The Mobile Phone Orchestra as a Classroom: Teaching Music with Mobile Devices

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Abstract. *This paper presents a pedagogical proposal for music education using mobile phone orchestras as an educational environment. By integrating mobile technologies with contemporary music teaching methodologies, we explore the potential of smartphones as accessible and versatile digital instruments. The proposal is structured in three main stages: musical experiences with everyday technologies, workshops on creating digital instruments with Pure Data, MobMuPlat, and Mixxx, and the formation of a collaborative orchestra. The theoretical framework is based on the STEAM approach and the concept of Ubiquitous Music (Ubimus), emphasizing sound experimentation, creativity, and cultural inclusion as central pillars. The project was implemented with high school and university lab students, revealing pedagogical gains, technical challenges, and high participant engagement. We observed that transforming the mobile phone into a musical instrument increases access to sound practice and establishes a bridge to formal education. The project also sparked students' interest in traditional music learning methods, demonstrating its potential as a gateway to more structured training. Finally, we discuss the technical challenges faced and future paths for applying the methodology in broader formal educational contexts.*

1. Introduction

Music education is the introduction of an individual to a range of musical knowledge and skills. It aims to provide students with the means to express themselves musically and experience music within their daily lives in a conscious and active manner. Given the diverse ways in which the population engages with music, music education has faced challenges. Among them is the need to adapt methodologies to the students' cultural context, driving the search for new pedagogical approaches capable of meeting diverse interests and expanding access to music learning. Such challenges, as well as the approaches that seek to overcome them, are further explored in Section 2.

Currently, both the production, distribution, and consumption of music are deeply linked to technology. It is possible to produce music with the aid of computers, using Digital Musical Instruments (DMIs), whose sound generation is entirely digital. To produce sound, digital devices need to be programmed and several knowledges are necessary, envolving Science, Arts, Mathematicas, engineering, and technologies. These inter/transdisciplinary content are commonly integrated in an educational framework known as STEAM, presented in Section 3.

A relevant example of this integration between technology and music is the context of digital orchestras, which utilize laptops and mobile devices widely available in today's society as musical instruments. A mobile phone orchestra consists of using smartphones and other mobile devices as musical instruments through applications that emulate various sounds, such as keyboards, strings, and percussion. This modern format of a musical ensemble is inspired by a larger movement of digital orchestras, as explored in Section 4.

We propose the mobile phone orchestra as a means of music education because it is democratic—by using objects already present in students' daily lives—and technologically versatile, as the instruments can be adapted to the orchestra's needs through the design of new DMIs, with the possibility of tailoring them to meet specific performance requirements.

In this paper, we detail our pedagogical proposal for implementing a mobile phone orchestra (Section 5) and discuss the challenges involved.

2. Music Education and Technology

Music education can be understood as an educational process aimed at developing musical perception, expression, and knowledge through meaningful sound experiences. According to Ilari (2002), "musicalization is a process of constructing musical knowledge through significant experiences with the elements of music, developing perceptual, expressive, cognitive, and affective abilities"[1].

Throughout the 20th century, various teaching methodologies were developed to make this process more accessible, dynamic, and meaningful. Among them, the **Orff method** stands out, integrating bodily and musical elements: movement, percussion, and improvisation are combined in a structured manner as a basis for musical learning[2]. The **Kodály method** emphasizes singing as the main instrument, using folk songs, movable-do solfege,

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hand signs, and rhythmic syllables to develop musicality and music literacy[3]. The **Willems method**, in turn, is based on the premise that "true music comes from the inside out" (cited in Macedo, 2005) [4], valuing sensitive expression and auditory perception as a starting point. The **Dalcroze method** is based on eurythmics, articulating rhythm, body movement, and improvisation as means to develop musical perception through body awareness. As Anderson (2013) highlights, "the sense of kinesthesia is at the heart of Dalcroze's approach"[5].

By analyzing classical methods, we perceive that music education should be understood as an educational practice that values the student's active participation. It is also worth noting that a truly inclusive music education is not restricted to formal or Eurocentric content but seeks to engage with musical practices that are already part of the students' daily lives, recognizing their experiences, repertoires, and sociocultural contexts.

Among the musical learning environments, the importance of informal and non-formal experiences is significant, playing an essential role in contemporary music education. As Wille[6] emphasizes, when investigating adolescents with both in-school and out-of-school musical experiences, it is observed that much of the significant learning occurs outside formal school settings, in contexts such as bands, churches, or spontaneous social interactions. Such environments not only stimulate the learners' autonomy but also promote a pleasurable, meaningful, and contextualized relationship with music.

These informal experiences stand out for offering a free space for experimentation, where students can exchange experiences and value their own musical references. In this environment, music ceases to be something distant, imposed by a standardized curriculum, and becomes a means of social interaction and personal expression. This is even more evident in proposals like the mobile phone orchestra, which relies on the use of technologies already present in the students' daily lives. Thus, they have the chance to bring their sounds, tastes, and unique ways of making music into the classroom. This student-centered approach is one of the pillars of our proposal, as described in Section 5.

3. Framework: Challenges and New Approaches in Music Education

The proposal of a mobile phone orchestra as a music education environment is situated within a context of broad debates on music teaching in Brazil. Several structural and pedagogical challenges hinder musical practice in schools, such as the shortage of specifically trained teachers, the lack of adequate spaces, and the scarcity of traditional musical instruments. Added to this are socioeconomic problems that impact the educational system as a whole.

Another critical point is the frequent curricular focus on European musical canons, which often distances itself from the students' cultural reality and interests. In this scenario, new methodologies emerge that seek to break with the traditional model and propose a more integrated and participatory education. The possibility of using digital music instruments on an educational point of view lacks the fact that no traditional methods for music education is focused in this kind of instruments. Beyond it, to use the technology in arts may be necessary to add to musical education, some theory and practices on other related subjects, transforming music education in other educational approach.

One of these approaches is **STEAM** (Science, Technology, Engineering, Arts, and Mathematics), which proposes the integration of these areas for the construction of interdisciplinary knowledge[7]. When applying the STEAM methodology to music education, music (Arts) becomes the central axis but connects explicitly with the other areas:

3.1. Science

Science provides the basis for understanding the raw material of music: sound. It encompasses the study of **Acoustic Physics**, which describes sound as mechanical waves by analyzing their fundamental properties. These include **frequency** (which we primarily perceive as pitch) and **amplitude** (which relates to intensity and loudness). The complexity of the waveform—particularly its harmonic content and how its amplitude evolves over time—is what determines a sound's **timbre**. the quality of a sound that distinguishes different types of sound production, such as a voice or a musical instrument. It's determined by the sound envelope, wave's shape and its unique combination of fundamental frequencies and overtones. **Biology** and **Neuroscience** by elucidating the functioning of the human auditory system and the complex cognitive processes involved in the perception, memory, and emotion of music.

3.2. Technology

Technology is the tool that enables the creation, manipulation, and distribution of music in the digital domain. It ranges from the **fundamentals of digital audio**—such as the processes of sampling and quantization that convert sound waves into binary data—to the use of production software (DAWs) and **computer programming**. The introduction to programming languages, especially visual ones, can serve to develop **computational thinking**, teaching students to decompose problems, recognize patterns, and design algorithms for expressive purposes.

3.3. Engineering

Engineering applies scientific knowledge to design, build, and optimize systems and solutions. In the musical context, this translates into the **design of musical instruments** (acoustic, electric, or digital), software engineering for the development of musical applications (apps), and the design of recording, mixing, and sound reproduction systems. The engineering mindset encourages creative and structured problem-solving: how to build a device that produces a specific sound? How to design an interface that is intuitive and ergonomic for the musician?

3.4. Mathematics

Mathematics is the abstract language that inherently structures music. It is present in the **frequency relationships** that define scales and harmony (such as the simple ratios of the harmonic series), in the **rhythmic division** of time (fractions, proportions, and sequences), and in the description of timbres through **periodic functions and Fourier series**. Concepts such as symmetry, transformation, and patterns, which are pillars of mathematics, are also essential elements in the composition, analysis, and appreciation of music across various cultures.

This perspective aligns with the concept of Ubiquitous Music (Ubimus), which values creativity and the use of everyday tools and objects for artistic and musical purposes[8]. By using devices that are already part of the students' lives, the mobile phone orchestra not only partially solves the problem of the lack of instruments but also promotes digital literacy and breaks with a purely expository teaching logic, encouraging curiosity and the exchange of experiences.

Thus, our proposal is based on the idea that technology, when mediated by a critical and inclusive pedagogy, can be a powerful ally in facing the historical challenges of music education, making it more accessible, relevant, and aligned with the experiences of 21st-century students. The practical application of these concepts structures our orchestra proposal, detailed in Section 5.

4. Related Work: Digital Orchestras and Computer Music

Digital orchestras represent a new way of making music in a group, born from the convergence of art and technology. This movement began to gain strength in the early 2000s with the emergence of so-called *laptop orchestras*. One of the pioneers was the **PLOrk** (*Princeton Laptop Orchestra*), founded in 2005 at Princeton University, USA. The idea was to bring together musicians playing laptops as instruments, exploring electronic sounds, musical programming environments, and real-time sound spatialization[9].

The success of this initiative soon inspired other groups, such as the **Stanford Laptop Orchestra (SLOrk)**, created at Stanford University and conceived by Ge Wang, which combined laptops, portable speakers, and live coding environments for collaborative and immersive performances[10].

With the advancement of mobile technology, these ideas evolved into a new generation: **mobile phone orchestras**. Lighter, more accessible, and connected to the students' daily lives, they leverage the popularity of smartphones as musical tools. A notable example is the **MoPhO** (*Mobile Phone Orchestra*), also associated with Stanford University. In it, musicians use iPhones and sensors to create collaborative sound experiences, highlighting mobility and bodily interaction as an essential part of the performance[11].

If we compare these ensembles with traditional orchestras, we notice important points of convergence and divergence. Both share the idea of a group that creates music in a coordinated manner, with distributed roles and attention to collective listening. However, while the traditional orchestra is anchored in acoustic instruments, fixed repertoires, and a long tradition of reading sheet music, digital orchestras operate in a more experimental territory, with electronic sounds, improvisation, and the use of algorithms[12, 13].

The composition of these orchestras also reveals a universe of possibilities. Instead of violins and oboes, digital synthesizers, interactive applications, and motion sensors take the stage. The repertoire is often developed in collaboration with the musicians themselves, promoting a more inclusive and inventive approach to musical practice[14].

These experiences help us to envision what our own mobile phone orchestra can be. More than replicating a traditional model, we have the chance to create something that speaks the language of our students, using the devices they already know, the music they listen to, and the ways they interact with the world. An orchestra that can accommodate the beat of funk, the melody of lo-fi, the ambient sound of the University itself, and the noises created with simple apps, all woven together by listening, creativity, and the desire to learn and make music together, in a way that makes sense for everyone.

However, unlike many of these academic initiatives that use languages such as ChucK, Max/MSP, or SuperCollider, our proposal emphasizes the use of accessible tools like Pure Data and MobMuPlat, prioritizing usability for beginners and application in educational contexts. The choice of visual and open-source tools allowed for more democratic access to digital instrument design.

5. Our Orchestra Proposal

Our proposal for a mobile phone orchestra emerges as a response to a set of cultural, technological, and social motivations observed in the current context. We notice a growing and convergent interest from different audiences: on one hand, students from technological fields, such as Computer Science, who possess great digital fluency but seek channels for artistic and musical expression; on the other, Music students who wish to incorporate digital tools into their practices but do not always find an accessible path. The legitimization of practices like DJing and computer-based music production reinforces this intersection.

In parallel, we live in a moment of smartphone ubiquity, which represents a vast creative potential still largely unexplored for collaborative music creation. This potential is amplified by the emergence of more musical programming languages, many of them visual and intuitive, and by the advancement of technologies like Artificial Intelligence, which open new frontiers for creativity.

Additionally, the post-pandemic context has highlighted a strong need for new spaces for socialization. The

orchestra offers a safe, collective environment that counteracts the fear of creating music alone, proposing a practice that is perhaps less pretentious and more focused on experimentation and fun.

It is at the confluence of all these factors—the convergence of audiences, the availability of technology, and the need for social connection—that our proposal is anchored. Our central objective, therefore, is the creation of a **mobile phone orchestra** that functions not only as a performing group but also as a music education environment. The proposal aims to value the personal repertoires of the participants, promote active listening, and encourage sound experimentation, starting from technologies already present in the students' daily lives. The structure of this proposal is directly supported by the theoretical framework discussed in Section 3, which combines the challenges of music education with the potential of STEAM and Ubiquitous Music approaches.

5.1. Methodological Stages

To achieve this objective, we have structured the project into three main stages:

Musical Experiences with Everyday Technologies

This first phase seeks to introduce participants to the world of sound in an accessible and meaningful way. Musical practices will be proposed using common applications, such as WhatsApp and Instagram, to explore the features of recording, playback, and sound manipulation. The choice of familiar tools aims to reduce technical barriers and encourage spontaneous engagement, based on the sound experiences and references of each participant.

Instrument Creation Workshops

Based on the experiences gathered in the initial phase, we will move on to workshops focused on the invention and adaptation of digital instruments. In this stage, participants will be invited to imagine and build their own means of sound production, using personalized applications or ones developed within the project itself. The focus will be on creativity, autonomy, and technological appropriation as part of music-making.

Orchestra Formation

Finally, we will consolidate the previous learning experiences in the formation of the mobile phone orchestra. This stage will involve organizing the participants as a performing group, composing collective pieces, and holding musical presentations with the created instruments. The proposal is that the orchestra be not only a space for performance but also for collaborative creation, critical reflection, and artistic expression.

6. The Orchestra in Practice

In this section, we report on how the stages described in the proposal were effectively developed in a real-world application context. The experience was conducted with a group of students from our own laboratory and from a high school, in weekly meetings lasting approximately 90 minutes each. The applied methodology followed the three main phases described in Section 5, as detailed below.

6.1. Musical Experiences with Everyday Technologies

The first stage of the practice aimed to create an accessible and familiar environment for sound exploration. Participants were invited to use their own mobile phones to record everyday sounds, such as sounds from the school environment and voices, and to share these recordings with the group. Tools such as native audio recorders and WhatsApp were used to capture and remix sounds in small active listening exercises.

These activities promoted the recognition of the environment as a musical space and sparked the students' curiosity about the elements that make up sound and noise. However, throughout the practice, it became evident that the standard applications used, such as native recorders and WhatsApp itself, had significant limitations. Among the main problems observed were the difficulty of creatively manipulating sounds and the absence of functionalities that would encourage freer and more expressive experimentation.

These technological restrictions revealed a central issue: although mobile devices are powerful and widely available, their creative use in educational contexts depends directly on the tools accessed and how they are pedagogically mediated. This initial diagnosis reinforced the importance of offering participants more flexible and open means for sound creation, as explored in the following stages—and detailed in Section 7.

6.2. Instrument Creation Workshops

In the second phase, we moved to a series of practical workshops aimed at expanding the participants' creativity and providing more robust tools for sound creation. We began with "DJing" and remixing workshops using the *Mixxx* software—which we discuss in more detail in Section 7.1—to introduce concepts of mixing, looping, and real-time track manipulation. The introduction to the world of DJing sparked interest in the logic of remixes and helped students better understand how to build musical structures from various elements.

Next, we held introductory workshops on *Pure Data*—covered in Section 7.2—in which students learned the fundamentals of visual programming for sound synthesis. The acquired knowledge was then applied in workshops with the *MobMuPlat* application—more details in Section 7.3—allowing participants to export their own patches and use them as interactive musical applications directly on their mobile phones. This stage marked the beginning of the development of original digital instruments, adapted to the ideas and aesthetics of each group as shown in figure 1.

By integrating these workshops—*Mixxx*, *Pure Data*, and *MobMuPlat*—the participants were gradually

led to create their own musical applications for collective performance, laying the groundwork for the formation of the mobile phone orchestra.

This stage encouraged creativity and technological appropriation while building bridges between programming, music, and interface design. The participants were able to experience firsthand how the construction of an instrument can be shaped by their own sound ideas and aesthetics.

Figure 1: Practical Workshops [15]

7. Technologies Used in the Mobile Phone Orchestra

The Mobile Phone Orchestra is based on a set of accessible and flexible technologies that enable the creation, manipulation, and performance of sounds collaboratively. The creative use of these digital tools allowed participants to develop their own musical instruments, adapted to mobile devices and their individual artistic expressions.

Below, we present the main software used throughout the formative process, highlighting their functionalities and contributions to the construction of the orchestra.

7.1. Mixxx

The DJing workshop, in turn, made use of the free software *Mixxx* [16], providing practice in real-time mixing. It was used to introduce concepts of DJing, looping, track layering, and sample manipulation. With it, participants understood the logic behind remixes and how to build live musical narratives.

This stage was important not only for developing musical hearing and a sense of rhythm but also for sparking interest in contemporary digital music practices, which are often closer to the soundscape of young people's daily lives than the tradition of classical music.

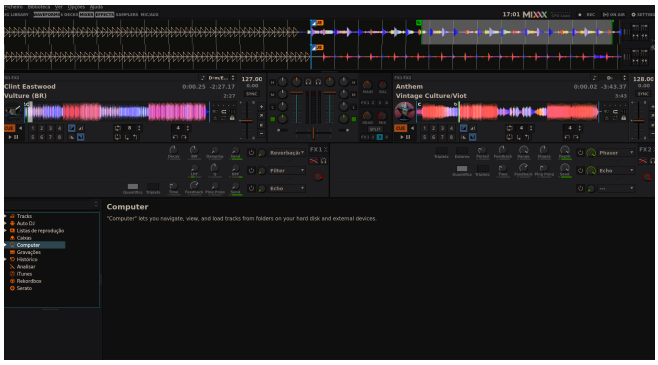

Figure 2: The user interface of Mixxx, the open-source DJ software used in the remixing workshops

7.2. Pure Data

We used *Pure Data* [17], a graphical programming environment created by Miller Puckette, which allows for the development of interactive sound structures visually. Through an interface based on blocks (or "objects"), participants were able to explore fundamental concepts of sound synthesis, signal processing, and interactive logic.

This tool was essential for students to create "patches," which are programmed structures that function as digital instruments. Pd offers creative and technical freedom, allowing for everything from simple sounds to complex systems of sound interaction. By working with it, students came to understand the internal construction of the sounds they produced, developing a musical computational thinking.

7.3. MobMuPlat

For porting the patches to mobile devices, the *MobMuPlat* [18] application was used, which integrates the sound creations into the touchscreen environment. It acts as a bridge between sound programming and performance on smartphones and tablets.

In addition to importing the patches, MobMuPlat offers a customizable graphical interface, which allowed students to create interactive screens with buttons, sliders, and other visual controls. Thus, each participant could transform their mobile phone into a unique, functional, and visually adapted instrument for the group's aesthetic.

8. Discussion

The practical application of the Mobile Phone Orchestra project not only allowed us to validate our proposal but also prompted a critical reflection on its potential and challenges. The experience proved to be fertile ground for discussing the intersection of pedagogy, technology, and contemporary musical practices, corroborating some of our initial hypotheses while raising new questions.

One of the most significant results observed was the confirmation of the orchestra as a "gateway" to music education. As reported, several participants, after contact with the workshops, actively sought out more traditional learning methods. This suggests that the approach, by demystifying musical creation and connecting it to a familiar technological universe, can effectively spark a curiosity that transcends the project itself, motivating students to deepen their studies autonomously and in more conventional formats.

Interestingly, the pedagogical journey began with an unexpected challenge. The proposal to use WhatsApp as a creation tool was initially met with skepticism by the students, who considered it "silly." However, this perception changed when they understood that the activity was part of a larger method focused on listening and musical structure. The turning point was consolidated in two key moments: first, when they experienced the freedom to manipulate their own favorite musical styles with the *Mixxx* software; second, when they perceived, even with a simple tool like WhatsApp, the structure of an orchestral performance. This transition from skepticism to engagement highlights the importance of anchoring the practice in culturally relevant references for the students while gradually building pedagogical complexity.

The practical experience also allowed for the observation of the materialization of the theoretical concepts that underpin this work. The **STEAM** approach manifested itself explicitly and in an integrated manner: **Science** emerged in discussions about acoustics, when students noticed the change in sound as they covered the phone's speaker with their hands; **Technology** and **Engineering** were central to the creation of their own applications and digital instruments; **Mathematics** became concrete in calculating BPMs and structuring *loops*; and finally, **Art** was the axis that united all these areas in musical performance. Similarly, the concept of **Ubiquitous Music (Ubimus)** was fully assimilated, with students reporting a change in perception that generalized beyond the project: the understanding that not only the mobile phone but any everyday object holds musical potential.

However, the implementation was not without its challenges. The complexity of the *Pure Data* programming environment represented a cognitive barrier for some participants, requiring careful mediation. Added to this were technical difficulties, such as the incompatibility of certain mobile devices with the generated files. Additionally, the progressive methodology, although effective for most, proved to be tedious at times for students with more advanced prior knowledge. This last point raises a fundamental question for the future of this research: the need to develop an ecosystem of applications with different levels of complexity, allowing for personalized teaching that meets the individual needs of each participant, from beginner to advanced. These challenges, however, do not diminish the value of the proposal but rather inform the next steps for its improvement.

9. Conclusion

Although this research is still ongoing, the results obtained from the two of the three methodological stages completed to date—detailed in Section 5 and applied as per Section 6—already demonstrate the strength of the proposal. This work reveals that the mobile phone orchestra is a powerful tool for the **democratization** of musical practice, directly addressing some of the challenges presented in Section 3. The methodology transforms the smartphone from a passive consumption device into a legitimate instrument of **creation** and empowerment, functioning as an effective **pedagogical bridge** to formal education, one of the central points raised in our Discussion (Section 8). Additionally, the experience validates, in practice, the integration of the **STEAM** methodology, whose concepts were explored in Section 3.

The importance of these partial results reinforces the need to continue the project. Future work includes not only the completion of the third methodological stage—the consolidation of the orchestra as a performing group—but also the development of applications with varying levels of complexity, a need identified from the challenges discussed in Section 8, and finally, the application of the methodology on a larger scale, such as in public schools, to systematically evaluate its curricular impact.

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