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Creativity-centred design for ubiquitous musical activities: Two case studies

ABSTRACT

This study is among the first that attempt to define a methodology for creativity-centred software design in educational contexts, more specifically for musical activities in ubiquitous settings. We propose and apply a set of design techniques – the Ubimus Planning and the Ubimus Design protocols – as alternatives to experimental procedures that leave out relevant aspects of social and procedural dimensions in educational research. Two workshops were conducted to assess both technological and domain-specific requirements for support of creative musical activities. The first workshop

KEYWORDS

ubiquitous music
education
dialogical approach
software design
creativity
ecocomposition

was conducted with music teachers and school teachers that had no formal musical training. The objective of this workshop was to assess domain-specific requirements for musical creative activities by educational staff. The second workshop focused on technological support for tool development by non-musicians. This workshop yielded two software projects that involved user evaluations of creative processes. Participants in the corresponding user studies included both musicians and non-musicians. The Ubimus Planning protocol served to raise important questions regarding technological usage by musicians and naive subjects in educational contexts. Non-technical approaches, such as those proposed by traditional soundscape activities, may not be suited for introducing non-musicians to sonic composition. Naive subjects may respond better to technologically based approaches, such as those used in ecocomposition. The Ubimus Design approach proved to be effective to test the usability of musical tools at early stages of development. Prototypes were implemented and usability studies were carried out by undergraduate IT students within a three-week time slot. Sharp differences were observed in the type of requirements expressed by musicians and non-musicians regarding creativity support tools. Nevertheless, both groups of subjects assessed the use of software prototypes within exploratory musical activities as being fun and expressive.

INTRODUCTION

The relationship between the sound world and people has become modified. New possibilities of direct action and intervention upon the world of sound have brought emergent forms of music-making. Furthermore, these tendencies have affected professional identities. An example of this is the self-identification of DJs – musicians that use electronic means of reproduction as their main tools – as music producers instead of composers. Thus, young music practitioners distinguish themselves from the instrumental tradition, usually linked to the label composition (Lima and Beyer 2010a). However, surprisingly, most musical education approaches seem to remain restricted to instrumental musical practices. Given this state of affairs, musical activities in educational settings become an extension of instrumental instruction and remain limited to a narrow set of skills and competencies.

In line with a growing body of practitioners (Brown and Dillon 2007; Burnard 2007), we consider music as a social activity for sharing musical experiences (Keller et al. 2011b; Miletto et al. 2011). We are interested in investigating social ways of music-making by novices. This viewpoint encompasses not only modalities for music listening and sharing but suggests turning consumers into active producers of musical content. At the intersection of informal educational spaces and socially grounded creative practices, technology may provide opportunities for new modes of learning through engagement, entertainment and self-expression.

Despite the range of possibilities afforded by the widespread access to tools and media contents, we perceive that a critical/analytical attitude is still necessary. Placed in educational contexts, teachers become mediators between the student and the technological milieu. The fact that musical and technological contents are easily available does not necessarily mean that students will become situated producers of creative culture and knowledge. Thus the role of the teacher is not just to encourage usage but it also entails questioning the implications of the students' creative choices. One aspect of our research involves unveiling users' expectations during actual musical activities. This

approach requires open investigative and educational positions, based on permanent dialogue among participants in musical experiences (Lima and Beyer 2010c).

Inspired by the open-source philosophy of sharing resources and by the dialogical approach to educational practices, we have gathered a pool of methods and materials within a small 'community of practice' (Granovetter 1983; Lave and Wenger 1991; Weick 1976): the Ubiquitous Music Group (g-ubimus). The g-ubimus is a research network encompassing three core groups (NAP at the Federal University of Acre, LCM at the Federal University of Rio Grande do Sul and the Sound and Digital Music Technology Group of the National University of Ireland, Maynooth) and several collaborators in Brazil and abroad. Our interests lie at the intersection of situated educational practices (Lima and Beyer 2010c), ecologically oriented musical practices (Keller and Capasso 2006), open-source music software development (Lazzarini 2008) and novice-oriented human-computer interaction techniques (Miletto et al. 2011). This emerging area of research – closely related to Information Technology Creative Practices (Mitchell et al. 2003) – has been labelled 'ubiquitous music' (Keller et al. 2011b). As a tentative definition, we could say that ubiquitous music deals with pervasive or ubiquitous systems (Weiser 1991) of human agents and material resources that afford musical activities (Keller et al. 2010) through creativity support tools (Shneiderman et al. 2006).

This article describes two experiments developed by the Ubiquitous Music Group (g-ubimus). We propose and apply a set of design techniques – the Ubimus Planning and the Ubimus Design protocols – as alternatives to experimental procedures that leave out relevant aspects of social and procedural dimensions in educational research. Our approach is exemplified by two case studies carried out in educational contexts (Table 1). Two workshops were conducted to assess both technological and domain-specific requirements for support of creative musical activities. The first workshop was conducted with music teachers and school teachers that had no formal musical training. The objective of this workshop was to assess domain-specific requirements for musical creative activities by educational staff. The second workshop focused on technological support for tool development by non-musicians.

Study	Subjects	Activities	Description/tools
Ubimus Planning	Music teachers	Low-tech workshop	Ear cleaning, soundwalks
	High school teachers	High-tech workshop	Recording, editing, mixing
Ubimus Design	IT undergraduate students	EcoDrum design	Qwerty repurposing, percussive sounds
		Keyboard Hero design	Qwerty repurposing, piano sounds
Usability assessment	Musicians, non-musicians	EcoDrum assessment	Creativity Support Index
		Keyboard Hero assessment	Creativity Support Index

Table 1: Summary of the experimental studies.

This workshop yielded two software projects which involved user evaluations of creative processes. Participants in the corresponding user studies included both musicians and non-musicians.

This set of studies is among the first attempts to define a methodology for creativity-centred design in educational contexts. The domain of application is software design for musical activities in ubiquitous settings. The sources of inspiration are twofold: the dialogical approach to educational practices pioneered by Paulo Freire (1999) and the open-source initiative of free circulation of know-how and material resources (Open Source Initiative 2011). From Freire, we adopt the participatory, community-based, subject-centred view of education. From the open-source perspective, we appropriate the concepts of ‘communities of practice’ and ‘resource sharing’. These two perspectives are both compatible with a creativity-centred view of musical education. The first section of the article addresses these concepts to provide a background for the experimental research reported in the second part. Through a discussion of current music creativity models, we identify a shortcoming of the experimental techniques applied in technologically enhanced environments for musical education: early domain restriction. In the second part of the article we propose and test a set of protocols to overcome this limitation and analyse their implications in the context of creativity-centred design for musical activities.

THE DIALOGICAL PERSPECTIVE IN EDUCATION

Influenced by the educational and philosophical ideas of Paulo Freire, Brazilian social and community movements have been implementing various educational actions over the last few decades. Adopting the idea of education as a responsibility of all – school, community, private sectors and government – some non-governmental organizations have helped to bring informal and community knowledge into the realm of formal education. The dialogical conceptions proposed by Freire have been instrumental in questioning hierarchical, authority-based educational practices. By expanding the cooperation and commitment from all sectors of society, the dialogical approach has fostered the emergence of a participatory framework, slowly exerting a transformative influence on official educational policies. These initiatives converged on what the Brazilian government defines as Integral Education – a set of priority policies adopted in public education throughout Brazil (IDEB 2011).

Concurrently, government-sponsored programmes such as the ‘one student, one laptop program’ (ProUCA) have fostered the adoption of technology in schools and community centres throughout Brazil. Despite these initiatives, the use of up-to-date creativity-oriented software tools – commercial or academic – for supporting students’ learning activities is hardly common. Especially in low-income rural or urban settings, few schools have enough technical staff or material resources to install and keep the equipment in working conditions. Due to lack of maintenance, hardware is underutilized and software becomes dysfunctional.

Internet access in Brazil is widespread. Low-income communities feature a significant demand for technology leading to the multiplication of *LAN-houses* or Local Area Network houses (establishments incorrectly labelled since they provide WAN access, where computers are rented by the hour for a low price). Free Internet accessibility is actively supported by governmental initiatives, a good example is the Floresta Digital programme that provides

free wireless access across all urban centres in the state of Acre. But again, lack of technical know-how restricts the educational usage to mere content consumption. Consequently rich-media, network-based tools are still rarely used in schools.

The strength of these social movements, allied with the rising demand for access to technology, has opened windows of opportunity for participatory, socially engaged research in music education. An example of the impact of the Brazilian music research community is the recent reinstatement of music education in the formal school curriculum (Lima and Beyer 2010b). The work we report in this article tries to fill part of the gap in the know-how required to implement participatory practices in educational settings, encouraging effective use of the available technological infrastructure.

OPEN-SOURCE AND CREATIVITY

Open-source software and open-source development projects have existed for many years under the general term 'free software'. Events like the Linux implementation operating system and the Android platform release for the mobile devices have focused the public attention on the importance of the open software adoption both by end users and by IT products producers. As a side effect, these events also led to recasting the concept of 'free' to 'open-source' software (Open Source Initiative 2011), emphasizing the tool implementation and support importance as a complement to software product availability.

Open-source software is 'free' in the sense that no license fees are charged for use or redistribution of binaries or source code, but as important as the access to the product is the access to the know-how that open-source tools embody. The ability to freely modify the source code, create derivative works and distribute the results not only fosters better IT products, it also changes the social practices related to technology. Open-source tools have effective support when problems are reported and get high-priority attention from a pool of active developers who contribute to the tools' improvement. Consequently, open-source tools stand better chances of sustaining long life cycles and widespread usage than the software developed behind closed curtains.

The free access to know-how and the fast circulation of resources within social groups with common objectives foster the emergence of a phenomenon quite relevant to the education area: the communities of practice (Lave and Wenger 1991). A community of practice is a simple social system that arises out of learning processes. A key aspect of this type of community is that it unfolds through practice, not prescription (Wenger 2010: 192), so it can be seen as a dialogical perspective extension (Freire 1999). Since open-source communities are nimble and flexible – consisting of volunteer developers who make contributions either individually or as part of temporary teams with shared governance – they foster engagement, imagination and alignment. We believe these characteristics may provide a fertile ground for creativity-centred design.

Aside from non-hierarchical social dynamics, open-source methodologies promote free material resources circulation. Within the creative endeavours context, material resources encompass both the enabling conditions and the products of the creative activity. Thus, an open approach to creativity-centred design for musical activities would need to foster both the exchange of sources – such as code and software – and of creative products – for example,

sound files, musical and experimental data. We feel that educational practices in music could also profit from the adoption of intensive resource sharing among stakeholders. The two case studies discussed in the second part of this article deal with two aspects of this issue: sharing of and reflection on musical data (Case study 1), and sharing of and reflection on source code and experimental data (Case study 2).

MATERIAL, PROCEDURAL AND CONTEXTUAL DIMENSIONS

Models of creativity in music can be grouped according to their emphasis on intrinsic and extrinsic factors. These factors determine the methodology adopted when applying the model in the field, so a theoretical background understanding should throw light onto the relationships between the model and its applications. Three dimensions can be extracted from the models: material (what), procedural (how) and contextual (where/when) (Keller et al. 2011a).

The material and procedural dimensions have been thoroughly covered in the literature. Collins (2005) – following Shah’s lead (Shah et al. 2003) – suggests that creativity models are either product or process based. Product-based models focus on the evaluation of compositional results, thus avoiding questions regarding how those results were obtained. He proposes the adoption of process-based models in order to study the strategies used by composers during the act of composition. For Collins, these studies should be longitudinal and as little invasive as possible.

The third dimension of musical creativity models – the context – encompasses the external factors that influence the compositional processes, including material and social factors. Material (or physical) factors can be related to two variables: time and place. Until 2003 most models were based on abstract space-time (see review in Keller et al. 2011a for details). Material context is usually included as an ad hoc factor. For example, Webster’s (2003) ‘enabling conditions’ encompass context, task, peer influence and past experience. But these factors are linked to ‘convergent thinking’. Thus, they are only relevant for thought processes. Hickey’s (2003) model accounts for social factors, such as peers, family and teacher support (social environment). According to the topology of this model, these factors are only relevant to ‘task motivation’, implying that the environment only influences the creative act through the cognitive factors that drive ‘task identification’ and ‘response generation’. Despite some limitations – such as the secondary role of the physical environment – this model provides an initial drive towards the inclusion of context as a relevant dimension in music creativity.

Converging trends in creative practice research (Keller and Capasso 2006; Truax 2002), educational research (Loi and Dillon 2006) and music education (Burnard 2007) point to context as a key factor in shaping creativity in educational settings. These approaches propose creativity as a research focus within socially informed paradigms, gather support from ecological methodologies (Keller 2000; Loi and Dillon 2006) and Activity Theory research (Burnard 2007; Keller et al. 2010), and situate technology as an integral part of creative environments. Loi and Dillon (2006) propose that adaptive educational environments can be designed as creative spaces that foster interaction through situational and social dynamics. Burnard (2007) applies this model within the music domain by placing creativity and technology as the two central forces enabling innovative educational practices. She cites the use of online and collaborative technology as means to support creativity in educational settings,

proposing descriptions of practice, participation and collaborative networking as objectives of music education research.

These situated, socially informed approaches stand in stark contrast to previous proposals in music creativity research. While most models were concerned with activities that (in theory) could be carried out without the need for social interaction or place-specific experience, such as 'problem solving' and 'thinking', situated approaches bring musical experience to the forefront of the research agenda. This change of focus opens up a methodological can of worms. How can musical creativity be assessed without disrupting the ecological validity of the experience? In other words, can musical creativity assessments be carried out *in situ*, while the activities are done, and by the relevant stakeholders? A closer look at the methodological implications of music creativity models may help to refine these questions.

EARLY DOMAIN RESTRICTION

Music creativity models that emphasize the material dimension provide the most direct window to experimental observation. Two of the three interrelated stages suggested by Dingwall (2008) – the generation stage and the development stage – can easily be assessed by measuring the quantity of material produced. 'Putting the piece together' may involve selection, grouping and disposal of materials (focusing, in Burnard's and Younker's terms); therefore subjective qualitative assessment may be necessary. This type of assessment can be done through Amabile's (1996) consensual assessment technique (CAT). Regarding materials, Bennett's (1976) model suggests that compositional processes start from a single germinal idea. Collins (2005) also adopts this view but allows for several musical ideas (themes, motifs) at the initial stage. Contrastingly, Hickey (2003), Burnard and Younker (2004), Chen (2006) and Dingwall (2008) models suggest that exploratory activities precede the selection of materials. The methodological difficulty resides in the task choice for creativity assessment experiments. If the materials are given by the experimenter or if the working environment predetermines what materials are made available to the subject-composer, then it will not be possible to draw any conclusions regarding the material dimension.

We label this problem as 'Early Domain Restriction'. We define the material domain as the collection of resources available to the composers. In this case, we are dealing with sound sources or tools used to generate musical products. Thus the connection to materials is direct. The underlying hypothesis is – as suggested by Hickey, Burnard and Younker, Chen and Dingwall models – that both restricting and providing access to materials are part of the compositional process. Therefore, by selecting materials or tools the experimenter is taking the place of the composer and the resulting data cannot be used to determine whether the compositional activity begins by exploratory actions or by a given set of materials. The section on the 'Ubimus Planning protocol' provides a method to circumvent this limitation and a case study of its application within the context of ubiquitous musical activities.

UBIQUITOUS MUSIC APPROACHES TO CREATIVITY-CENTRED DESIGN

The Ubimus Planning protocol's objective is to obtain a set of social, procedural and material requirements to be applied in the design of creativity-centred systems (Figure 1). Social aspects of creative activities are related to the

interactions among agents and to the factors that influence the dynamic of this process. Technological systems may facilitate the access to informational resources and providing support mechanisms for social interaction. But in educational contexts, these same mechanisms may hinder creativity by limiting the type of relationships that agents establish among each other and the access to the available material resources. The purpose of our experimental studies is to identify the minimal requirements that would foster creativity, avoiding the introduction of unnecessary restrictions on the subjects' creative approaches.

Given that material aspects of creativity encompass the sonic elements and the physical context where the activity takes place, music-specific support and location-based mechanisms are significant factors. Because we want to avoid early domain restrictions, sonic materials become variables to be assessed. Thus, they are by-products of the ecological niche where the creative activity unfolds (Fiedler and Pata 2010; Keller 2000; Loi and Dillon 2006). In other words, the interactions between the agents and the objects foster the creative process and constrain the possible results.

One of our research objectives is to gather insights on the relationships between the subjects' profiles and the strategies they use to handle the creative tasks (Barbosa et al. 2010). Subjects may choose to approach the creative activity by applying previously learned strategies. Sometimes, this background knowledge may not be applicable to technologically enhanced environments. So we adopt a parsimonious method for increasing tool access without hindering reuse of previous knowledge. Tools are presented as opportunities for interaction, but they are not given as requirements until the planning stage is completed. Depending on their specific profile and their previous experience, some subjects take advantage of computationally based support while others limit their actions to simple forms of sonic manipulation. Again, this aspect of the procedural dimension is treated as a variable to be observed instead of being a predefined condition.

From an educational perspective, our approach is based on Paulo Freire's conceptions (1999). Developed since the early 1960s, Freire's educational philosophy pushes the teacher's role beyond a mere conduit for technical-theoretical information and encourages active protagonism by the student. In the dialogical approach, the educator encourages the pupil to assume a creative-protagonist role, reflecting and justifying the choices and references used during his or her creative processes.

This conception also emphasizes the importance of considering the cultural references and the experiential knowledge brought by the students from their personal and social contexts. In line with other socially oriented perspectives, the dialogical approach is based on the premise that knowledge is constructed. This knowledge is considered the basis for dialogical and reflexive actions. Educational actions are supported by the idea that the teacher must propose instigating questions that lead students to reflect and deepen their knowledge (instead of imposing tasks). Therefore, the acquisition of superficial or decontextualized technical information is considered a hindrance to effective learning rather than a requisite (Lima and Beyer 2010c). By establishing relationships between their previous experiences and the new experiential contexts, the pupils themselves may become researchers.

One of the aspects emphasized by Freire that concerns us in particular is the respect for diversity. Knowledge brought by the students and the new references brought by the educators are based on a conscious and respectful

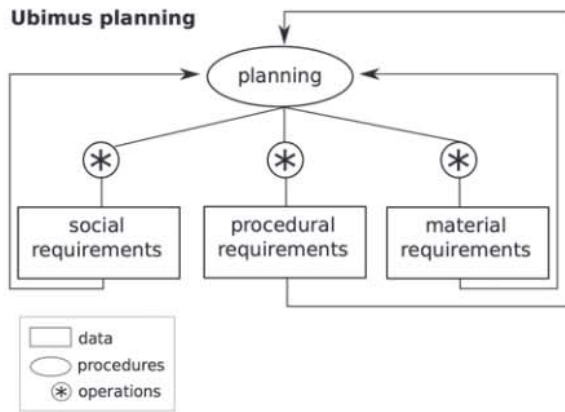


Figure 1: Ubimus Planning protocol: Planning methods for creativity-centred design.

attitude in face of diversity. Within the dialogical process it is important to emphasize exchange without confrontation (because I respect my own context I share it with satisfaction, hence I respect the others’ opinions and their context). Thus, the collective construction of knowledge through dialogic interactions among peers, students and educators opens a space for coexistence of diverse and sometimes opposing views.

Through hands-on activity and social interaction among peers, students are stimulated to evaluate their work, developing a critical view on their products with a clear perspective on the local reality. The dialogical conception sharply contrasts with views that see creativity as a purely mental process. Given its consideration for the students’ local referents, this is the stimulus that leads the students to reflect about their own processes and products during musical activities. Thus, dialogical methods are focused on social interaction, adopting an iterative cycle of exchanges to foster individual and collective reflections.

CASE STUDY 1: UBIMUS PLANNING STUDY

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We conducted two workshops during the month of July 2011. Teachers from a public municipal high school in São José, SC, Brazil – encompassing different ages, areas of expertise and levels of training – participated in one of the workshops. Music teachers from the NGO Música e Cidadania (M&C), featuring both formally trained musicians (with undergraduate degrees in music pedagogy) and practicing musicians without academic training, took part in the other workshop. The workshops focused on aspects of sonic creation and compositional processes and the possibilities afforded by the use of everyday technologies for educational music-making, emphasizing the assessment of the complete creative experience as opposed to usage of isolated tools. In addition to enhancing the perception of our everyday listening environment, the workshops had two objectives: (1) to propose that

1. Participants with no formal music training or little training (under two years) were labelled 'non-musicians'. College-level music students or practitioners whose part of their income was obtained through musical activities were labelled 'musicians'.

N	Average age	Sex		Musical training ¹	
		Males	Females	Musicians	Non-musicians
10	35.9	3	7	5	5

Table 2: *Ubimus Planning study: Subject profiles in the low-tech and high-tech experimental sessions.*

teachers carry out their own interventions and creative experiences taking a stand point of active engagement in authoring their own sound environments (Soundscape approach); and (2) to encourage teachers to appropriate new technologies to explore the possibilities of sonic interventions, carrying out their own musical creations inspired by their daily activities (Eco-compositional approach).

The goal of the experience was not software development but usage of easily available, highly compatible tools, for maximization of creative possibilities by students and music teachers. Although the focus is musical, this method closely resembles community-based software development regarding the fostering of a small community of practice and the free circulation of resources. Sources and products were shared among participants. Social interaction was a key component of the experience. And the final product emerged out of this socially based process.

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The meetings were divided into two stages: (1) low-tech (i.e. the use of technological resources was optional) featuring activities such as 'ear cleaning' and 'soundscape walks' proposed by the researchers and composers R. Murray Schafer (1977) and Barry Truax (2002); and (2) high-tech activities (with focus on the use of technological resources), a proposal based on ecocomposition and ubiquitous music, as articulated by the composer and researcher Damián Keller (Keller 2000; Keller and Capasso 2006) and the *ubimus* group (Keller et al. 2011b; Miletto et al. 2011). During the workshops, these activities provided the context for a series of actions directed to:

1. discuss concepts related to technology, media, sound, music and ubiquitous computing
2. handle and explore the possibilities of consumer media gadgets (portable computers, phones, mp3 players) and software tools (sound and musical data editors, sequencers and DSP tools)
3. produce, create sounds and soundtracks through the combined use of technologies
4. replicate, evaluate and assess results through controlled experiments
5. share and discuss the creative experiences.

The first meeting (low-tech) was performed with a group of mixed profiles, encompassing high school teachers with no musical training and music teachers from the M&C NGO, who had formal training or previous ad hoc musical experience. On the first day, the participants were asked to perform 'ear cleaning' activities, listing all the found sounds within the school environment. Both musicians and non-musicians described sounds produced

by human agents (screams, beatings, people talking and rolling chairs). During the activity, a section of the school was under construction, so there were sounds of machines, saws, drills, hammers mingling with the usual school sound environment.

After providing a description of the sounds heard within the school premises, subjects were asked to take up a route from the school to another institution within the district. During this soundwalk, subjects were asked to write down what they heard and to make recordings with their own devices (using either mp3 recorders or cell telephones). Although some subjects were familiar with the use of portable devices for registering sound, everyone – including the musicians – preferred to document their path by jotting down descriptions of the sounds on paper. A wide variety of sounds were listed. Some sounds were described as being surprising while others were labelled as funny (e.g. several subjects mentioned the sound of a tired dog lying on a sidewalk).

During the low-tech session, there was a certain level of anxiety among the participants regarding what they were doing. Several subjects expressed that they had never done this type of activity before and in several occasions they interrupted their listening tasks with verbal observations and questions. After each listening session, the group provided their reflections on the experience. Overall, they considered the proposal to be fun. One of the younger teachers felt difficulty to focus on exploring the sonic aspects of the experience; this person did not enjoy doing the activity. Most of the M&C music teachers had previous exposure to the Soundscape approach through readings during their music training. These subjects felt it was important to adopt open-ended activities and methods as alternatives for practical creative work with their students.

The second workshop (high tech) was carried out in the school's computer laboratory. Before dealing with the tools, we discussed technical concepts related to musical data formats and open-source editors and sequencers. Recalling their experience of the 'ear cleaning' and soundscape field activities, teachers expressed their impressions on issues such as noise pollution and the environment. After this initial discussion, the coordinator (the first author) exposed several ideas related to ecomposition and its relation to the creative application of technology. Participants brought up previous experiences with sound software and formulated questions regarding the tools they were going to use. At this point the sound editor Kristal was introduced and sound samples were provided.

Both Kristal² and Audacity³ were used in previous experiments performed by our team between 2006 and 2008 with high school students from the UFRGS Application School – a Brazilian public school linked to the Federal University of Rio Grande do Sul (Lima and Beyer 2010a). Their interfaces adopt the standard tape-based metaphor in which samples are represented by rectangles that are cut and pasted. The horizontal axis represents time, thus the longer the sample the larger the rectangle. Multiple samples can be superimposed by using vertically piled tracks. For this study we chose Kristal so that we could gather data for comparison with previous studies.

Subjects were instructed to explore the sonic possibilities of the tool with the objective to obtain a musical product. Participants worked in groups of two and three members. The activity lasted one hour. All groups made use of the sonic materials provided and managed to come up with a satisfactory musical product within the given time frame.

2. <http://www.kreatives.org/kristal/>

3. <http://audacity.sourceforge.net/>

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Several subjects assessed the second experiment (high-tech) as being difficult, out of the seven participants, only three found it easy to deal with the tools. The younger teachers that had no formal music training frequently laughed at the results and used expressions like ‘that’s cool’ and ‘awesome!’ while performing the tasks. The exploration of materials and the creation of sonic products were described as fun experiences, and these participants enjoyed sharing their results. One of the teachers that had extensive musical experience but no formal musical training showed a conscious and concentrated effort to attain musically interesting products and evaluated the activity as being enjoyable.

We also noticed that during the exploratory activity, the two teachers with formal music education – i.e. with previous experience in instrumental practice and expertise in traditional musical notation – had great difficulties in executing the task. These subjects were very concerned with nineteenth-century musical parameters, such as pitch and rhythm, and were not able to explore other aspects of the sonic palette. Their focus on a specific type of result seemed to hinder their ability to test new outcomes.

As a whole, we could classify these results as a two by two matrix. Subjects with formal music training and subjects with unstructured musical experience had very different reactions to ecompositional techniques. The first group did little exploration and had difficulties in realizing ecompositional activities. The second group labelled these activities as being easy, enjoyed the process and attained a high level of engagement. Naive subjects were less receptive than musicians to soundscape proposals. Generally, these activities were not very demanding but generated anxiety and estrangement among non-musicians.

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The objective of the study was to establish constraints on the strategies adopted for design of support for creative musical activities. Unintuitively, activities that do not demand any technical expertise – such as those proposed in the low-tech conditions – were not necessarily straightforward to naive subjects. Given the high familiarity with the usage of consumer devices by the younger generations, introducing technology in musical activities at an early stage may stand better chances of success than adopting a traditional Soundscape approach. This conclusion goes against the grain of the current music education canon, thus further studies are required.

On the other hand, seemingly complex activities – such as those proposed by ecompositional techniques – are more enjoyable and easily graspable to naive users than to formally trained musicians. Hence, creative activities establish very different sets of requirements depending on the profile of the target group. Trained musicians seem to rely heavily on notation and on instrumentally oriented forms of interaction. Exploring other forms of music-making is not a requirement and in some cases may increase the learning curve of the tools. Support for legacy systems and interaction techniques may be the most appropriate approach for this user group. Accessibility barriers for naive users may be experienced as positive features by instrumental musicians and vice versa.

There is only one common trait that cuts across all user groups. Our observations point to familiarity built upon previous experience as the main factor in determining the chances of engagement and enjoyment of tool

usage. But how could this trait be explored in the context of system design? Our group has been applying two strategies: (1) tool repurposing – existing technologies are redesigned to serve musical goals; and (2) creative awareness support – daily activities are recontextualized as creativity-designed environments. For the present moment, we focus on the first strategy. Since we are just starting to collect data on creative awareness support, we will address this proposal in a future publication. The two design studies reported in the next section deal with a specific form of repurposing: the use of a low-cost legacy device for musical exploratory activities. This approach may be useful for enabling creative musical activities within non-specific contexts. Therefore, it is particularly promising for supporting school-based teaching practices.

CASE STUDY 2: UBIMUS DESIGN STUDY

We conducted a study with a group of advanced undergraduate IT students to assess the effectiveness of our rapid-prototyping tools and design strategies in a design activity realized within educational settings. The objectives of the study were to identify methodological flaws and conceptual gaps in our approach and to obtain feedback from non-professional designers within a time-constrained workflow.

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A group of fifteen undergraduate students took part in a three-week workshop on techniques for rapid prototyping of music systems. The workshop was offered as partial credit for the regular course-load on multimedia systems offered to eighth-semester Information Technology (IT) students. None of the students had any previous experience in development of multimedia systems and only seven of them had programming experience in Javascript.

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Students were divided into five groups and were instructed to choose a music-related project. No restrictions were placed on scope, programming languages or platforms. A timeline of three weeks was established dividing the work into three stages: week 1, concepts and methods for musical data processing; week 2, concepts and methods for audio processing; and week 3, presentations of student projects.

During the first week, basic concepts and tools were presented, including MIDI format, MusicXML format, open-source sequencers and editors. The second week was dedicated to introductory concepts in audio and digital signal processing. Examples of research being carried out by our group were shown, emphasizing evaluation techniques with focus on musical creativity processes and products. Two programming environments were discussed: (1) MOW3S – a Javascript-based library that uses standard browsers for user interaction and generation of musical control data (Keller et al. 2011c); and (2) Ecolab – a wavetable synthesizer implemented in Java that adopts the MIDI and DLS standards and supports Ethernet communication (Keller et al. 2011c). Both tools were presented through practical examples involving simple forms of interaction on fixed devices with immediate sonic outcomes.



Figure 2: Keyboard Hero prototype interface (Vieira et al. 2011).

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All five groups participating in the study opted to adopt Javascript as their main programming environment. Three groups decided to include the MOW3S and Ecolab libraries to overcome specific limitations they encountered during the development process. Of these three groups, all of them managed to develop working prototypes within the timeslot provided. But only two of them had enough time to carry out usability studies. Our report will only include these two cases since without a preliminary user study it is hard to determine whether the tools provided enough support for rapid prototyping of working systems. The results apply to a target population of developers with little experience in multimedia, no music knowledge and intermediate programming skills. The objective of this preliminary study was to assess the feasibility of the approach and to determine the shortcomings that would need to be addressed for a population of non-musicians with intermediate programming skills.

We present a summary of the methods employed in the two usability studies. Since both studies adopted the techniques proposed by our group in Keller et al. (2011c), they provide good examples of the application of the ubiquitous music design protocol that we are discussing. Accordingly, the results can be discussed from a common theoretical perspective.

KEYBOARD HERO

Each of the teams were composed of three males, with at least one participant having intermediate Javascript knowledge. Both teams conducted preliminary tests to determine the feasibility of implementing their systems without resorting to special purpose libraries.

The objective of the Keyboard Hero project was to implement a simple mapping algorithm that would provide a qwerty-based interface for piano emulation (Vieira et al. 2011) (Figure 2). Requisites of the prototype were: real-time response with unnoticeable delay on a desktop machine; intuitive mapping between qwerty keys and piano keys; support for articulations.

ECODRUM

The EcoDrum project entailed creating a system that would support real-time interaction with a virtual percussion set, with a low-cost interface suited for music beginners and non-specialist musicians (percussionists would demand special purpose controllers, so they were excluded from the target population) (Domingos et al. 2011).



Figure 3: Interface of the EcoDrum prototype (Domingos et al. 2011).

The EcoDrum group opted to adopt the library jQuery to simplify the mapping mechanism between the qwerty keys and the control data. Their development cycle encompassed four prototypes which were tested by the members of the group until no major problems were detected. At this point, a formal usability study targeting creativity was conducted.

KEYBOARD HERO SUBJECTS

Ten users participated in the software evaluation procedure. Three were female and seven male subjects, with a mean age of 23.7 years. Seven reported no musical knowledge and two were professional musicians. One subject had introductory musical training but no extensive musical expertise. Thus, he was classified as a non-musician.

ECODRUM SUBJECTS

Fourteen subjects participated in the EcoDrum study. Half of the subjects were musicians and the other half were undergraduate students with no formal musical training. Average age was 25 years. Two of the non-musicians were females and four of the musicians were males.

USABILITY RATINGS

Usability ratings were obtained by applying an adapted version of the Creativity Support Index (CSI; Carroll et al. 2009). This technique provides quantitative assessments of creative activity within a wide artistic context, without requiring the use of metrics linked to specific compositional methods. Our preliminary studies have yielded relevant results in assessing activities such as exploration, imitation and creation by individuals and small groups (Keller et al. 2011c). Given the standardization of the metrics and the factors,

Usability study	N	Average age	Sex		Musical training	
			Males	females	Musicians	Non-musicians
Keyboard Hero	10	23.7	7	3	7	2
EcoDrum	14	25	8	6	7	8

Table 3: Subjects profiles in the EcoDrum and Keyboard Hero studies.

Factor	Descriptor	Scale
Productivity	Trash/excellent	0–10
Expressiveness	Awkward/free	
Explorability	Hard/easy	
Concentration	Distracted/focused	
Enjoyment	Boring/fun	
Collaboration	Hard/easy	

Table 4: NAP adaptation v.1 of the CSI (Keller et al. 2011c).

the data are comparable between subjects, between experimental conditions and can be applied to a wide range of studies on musical creativity. We implemented an online questionnaire with the factors presented in Table 4. All questions were answered using a Likert-type scale and we added descriptors to the numeric ratings to clarify the meanings of the evaluations. A field for comments was also made available.

The evaluation procedure consisted of individual interaction sessions. Subjects were given two minutes to get familiarized with the software and the activity. However, no explanations or descriptions were given regarding the type of sound results. The intention was to allow for free exploration of sound features, without limiting the creativity of the subjects. Subsequently they were asked to explore the sonic possibilities of the software. This activity lasted 30 seconds. The sound product was captured on disk as a stereo, 44.1 kHz, 16 bit file. After concluding the sonic session, subjects answered the CSI questionnaire.

USABILITY RESULTS

Overall averages were high in most of the items for the EcoDrum prototype (Table 5 and Figure 4). The subjects evaluated two factors with scores near the maximum value (concentration mean=9.43, SD=0.84; enjoyment mean=9.21, SD=1.41). Variability among subjects is low for concentration (SD=0.83) but it rises slightly in the case of enjoyment (SD=1.41). The worst performance is in the items collaboration (mean=7.79) and productivity (mean=7.21). But the variability in this last item is high (SD=2.63), so subjects may be using different strategies to evaluate the productivity factor. While these results can only be read as tendencies to be confirmed in larger studies, the users evaluations indicate that the EcoDrum prototype provides good support for creativity in exploratory activities, with very good ratings in enjoyment. The high scores in concentration can be interpreted as engaging experiences for most subjects.

In the case of the Keyboard Hero prototype, CSI averages were high for enjoyment (mean=9.80), expressiveness (mean=9.20) and collaboration

	Productivity	Expressiveness	Flexibility	Concentration	Enjoyment	Collaboration
Mean	7.21	8.79	8.21	9.43	9.21	7.79
SD	2.63	1.68	1.90	0.84	1.41	1.49

Table 5: EcoDrum study overall results.

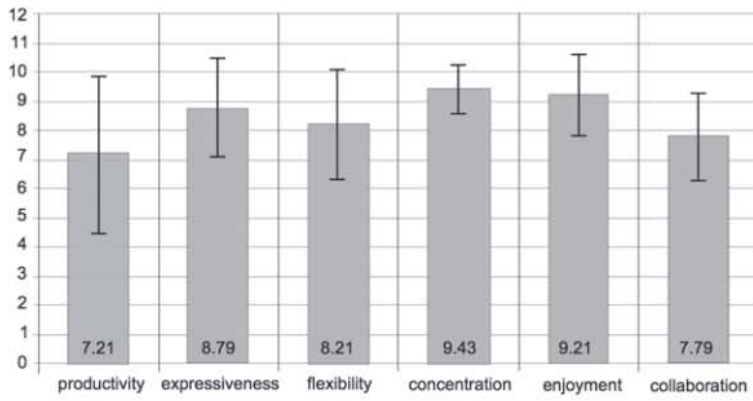


Figure 4: EcoDrum: overall results.

	Productivity	Expressiveness	Flexibility	Concentration	Enjoyment	Collaboration
Mean	6.4	9.2	7.6	8.2	9.8	9.1
SD	2.55	1.4	3.34	2.66	0.42	2.02

Table 6: Keyboard Hero study CSI results.

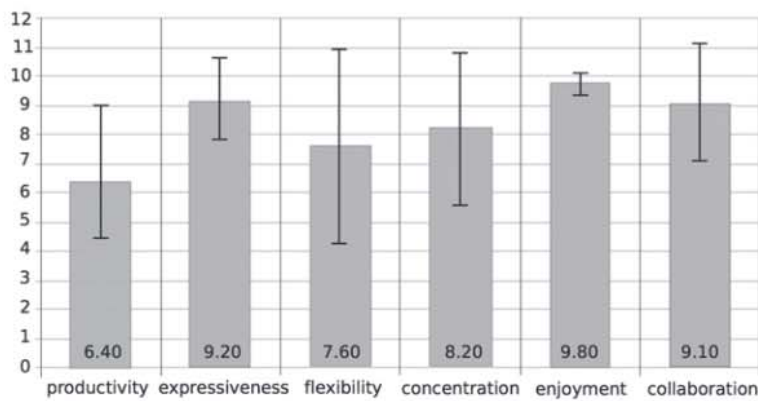


Figure 5: Keyboard Hero: overall results.

(mean=9.10) (Table 6 and Figure 5). A possible interpretation of the variability among subjects may indicate that musicians and non-musicians use different perspectives for the evaluation of expressiveness (SD=1.40) and collaboration (SD=2.02). The factor concentration shows a high variability, so its evaluation may depend on the subject's profile. The only consistent item for the whole

		Productivity	Expressive-ness	Flexibility	Concentra-tion	Enjoyment	Collabora-tion
Musicians	Mean	8.43	9.71	8.14	9.71	8.86	8.14
	SD	1.81	0.49	2.12	0.76	1.86	1.57
Non-musicians	Mean	6	7.86	8.29	9.14	9.57	7.43
	SD	3.11	2.04	1.98	0.9	0.79	2.15

Table 7: EcoDrum study: musicians vs non-musicians results.

group is enjoyment, with very low variability (SD=0.42). The lowest evaluations go for productivity (mean=6.40) and flexibility (mean=3.34); therefore, these two factors need more detailed analysis.

In order to determine the source of variability, let us take a closer look at the results of the EcoDrum usability study (Table 7 and Figure 6). The overall means were comparable to the Keyboard Hero study. Enjoyment (mean=9.21) and expressiveness (mean=8.79) were high. But scores dropped for the items collaboration (mean=7.29) and productivity (mean=7.21). Productivity showed the highest variability (SD=2.63), followed by flexibility (SD=1.90). Thus, those two factors seem to be the best candidates for possible differences in evaluation strategies among musicians and non-musicians.

In fact, productivity got contrasting evaluations in the two groups. The lower score was due to an average value of 6.0 by the seven non-musicians participating in the study. But even within this smaller group, dispersion was high (SD=3.11). A clear difference could be observed in the assessment of expressiveness. Musicians consistently gave high scores (mean=9.71, SD=0.49) but naive users were not as positive in their evaluations (mean=7.86, SD=2.04). Both groups coincided in their assessments of the flexibility factor (musicians mean=8.14, non-musicians mean=8.29).

Although the number of subjects does not allow to draw final conclusions, some preliminary observations can be made by comparing the evaluations

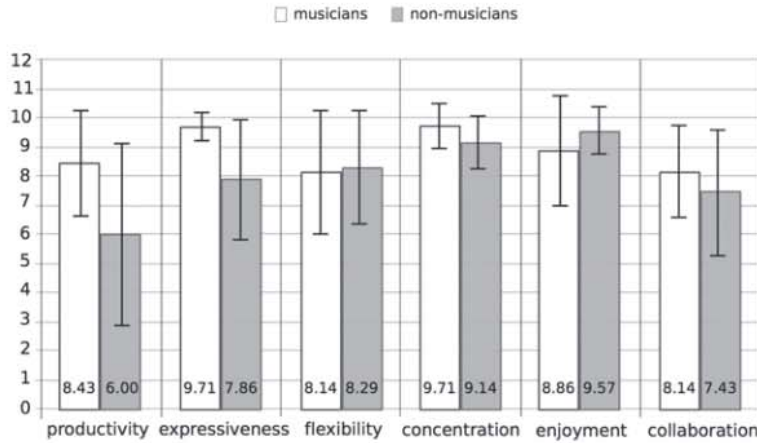


Figure 6: EcoDrum study: musicians vs non-musicians results.

		Productivity	Expressiveness	Flexibility	Concentration	Enjoyment	Collaboration
Musicians	Mean	4.5	10	8.5	9	10	10
	SD	0.35	0	1.06	0	0	0
Non-musicians	Mean	6.88	9	7.38	8	9.75	8.88
	SD	2.64	1.51	3.66	2.98	0.46	2.23

Table 8: Keyboard Hero: musicians vs non-musicians results.

by musicians and naive users that took part in the Keyboard Hero study (Table 8 and Figure 7). Most ratings by musicians are higher than the scores given by non-musicians. Two factors are good candidates to show different tendencies among groups: flexibility and productivity. Although scores are slightly better for musicians when assessing flexibility (musicians mean=8.5, non-musicians mean=7.38), the great variability among untrained users (SD=3.66) does not confirm a clear tendency. The surprising result is the inverted tendency in the productivity factor. While musicians that use EcoDrum give relatively high scores in productivity (mean=8.43), musicians using Keyboard Hero rate this factor negatively (mean=4.5). Non-musicians are not very reliable in their productivity ratings of Keyboard Hero (mean=6.88, SD=2.64), but their scores are slightly higher than those given to the EcoDrum (mean=6, SD=3.11).

DISCUSSION OF THE USABILITY STUDIES

Because we are dealing with preliminary studies, results have to be taken as indicators of trends that may be confirmed by larger studies. Both usability experiments yielded very high enjoyment values for all users. Expressiveness also got high ratings for both tools, but a more detailed analysis showed that musicians may feel more at ease than naive users when dealing with

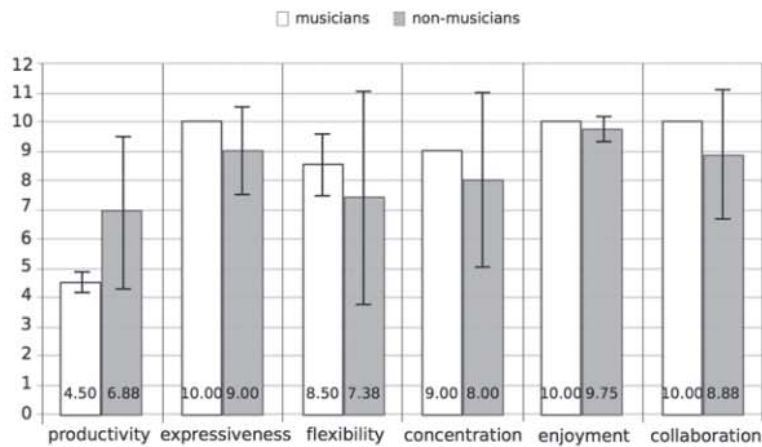


Figure 7: Keyboard Hero: musicians vs non-musicians results.

expression in exploratory activities using these tools. A possible explanation for this difference among groups lies in the interaction metaphors adopted for the prototypes. Both systems used the instrumental paradigm as their frame of reference. Musicians are familiar with piano keyboards and drum sets. They have previous experience in dealing with the underlying twelve-note, octave-based pitch organization and can grasp immediately the cause-effect relationship between key-press and sound attack. Non-musicians may feel that the symbol to sound mapping strategy involving multiple characters is not an easy task. For naive users, pressing a key may not necessarily be linked to sound making, thus this type of temporal organization of events may lie outside the type of experience they previously had with sound.

The theoretical question opened by these two studies is how to explain the contrasting tendencies in the scores of the productivity factor. As it is expected, musicians are more reliable in their assessments. While naive users yielded highly variable ratings (SD between 2.64 and 3.11), musicians scores were within reasonable bounds (SD between 0.35 and 1.81). What is not expected is the opposite outcome for two tools that use similar interaction metaphors. Why do musicians rate productivity negatively when using the Keyboard Hero prototype and positively when using the EcoDrum software? At this point we do not have enough data to draw conclusions. Two variables may be at play: subject-related factors or tool-related factors. Comparisons of results with other tools may help to constrain our search.

DISCUSSION OF THE UBIMUS DESIGN STUDY AND THE UBIMUS PLANNING STUDY

The Ubimus Design study yielded two main results. On one hand, it confirmed our hypothesis that rapid prototyping techniques, such as those supported by the MOW3S-EcoLab libraries, are effective for tool evaluation and research strategy assessment. Of the five groups that took part in the workshop, three managed to obtain working prototypes and two completed usability studies. Through actual usage of the tools in exploratory musical activities, 24 subjects provided effective feedback on the features for supporting musical creativity. The outcome of these two studies pointed to very high ratings of both systems in the enjoyment factor. Other creativity factors were high but not necessarily consensual across user groups.

An interesting outcome of this set of studies is the observation of different requirements for musicians and naive users in exploratory activities. Musicians find instrumental metaphors straightforward to use and expressive. Non-musicians do not necessarily share this view. Interfaces based on instruments are not rated as expressive and productive when it comes to exploring the musical possibilities of the tool. This profile-specific characteristic confirms the observations done in the context of the Ubimus Planning study and also the previous claims about the importance of careful design of user interfaces for musical activities (Miletto et al. 2007).

Legacy interaction techniques, such as those implemented within the context of the instrumental paradigm, sometimes may be appropriate for musically experienced users. Support for music notation and instrumental metaphors seem to be a requisite for traditionally trained musicians. On the other hand, self-taught music teachers and untrained users do not show preference for this type of support. Thus, innovative forms of interaction may find a more receptive public in teachers with a non-conservatorial profile.

Soundscape-oriented activities which do not demand any technical expertise from teachers are not necessarily easier to adopt than technology-based compositional strategies, such as those proposed by the Ecocompositional approach. Once again, teachers that are not musically trained may be at an advantage when it comes to applying technological approaches in school classes. A generalization of these results points to a simple rule of thumb: users like what comes closer to reenacting their previous musical experience.

LAST WORDS

The studies reported in this article provide a starting point for the development of creativity-centred software design strategies. Through a set of triangulation studies, we obtained partial answers that served to constrain the methods utilized to assess the effectiveness of creative tools for music-making. We focused on the methodological issues that arise when open, participatory techniques are applied for supporting creative musical activities. First we targeted the creativity requirements of technologically enhanced musical environments. Three dimensions were extracted from existing models: materials, procedures and social context. One of the limitations of the design methods previously used was identified and labelled as 'early domain restriction'. Early domain restriction occurs when design decisions introduce constraints that limit the potential of creative systems. These limitations may impact both the creative outcomes and the research results. Thus, extra care needs to be taken when adopting tools in creatively oriented educational settings.

Through the triangulation studies on planning and design, we assessed the effectiveness of creative tools for ubiquitous music-making. Two experimental protocols were tested in the context of ubiquitous musical activities: Ubimus Planning and Ubimus Design. The Ubimus Planning protocol was implemented in a workshop that evaluated the educational effectiveness of two contrasting compositional approaches: traditional soundscape (Schafer 1977) and ecocomposition (Keller 2000). The Ubimus Design protocol was tested by fostering development and software-usability evaluations within a creativity design workshop with undergraduate IT students.

The results pointed out several limitations and some advantages of the proposed protocols. The Ubimus Planning protocol served to raise an important question regarding technological usage by musicians and naive subjects in educational contexts. Non-technical approaches, such as those proposed by traditional soundscape activities, may not be suited for introducing non-musicians to sonic composition. Naive subjects may respond better to technologically based approaches, such as those used in ecocomposition.

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Although these results are preliminary, they provide a new perspective to discuss previous findings in development and usage of technologically enhanced environments for musical education. Through several years of deployment in educational settings, Brown and Dillon (2007) have gathered a rich set of experiences on the application of their musical system jam2jam. Jam2jam is a tool that let's users handle high-level control parameters enabling real-time improvisations by novices over local and wide area networks. An interesting aspect of jam2jam is its ability to generate autonomous behaviour: the system does not depend exclusively on the user to produce sonic events. Thus, it allows for 'parameter navigation' instead of imposing the

‘one-gesture-one-sound’ interaction metaphor featured in acoustic instruments (Wessel and Wright 2002).

Following a similar design strategy, Bryan-Kinns (2004) found that users consistently reported high levels of engagement during activities with Daisyphone – a musical environment for remote group music improvisation developed by his team. Daisyphone adopts a loop-based strategy for the organization of musical materials. So similarly to jam2jam, it frees users from the burden of producing every sonic event. Two interesting observations were made during the trials of Daisyphone. Students with basic musical training were confused by the lack of formal musical elements, i.e. they asked ‘Where are the notes?’. Second, although all users were able to produce musical results, when asked whether they could create ‘a tune that they liked’ only 50 per cent gave an affirmative answer. On the one hand, these results support Brown and Dillon’s (2012) view that technology-based musical activities may demand and foster a different set of skills of those used in instrumental instruction. But it may be argued that these results only apply to systems that support synchronous activities, such as real-time group improvisation.

The positive response of users to technologically based musical activities is not limited to synchronous systems. Since 2005, some members of our group have been testing CODES, an online compositional system for novices (Miletto et al. 2011). Through data gathered in multiple studies, non-musicians have reported high levels of satisfaction in musical activities using CODES. A particularly attractive feature of this system is the ability to apply community-based strategies to musical creation. Users cooperate in making musical prototypes from scratch fostering negotiation and argumentation among stakeholders. Given the non-hierarchical form of social interaction supported by CODES, experts negotiate on an equal basis with novices. Thus, loose social networks featuring weak ties (Granovetter 1983) and fast information flow are encouraged.

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If the rule of thumb previously stated holds true (users like what comes closer to reenacting their previous musical experience), musically naive students would welcome easiness of use and naturality while musicians would tend to prefer interfaces that reproduce behaviours based on acoustic instrumental metaphors and common-practice music notation. Therefore, design of educational technologies would need to fulfil different requirements depending on the intended user base. The Ubimus Planning protocol could help to unveil some of these requirements. On the other hand, basing educational situations from previous experiences does not mean restricting these experiences to a proximal zone of knowledge.

The Ubimus Design approach proved to be effective to test the usability of musical tools at early stages of development. Prototypes were implemented and usability studies were carried out by undergraduate IT students within a three-week time slot. Sharp differences could be observed in the type of requirements expressed by musicians and non-musicians regarding creativity support tools. Nevertheless, both groups of subjects assessed the use of prototypes within exploratory musical activities as being fun and expressive.

The results obtained in the Ubimus Planning and Ubimus Design studies underlie the view that support for musical activities is not the same as support for instrumental playing (Brown and Dillon 2007, 2012; Miletto et al. 2007). During the last few years, our research group has been investigating the use

of computing technology to support novice-oriented computer-based musical activities. The main motivation of our work is the belief that no formal musical knowledge should be required for participating in music creation experiences. The development of this support has followed an interdisciplinary approach, pointing towards a new field defined as Ubiquitous Music (Keller et al. 2011b).

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The Ubimus Planning and Ubimus Design studies we conducted unveiled yet another theoretical issue to be addressed: can the problem-solving approach to creative activities (Collins 2005) be applied to the study of creativity in community settings? Our preliminary results support the dialogical view: social factors seem to exert a strong influence on creative musical activities.

Similarities between the open-source movement and recent tendencies in Brazilian educational context and research may foster the expansion of a broader multidisciplinary dialogue. Great changes have come around since the end of the 1990s with the popularization of portable electronic devices and the widespread accessibility of digital resources. Especially among the school-aged population, access to computers, cell phones cameras and recording devices has increased exponentially. The ease of access and transfer of sound and image files has also produced a growing exchange among esthetic, cultural, educational, professional contexts, raising ethical issues on the usage of this massive amount of information.

It is no longer possible for the teacher to remain passive, as Paulo Freire would put it, 'the teacher is a researcher by nature' (1999). We believe that the new daily possibilities which emerge through the use of new technological resources and the dialogue with the social context – students, programmers, users – could help to strengthen this posture. This posture must permeate a political stance applied not only to educational practices and technological developments as well as the dialogical and participatory musical education methods and curriculum.

The active reflection about the actions and decisions of the students regarding content, leading to connections between content and context through actions are the hallmarks of dialogical education (Freire 1999; Lima and Beyer 2010a). Taking into account daily experiences with music, technology and education is perhaps an effective way to conduct inspiring, instigating, participatory and creative practices for educational goals.

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