Collaborative Learning with Interactive Music Systems

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ABSTRACT

This paper presents the results of a research study investigating the collaborative learning processes of a group of performers using a novel interactive music system. The purpose of the study was to explore learning methods and developing practice to generate future pedagogical methods. During a period of six months, four participants regularly engaged in workshop-type scenarios. The lead researcher, involved as participant-observer, did not impose learning objectives nor prescribed specific actions for achieving them. Rather, all participants proposed and guided learning objectives. Results show the learning environment is rich in opportunities for learning and mutual teaching. Key findings suggest learning occurs through observation and modelling. Further, a continuous dialogue and flow of information was necessary to motivate and further learning. It was found that participants managed to quickly establish a shared practice for this interactive music system.

Author Keywords

Collaborative learning, modelling, communities of practice, NIME pedagogy

CCS Concepts

•Applied computing → Sound and music computing; Collaborative learning;

1. INTRODUCTION

1.1 Learning and technologically mediated musics

Teaching and learning practices within the context of NIME are mainly oriented towards the design and technical understanding of interactive systems [23]. In other instances, interactive music systems are designed to support the development of elementary music skills, whether improving rhythmic timing [15], score reading [3], or performance with traditional music instruments. For example, [29] presented a haptic system for facilitating learning the flute. According to these authors, *"Traditional instrument learning is time-consuming; it begins with learning music notation and necessitates layers of sophistication and abstraction. Haptic interfaces open another door to the music world for the vast majority of beginners when traditional training methods are not effective."* In this case, the system is a substitute for the music teacher and through its interface facilitates learning and developing performance skills. However, this perspective fails recognize the importance of context and process in learning music. That is, it assumes learning as individualistic and musical practice develops in a linear fashion. These authors suggest playing a music instrument requires learning music notation first. While this might generally be the case within a Western music conservatory tradition, this work also ignores the diversity of musical practices and approaches –within and outside this context– that also contribute to playing a music instrument (see [11]). Additionally, we must note that the teacher not only transmits knowledge, but also helps the student "decode" a particular symbolic system that is situated within a specific musical practice. The student not only learns to read and play musical notes, but is also enculturated within a musical tradition.

Without a doubt, becoming proficient with a musical instrument requires time, but also necessitates a structure for guiding learning efforts. In a broad technologically mediated music context, as in NIME, learning to play interactive musical systems has often resorted to drawing from pedagogical methods commonly found within Western music conservatory tradition as a way to structure learning [21, 5, 30]. However, as [23] observes, "very little has been written until now in the NIME context about teaching and transmitting know-how about techniques, methods and strategies of dealing with a technologically mediated instrumental practice."

Several factors can determine the degree of success of these approaches. Interactive digital music systems are extremely idiosyncratic and given their novelty offer little information regarding their operation, aside from a technical document (if it indeed exists) [9]. Also, the designer is often the performer and only a single, or very few copies, of the instrument are fabricated. The learning process is therefore presented from an individual perspective. Such interactive systems are designed and executed in non-traditional musical contexts (free improvisation, electronic, and computer musics) in which musical texts are not central to the practice. This produces a multitude of performance practices, as well as varied forms of documentation of performance and reification of knowledge. The diversity of interactive systems, sonic and aesthetic concerns, as well as musical practices pose a challenge for standardizing performance techniques and texts for both learning and performance, as well as making the profile of the teacher much more complex. The new role of the interactive music system teacher is no longer limited to evaluating the technical proficiency, musical accuracy, nor the appropriateness of style of the

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student.

Certainly there is value in transferring pedagogical methods from other musical contexts, as this acknowledges that practitioners are well situated within an extensive musical tradition and that new practices do not emerge within a vacuum. We must recognize the limitations presented by such methods and common practice musical notation, as they may fail to represent the complexities of sound and interactive / collaborative behaviors that are central to new interactive music systems. While it is recognized that prolonged learning and practicing is important to the development of musical practice [23, 9], few cases have documented strategies and processes. One possible way towards developing new performance practices for these musical artefacts is to explore how such practices emerge within a group of performers that collectively propose, negotiate, learn, and determine the value of different performances approaches, techniques, and methods. As suggested in [20], this particular approach for learning can be fostered through communities of practice (CoP, [28]) and through open-ended, exploratory and collective learning approaches such as an ecological pedagogy of music. A community of practice can offer its members a learning environment whose objectives and goals are developed collectively and based on the needs of each member. The dynamics of a community of practice can provide a flexible and adaptable learning environment in contexts in which there are no such conditions, just as those observed within the context of NIME. Although such proposal is compelling, it is not entirely clear how to deploy such an environment along with the activities that support it.

1.2 Socially mediated learning

Traditional music education centers on individual learning and is based on the presence of a teacher who imparts and evaluates the necessary skills to advance into a professional career. However, this pedagogical tradition can prove to be challenging for the student and, for example, given the competitive nature if this environment students can suffer physical and psychological distress [22]. In order to mitigate these effects alternative music learning approaches have been presented. For example, Green [11] draws from the learning done by popular musicians, outside of institutional or formal education contexts. This type of learning more than reproducing material involves the realization of diverse musical practices such as listening, composing, improvising, and playing with others in informal settings. The creative and social aspects of informal music learning prove beneficial to both development and motivation of the student. Indeed, the collaborative aspect of of music making, as suggested by [25] and [4], can provide a space for musical exploration, as well as the development of creativity, additional musical skills, and culturally-aware attitudes in students. How learning occurs in social contexts can be explained through Vygotsky [26] and Bandura's [1] social learning theories. For Vygotsky, learning is socially mediated in children, modelling their own behavior after another person's behaviour. Imitation and learning are not purely mechanical processes, *"But recently psychologists have shown that a person can imitate only that which is within her developmental level"* [p.88]. Imitation can lead children to extend their capabilities, such that by *"Using imitation, children are capable of doing much more in collective activity or under the guidance of adults"* [ibid]. In a similar fashion, Bandura proposes that learning involves modelling others behaviors. The learner is not passive and there is a process of reciprocal determinism in which cognition, the environment, and behavior mutually influence each other. While Bandura's social learning theory involves the direct experience and learning of novel behaviors, it does not fully explain the social dynamics involved in learning. Recently, Downey [8] while recognizing that imitation within a learning community is important, further suggests that knowledge is fully embodied not only in what is learned "in the head" and how one goes about its business within the community, knowledge literally shapes our bodies. Further, Downey's account of learning introduces and describes the role of scaffolding structures.

The scaffolding structures observed by Downey and their deployment in practice is closely related to the constraint led approach (CLA) to learning proposed in nonlinear pedagogy [6]. Informed by Gibson's theory of ecological psychology and by nonlinear dynamic systems, the CLA proposes that behavior is shaped by specific ecological constraints in order to prompt cognition, decision making, and action. In a similar fashion to Downey, tasks are simplified by reducing their degrees of freedom and learning occurs when novel behaviors emerge through a process of exploration. Indeed, recent research attempts to describe music learning environments as a dynamic systems [2, 16, 24]. For example, Kupers et al. [16] present a model stating that there is a real-time interaction (mutual adaptation) between the student and learner during a music lesson. Both agents co-regulate their behaviors, motivation, and particular needs. Further, a scaffolding method where gradual and deeper understanding of the task requirements is developed by the student, requires active participation and responsibility in her learning so as to become less dependent on the teacher's support. The main challenge offered by these approaches is maintaining motivation and engagement of students in their learning process given that most of the responsibility of determining their goals are left to them. The teacher in this context is only a guide and not an authority.

2. METHOD

A new digital musical instrument was developed for the purposes of this study following the design principles described in [13, 10]. The instrument (Figure 1) consists of a 3D printed case and two outward facing speakers. Four push buttons controlling pitches organized in a one-octave chromatic scale. Two linear soft potentiometers control the pitch and coupled grain-time factors of a granular synthesis engine. Finally, a force-sensing resistor controls the output volume. A one-octave chromatic scale was implemented through the use of the buttons and notes outside the established fingerings produced white noise. Octave changes could be obtained through specific positions of both softpots.

Three volunteers were recruited; all had traditional music education and extensive performance experience ranging from Western concert music, free improvisation, and folk musics. None of them had prior experience performing with musical technologies or interactive musical systems. Participants are coded in the text as AW, JS and VH. The main researcher [AM] further played a role in the study as a participant-observer[18]. The research period started once each participant received a copy of the new instrument and were given instructions regarding its operation and functioning. Participants were informed to play and practice freely for a period of two weeks. After this period, an individual interview was conducted. The interview consisted of a semi-structured questionnaire and all participants were asked to perform for 2-3 minutes. Upon completion of the individual interviews, group sessions were scheduled to be spaced 2-3 weeks in between sessions. The en-

Figure 1: The instrument.

tire research period, lasting a total of six months, consisted of one individual session and seven group sessions. Group sessions were organized in the manner of workshops. Although some materials and activities were prepared by the main researcher beforehand, all sessions were open-ended and encouraged the contribution of participants in the development of the session. All sessions were video and audio recorder for further inspection, transcription, and analysis through a qualitative research approach. Produced documents were photographed or scanned. Media and transcript analysis was realized through content analysis [17].

3. RESULTS AND DISCUSSION

3.1 Initial steps

During the individual learning period of three weeks, participants engaged in free exploration of the instrument in order to become acquainted with the device's operation and sonic capacities: *[VH] "I wanted to know how they worked because there are some that don't sound alone... So it was that I started thinking, what are the combinations? 'Ah, that sounds like a C?' Let's see how the chromatic scale sounds."* Such explorations were often without any predetermined objectives as they were a means to find the instrument's sonic range. However, because participants were informed about the possibility to perform a chromatic scale, they were able to quickly identify the fingering to reproduce the scale, as well as finding the "wrong" notes. In the case of VH, such tones were initially deemed as errors: *"So how do I make the noise sound only when I want and not like in the middle of... a melody or phrase."*

After this initial period, learning objectives, whether further exploration or the development of specific techniques, were determined as more knowledge about the device was gained. As participant JS commented, *"OK, I can do this [technique] better. I can practice this now I need to focus and set a series of objectives to meet."*. In this manner, learning shifted from an open-ended exploration to more a more structured approach. For example: when asked about how to continue learning, AW responded: *"have more structure in what I do with the instrument. Maybe one day use all the buttons. Maybe on another day just the sensors."* As shown, this initial period of learning yielded a basic familiarity of the instrument. However, it was observed that learning during this period was rather limited since the potential of the instrument was not fully visualized or imagined at that time. However, all participants often expressed that they still had more things to discover and work on.

3.2 Observation and modelling

Following this initial time, all participants regularly engaged in a group work context up until the end of the research period. Within the group setting it was observed that participants were able to accelerate their learning by implementing various strategies. First, their could observe and model (imitate) what other participants had developed and subsequently make comparisons between the different methods, styles, and approaches demonstrated by each member. In this manner it was possible to determine common materials, as well as compare and differentiate amongst the rest of the group. Therefore, participants were able to learn things that they could not find on their own and, through this process enrich their knowledge and repertoire of techniques. VH explains her experience: *"You do learn. I am seeing what AW is doing, what you are doing [JS], what you are doing [AM] and then I try it. Perhaps at home I would be more focused on doing what I already know... and not so much to explore."*

This comparative process was the product of mutual learning within the group as a demonstration-observation-modeling in which a member of the group demonstrates the work she has done. The other members observe and try to imitate the gesture or technique. This process of observation and exploration as methods for revealing information about something follows an ecological learning model [19]. However, this demonstration was seen in both deliberate and non-deliberate forms. Each member of the group engaged in this behavior during the entire course of the study whether they were aware of it or not. This approach not only served to illustrate new materials, but more significantly, it served as a way to solve problems that other members might have when trying to execute similar materials. The following discussion illustrates this point:

AW: Well, I checked these notes twice and in the end I didn't know very well what they were.
VH: Can you play these [notes]?
AM: But your second finger is always there in the center. Or does it change?
AW: I tried to change it, but it was the same. For example, it is a bit difficult to do [plays]. This is what changes the height [left soft-pot].
VH: Just one note.
AM: Yeah, you can play it [plays].
AW: It changes... the vibrations within that note.

By discussing and attempting to provide practical solutions for a particular problem, individual experiences contributed to the shared body of knowledge developed by the group.

3.3 A rich learning environment: developing musical practice and repertoire

It was noted that the learning environment created by the group was inherently rich in learning opportunities. While some of these were planned due to the principal investigator's research objectives, other opportunities emerged as result of the dialogue, exchange of information, and interaction between all members of the group [7, 27]. For example, planned opportunities involved the information initially disclosed by the investigator, as well as proposed activities such as (individual and group) improvising and composing. On the other hand, participants themselves established other learning opportunities. For example, a few participants developed notation for the instrument, functioning as an extended memory resource and as a learning aid. However, participants developed this strategy on their own and without encouragement from the lead investigator. Indeed, by notating the fingerings corresponding to the chromatic scale (Figure 2), participants were able to easily assimilate the materials as they expressed being more comfortable seeing such contents. But also this notation additionally served to refresh their memory whenever they spent more than a few days without practicing the instrument. VH explains: *"I wrote it down because wanted to know exactly what [each note] were. Because I didn't have this I was frustrating myself because I didn't know. I was going blank the next day. I haven't learned it, but I [now] know more or less where [the sounds are]."*

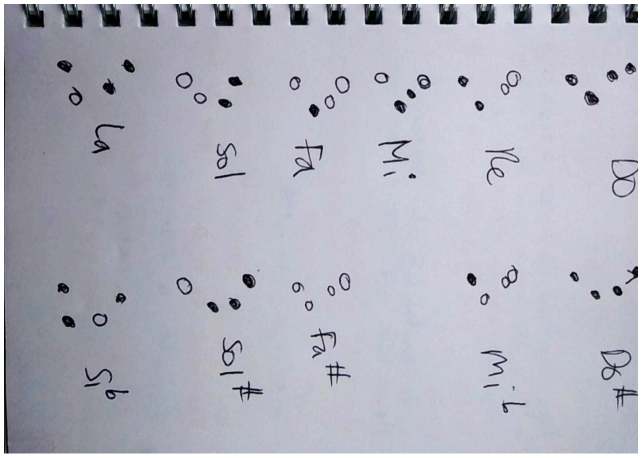

Figure 2: Fingering Annotation.

Perhaps the most important learning opportunity was provided through group playing. These sessions served as additional spaces for further exploration and testing out both learned and new techniques. Group performances consisted in free improvisation, as well as composed pieces for the ensemble. Improvisation sessions exposed what kinds of things participants were able to do, as well as observe new techniques. Improvisations, as a mutual activity, yielded participants a space to know each other musically, as well as displaying their particular musical styles and interests: *"I believe that in my own experience... was like 'OK, this is what I did or not discover' and sometimes there were many similarities... [and] there were small details [that were different]. So I think being in a group helped us refine how little or much we did each one alone and to discover things we had never done" [JS].* Similarly, VH expressed how group interactions gave important feedback that contributed to motivating new explorations, *"So when we are all playing or when I remembered when AW played a sound that hit me, 'wow! how do you do it? What if I move here?' I think the group gave a lot of feedback."*

Group activities were not only limited to free play. On several occasions, participants developed a series of group exercises in order to explore new musical spaces. For example, VH proposed an imitation group exercise where one person played a note, while the next person besides her imitated the note. The sound was gradually introduced into the texture. Once this person played the note, the previous player faded out and the next player faded in. The intended effect was of one note being passed around the group until everyone agreed on stopping. As observed, this particular exercise contributed to developing a greater sense of dynamic control, as well as developing group coordination through visual cues and attentive hearing. AM describes this experience: *"it forces you to focus on volume control because in the end you want that tail to hold... you start some weird harmonics, it sounds very cool. I had to focus on playing very softly at the end to hear those little details. The crescendo and decrescendo's are difficult."* Variations of this exercise were also explored.

Finally, one of the prescribed activities by the researcher was performing group compositions developed by participants. All four performers composed a brief piece that was discussed and rehearsed several times during an individual session, as well as being rehearsed again in future sessions. Scores demonstrated a mix of common practice and graphical notation elements (Figure 3). AM explains the goals of this exercise: *"Why don't we compose something together? We know that we can definitely do at least three octaves, if not four. We have textures and we are discovering those patterns that give us like a counterpoint or polyphony. I imagine that we could use [these] resources, as well as traditional notes. And [we can] also use these articulations that you [VH] are discovering that I think give us a little more expressiveness."* This quote suggests that the group already has at its disposition a developed repertoire of performance techniques that have been mastered to a certain degree. Specifically, the group's repertoire of techniques consisted in a chromatic scale of several octaves; various articulation types; trills and tremolos; ample dynamic range; as well as a variety of available textures and timbres. The main challenge of this activity being how to notate such idiosyncratic techniques and how to employ traditional music notation in order to fully represent the sonic and musical capacities of the instrument. By regularly working together in a workshop setting, participants were able to come to an agreement about how the pieces were to performed and which performance techniques are required for the given situation of the piece. The main goal of this exercise was to achieve a satisfactory degree of musicality for each composition.

3.4 Musicality and style

These last two group activities were oriented not only towards instrumental technical development, but also towards musical development related to melodic, harmonic, rhythmic, and timbral parameters. These activities emerged naturally amongst the members of the group whose dialogue allowed for specific criteria to be established for their execution and evaluation. In other words, the group itself determined the value of each performance technique, as well as determining which technique was difficult or easy to learn or perform. While technical concerns were brought up early on, musicality with the instrument was also initially impor-

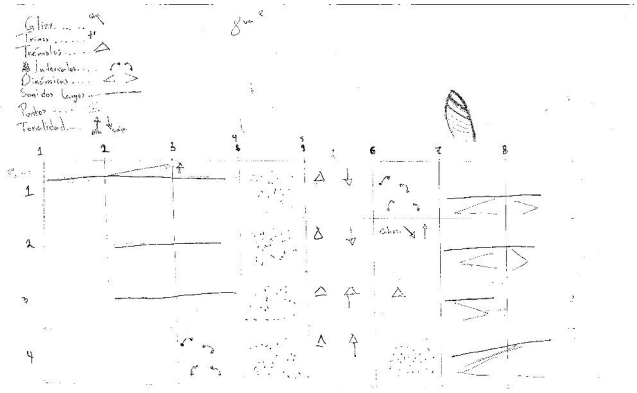

Figure 3: Example Composed Score.

tant for performers. For example, VH initially questioned the musicality afforded by the instrument. However, at a later time her views changed noting that musicality meant not only the ability to play notes, but to show an intentionally behind performative actions. Meaning having a range of dynamic variation, demonstrating control over the range of sounds and their disposition (scale, intervals) in order to express a given musical idea. Of course, defining musicality lies out of the scope of this study. However, for participants musicality was an important concern regardless of the skill level attained with the instrument during the period of study. Indeed, as JS expressed, *"there was less concern about experimentation and more on musicality,"* suggesting that concerns shifted from technical to musical thanks to a shared experience and repertoire.

As the group rehearsed and developed, a notable improvement in terms of group performance was noted from the first to the last sessions. Early performances were more chaotic, showing little structural organization. While later performances were much more organized and well-structured musically, as AM explains: *"I remember that in the last sessions [it was an] experience that we didn't have. [we were] 'What do I do? Does or doesn't sound good?' But now [it's like] 'I know what you do and what I can do to complement you. Either I follow you or I give you space.' We are already interacting in a slightly more musical way."* This self-organization depended on the diverse activities the group engaged with, whether performance, discussion, or experimentation [14] that yielded an shared understanding and musical repertoire. But also it was a matter of group interactions becoming more organized as participants knew each other musically as they engaged in more collective playing sessions. Further contributing to the development of musicality was the development of individual performance styles. JS comments, *"I think everyone has more or less a different sound. But the character of each one of us is a little more defined."* As AM noted, more than a development in instrumental virtuosity, there was a development in individual performance styles based on personal histories, preferences, and learning trajectories. However, despite all participants having the exact same instrument, each one developed their own performance style that uniquely contributed to the collective sound by exploiting what they deemed particularly interesting about the instrument. In this manner, every performer occupied a unique space within the group.

4. CONCLUSIONS

This study shows that a collective learning environment offers a wealth of learning opportunities and for developing performance practices with interactive music systems. Learning was open-ended, exploratory, and drew from both traditional and alternative music pedagogies such as ecological and enactive music pedagogies. This suggests that while some traditional exercises were suggested due to the capacities of the instrument (e.g., playing interval studies or scales), other learning strategies, like the imitation exercise, were proposed in response to both instrumental features and lack of other learning materials. Despite the absence of a formal teacher or expert, the self-organizing capacities and activities developed by the group produced a series of learning goals that both oriented and motivated learning efforts. A collaborative learning environment proves relevant when creating new practices for a particular musical system as it elicits its diverse artistic possibilities and grants value to its repertoire given the shared experiences.

It was surprising to see how in a relatively short period of time participants demonstrated a significant improvement in their instrumental performance. This not only reflected in instrumental technique –which everyone recognized there was much room for improvement in spite of advances– but also in terms of musicianship where it was possible to develop a sophisticated repertoire of learning methods, instrumental techniques, compositions, and individual styles from a rather simple instrument [13, 9]. The realization of mutual activities of playing, rehearsing, improvising, and composing, provided many learning opportunities that contributed towards individual and communal development. Products of such activities also included fixed materials, such as written annotation and compositions that constituted the repertoire. As [12] comments, there is value in exploring notated practices and in the diversity of performances and interactions they may engender. Most important of all, it was observed how thanks to the fluid exchange of ideas, as well as a similar technical level and a common learning experience, all participants came to a unified language and conceptualization of the instrument. Therefore, it was relatively easy to solve emergent problems and carry out activities dedicated to the development of the community as a whole.

The novelty and idiosyncrasies of the instrument itself contribute to the lack of a practice or tradition that prescribes how to learn, perform, and evaluate the performance of the musician with that instrument. However, by taking a non-linear and ecologic pedagogical perspective, learning objectives are generated from the student-environment relationship that includes her instrument, as well as the particular social dynamics within the learning environment. Employing non-prescriptive and collaborative learning approaches grant flexibility given that strategies from other contexts can be easily adopted and adapted. Collaborative learning environments demonstrate one possibility for generating practice with interactive music systems, which can in turn inform new performance oriented NIME-curricula.

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6. ETHICAL STANDARDS

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