions emerged about sound, its sources, and methods of its production, as stated in the following children's opinion: "I can set this coin to sound whatever I want … not only this coin but also me [his body] … super!" (FN 6). At the same time, they formed a critical perspective on the soundscape, as captured in the phrase: "I chose birds [sound] because I don't hear them often. I'll put on a river, too" (FN 12). The visual representation of the waveforms, as well as the sound processing, formed the necessary conditions to allow the children to come into contact with sound in a multimodal way through experimentation and discovery. A child explained this procedure: "Now I understand why what [I recorded] doesn't sound good. It seems to be bad in 'Scratch', so I need to investigate further" (FN 25). On top of that, the audio editing capabilities embraced further creativity and participation, as stated in the phrase: "I recorded myself doing my mom … to see if I could make [the recording] sound like that" (FN 34).

Creativity enhancement

As the intervention emphasized creative activities, the children had the opportunity to experiment with sounds and make music through improvised DIY artifacts. Although they had no prior musical knowledge, they realized that creation is not limited to the sound-auditory effect but extends to the creation of ubiquitous digital musical instruments. They were willing to participate in the maker culture activities even from the first lessons. They gradually gained the confidence to create their own artifacts without the teacher's guidance. The following two phrases summarize their surprise: "Is it that easy to make a musical instrument?" (FN 5), and "All things can make a sound? Let's make music out of everything!" (FN 13).

By the final lessons, the children seemed to have acquired the appropriate musical and technological skills to decide about their creations. Decisions were taken in a collaborative framework between groups and after implementation. As they said: "We had said that we wanted to put a school bus in the story [...], but we didn't like the sounds we recorded [...], so we changed the heroes" (FN 48).

During this phase, the children came into contact with various forms of creativity, from improvised and unconventional musical instruments to ubiquitous music tools. They realized that the phenomenon of sound offers ideas for many creative actions – recording and editing – and how they could use technological means of pervasive music to expand these practices (see Lazzarini et al., 2020). It was also essential that the children utilized digital web applications and tactile interfaces with physical objects in various ways, depending on their individual and collaborative constructions and creations. All tools were explored intuitively and based on the children's musical and technological skills, satisfying complex creative tasks (see Keller, 2020) tailored to their needs and particularities. For example, when a child was exposed to the randomization commands, he adopted the new information into the artifact he was constructing:

> My code changes the sound every time without [knowing] how. When I touch the coin, the faucet [I recorded] is heard, but higher or lower [inc. pitch]. Every time it's different. Isn't it awesome? I'll do the same for the rest [sound samples] and see what happens! I might put fruit instead of coins, or maybe nothing … I don't know yet (FN 63).

Cultivation of computational thinking

Most educational activities reflected the philosophy of ubiquitous music ecologies, which constitute a transdisciplinary STEAM framework with diverse fields of knowledge, including Science, Engineering, Technology, Arts, and Mathematics (see Lazzarini et al., 2020). Within these environments, DIY practices that utilize web applications, interfaces and microcontrollers, programming languages, and mobile computing that requires technical skills and computational thinking, are integrated (see Kalovrektis et al., 2020).

The children did not have any prior knowledge of coding procedures or been involved in similar activities. However, a change in the ways that they participated in the actions was observed, especially in maker movement activities and programming practices, transforming the ways they subsequently asked for help. While at first the questions were general: "How should I start?", "What should I do first?", they gradually focused on problem-solving techniques: "After 'play sound" [a command in 'Scratch'], what else is left?" (FN 18). This focus on targeted issues contributed to the children being able to understand the stages of the problem of decomposition, actively participating in the actions and expressing willingness to expand their knowledge through abstraction: "Nice … now that we've done that, I'll change the order [of commands of the code] to see what will happen" (FN 72). This was obvious, even in the most complex actions, such as augmented reality.

More broadly, the children appeared to gain confidence and show an interest and willingness in solving complex problems through collaborative practices, leading to algorithmic thinking enhancement. This was apparent in peer-to-peer learning procedures, as it was expressed through the dialogues between the children: "Don't rush ... we have to do the steps in order, or it won't play" (FN 48), "Wait ... you haven't put in 'forever' [a command in 'Scratch'], so how do you expect it to play [the sound]?" (FN 53). Programming languages and interfaces offered new perspectives to the children's creativity (see Selby & Woollard, 2013), giving opportunities for computational thinking development. The structured steps of a process – algorithmic thinking – can also be seen from the point of view of a child who, after the construction of the digital sound map, emphasized:

> The purpose was to make an instrument [a digital sound map] unlike any other … our own unique [digital] map. First, we had to decide the things [to connect] to the board … then the shape [of the digital sound map], and then the [‘Scratch’] program. We [definitely] changed it in the end, but we still went through the same [steps] again until we got it right. (FN 37)

Digital and physical world interaction

Since digital and physical world shaping was another aim of the intervention, all educational scenarios followed a student-centered approach, promoting the conditions necessary for acquiring self-regulation through participation and encouraging the development of creative environments.

Regarding the children’s different previous musical and technological experiences in informal learning contexts (home, peers, internet, etc.), an additional goal was to observe their engagement from the very beginning. The children’s choices appeared to be meaningful (see Truax, 1996) on a personal and social level, as they obtained satisfaction and pleasure from experimentation and encouraging self-regulation. Each creation – digital in ‘Scratch’, tactile with physical objects and boards, audio with recording, editing, etc., and / or a combination of the above – varied according to the background and the expectations of the children. The choice of digital media and physical objects depended on the goals set by each team and had creative expansions: “We decided not to use a board; we’ll do it all on the computer" (FN 32).

Within a broader context, participants appeared to positively address the combination of the physical and digital worlds, perceiving them not as separate entities but as a unified whole, a philosophy reflecting that of ubiquitous musical ecologies (see Lazzarini et al., 2020). This was also observed from the interviews, where the children emphasized that: "It's perfect [the fact] that I can work with things [physical objects], change the sound [its features], this orange is now an instrument … not a fruit", "I can make a hero [in 'Scratch'] and touch it to make a sound (not just see it) … I can make it do whatever I want!". The association between the physical and digital worlds was also underlined in the pupils' statements. Although they preferred to use the computer: "We decided not to use a board; we'll do it all on the computer" (FN 32), they also stated in the interviews that "If we did it again, it would be different [...] we would put coins to change the height and water for the volume … it would be nicer [than using the keyboard]" (FN 32).

Coda

To sum up, the children's active participation in the actions of the current educational intervention meant that they were able to interact with their physical and digital worlds. The practical applications demonstrated positive outcomes from the utilization of STEAM scenarios and technological tools in ubiquitous music ecologies for the development of their auditory perception and creativity, the cultivation of their computational thinking, and self-regulation. The results of the educational intervention underlined the fundamental role of the ubiquitous music ecologies perspective in planned actions, which served to widen the understanding of the students' musical worlds. Findings demonstrated that pupils enthusiastically embraced activities and emerged in music-making as active participants. The new emerging learning environment enhanced their engagement, developed their creativity, transformed their experiences, and, in a general context, shaped and enriched their physical and digital musical worlds. The children seemed to enjoy getting acquainted with the new vocabulary related to music and soundscape characteristics. At the same time, they found various patterns and techniques that they could incorporate into their sound-musical creations.

Similar conclusions were reached by de Lima and her colleagues (2020) in their research that used different technological means and was carried out in schools in the Brazilian general education system. Through practical applications, the authors observed an enhancement of creativity through a critical look at everyday life, the development of collaboration skills, and self-regulation, as well as skills in various fields of knowledge such as technology and mathematics (de Lima et al., 2020).

The small number of participants in the present intervention does not allow for the generalization of the results and the conclusions. However, it does give an insight into the experiences and behaviors of children as they relate to new practices and strategies within the realm of ubiquitous music ecologies. In any case, the aim was to understand the process of interaction and complementarity of the educational environments so that the students could form a holistic view of their musical – physical and digital – worlds. Activities and scenarios designed for the needs of the present educational proposal seemed to raise feelings and memories and develop the imagination, which the children found meaningful. This is best illustrated in the following excerpt from a dialog between the children while making their digital map during the seventh meeting:

- I really like coming here. We have many options [apps and interfaces], and I can do whatever I want.
- It's a game, not a lesson.
- Me too … it's like a game, but we're still learning!

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