

# Characterizing resources in ubimus<sup>1</sup> research: Volatility and rivalry

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***Abstract.** In this paper I identify three methodological approaches to creativity-centered design: the computational approach, the dialogical perspective and the ecologically grounded framework. And I analyze how these three methods relate to a current definition of the ubiquitous music field (ubimus). Social interaction is one of the factors to be accounted for in ubimus experimental studies. I propose the label social resources for the shared knowledge available within a community of practice. I identify five aspects of creativity-centered design that have targeted social resources. Then I discuss material resources as factors to be considered for the design of ubimus ecosystems and present two new design qualities as variables for experimental studies: volatility and rivalry. This discussion is framed by a split between creative products and creative resources which points to three observables: material resources, material products and material by-products, including creative waste. I conclude with a summary of the main proposals of the paper and point to applications of these concepts in experimental design studies.*

***Resumo.** Neste artigo identifico três linhas metodológicas em design criativo – o enfoque computacional, a perspectiva dialógica e o método cognitivo-ecológico – e analiso como essas linhas se relacionam com uma definição recente do campo de pesquisa em música ubíqua (ubimus). A interação social é um dos fatores que devem ser considerados nos estudos experimentais em ubimus. Proponho o conceito de recursos sociais para o conhecimento compartilhado dentro da comunidade de prática e identifico cinco aspectos do design criativo que tratam dos recursos sociais. Seguidamente discuto os recursos materiais como fatores para o design de sistemas musicais ubíquos, sugerindo duas qualidades de design como variáveis para estudos experimentais: a volatilidade e a rivalidade. A proposta tem como contexto a separação entre os produtos criativos e os recursos criativos, apontando para três tipos de fatores observáveis: recursos materiais, produtos criativos e produtos materiais não intencionais, incluindo o lixo criativo. O texto finaliza resumindo as propostas conceituais e indicando aplicações desses conceitos nos estudos experimentais de design.*

## 1. Ubimus methodological proposals

Since 2007, our group has been engaged in a multidisciplinary effort to investigate the creative potential of converging forms of social interaction, mobile and distributed technologies and materially grounded artistic practices. We have proposed the adoption of the term 'ubiquitous music' (ubimus) to define practices that empower participants of musical experiences through socially oriented, creativity-enhancing tools [Keller et al. 2011a]. Ubiquitous music is defined as a research field that deals with distributed systems of human agents and material resources that afford musical activities through sustainable creativity support tools. This consensual definition, established through collaborative work within our community of practice, summarizes the research efforts of three distinct but complementary methodological approaches to the study of ubimus

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<sup>1</sup> Ubimus: short-hand for ubiquitous music, a research field proposed in [Keller et al. 2011a].

phenomena: (1) the computational perspective, (2) the dialogical view, and (3) the ecologically grounded framework.

### **1.1. Information technology creative practices: proposals for ubimus infrastructure**

The computationally oriented perspective on ubimus research has contributed to the *material resources* and the *creativity support* components of the above definition [Pimenta et al. 2012]. This line of investigation attempts to expand what is currently known about musical interaction, focusing on human aspects of Information Technology Creative Practices [Mitchell et al. 2003]. Whether involving computing devices or not, musical interaction is defined as interaction that produces creative sonic products through a variety of musical activities. Seen from this light, ubiquitous music comprises sound oriented activities supported by ubiquitous computing (or ubicomp) concepts and technology [Weiser 1991]. *Material resources* and *tools* are the various kinds of stationary and portable computing devices integrated into ubimus ecosystems [Flores et al. 2010; Lazzarini et al. 2012]. *Distributed systems of human agents and material resources* generally involve interactive computing processes and synchronous or asynchronous exchanges of data. Complementarily, musical interfaces comprise the material and the virtual resources that support musical experiences in real-world contexts. Therefore, experimental work from the computationally oriented perspective strives to capture human-computer interactions that occur during actual music making, independently of the type of interfaces employed, the locations of the participants and the temporal distribution of the interactions.

Given the multiplicity of factors involved in music making, it comes as no surprise that ubiquitous music systems place high demands on the design of the support infrastructure. These requirements are hard to satisfy if the relationships among the components of the systems are not taken into account. Depending on the context, devices may provide sensor or actuator capabilities encompassing both stationary and mobile components. Synchronous activities place high pressure on the computational resources, especially when synchronous rendering of audio is involved [Lazzarini et al. 2012]. In the context of mobile, external group activities, both reliable connectivity and the ability to handle fairly large amounts of data may be necessary. When engaged in musical activities with portable devices, participants may need access to the state of the system regardless of the location where the action takes place [Pineiro da Silva et al. 2013b; Keller et al. 2013]. Distributed asynchronous activities require consistent data representations for simultaneous or intermittent access by multiple users [Miletto et al. 2011; Scheeren et al. 2013; Testa et al. 2013]. While in this scenario time synchronization support may be forfeited, ensuring persistent data mechanisms across all the network components is a minimal requirement. The multiplicity of use scenarios and contexts proposed for ubimus activities [Miletto et al. 2011; Keller et al. 2011a; Pimenta et al. 2012] relegates the case of the collocated, synchronous performance of digital musical instruments to the exception rather than the ideal model on which to base all design decisions. The results of seven years of ubimus research indicate that a ubiquitous music ecosystem can hardly be considered a musical instrument or a passive object to be played by a musician. A more appropriate metaphor encompasses agents in a dynamical system adapting to the local environment and to remotely accessible resources while carrying out musical activities [Keller et al. 2011a; Lazzarini et al. 2012].

### **1.2. The dialogical approach to ubiquitous musical phenomena: the local context**

The focus on human agents and the centrality of sustainability issues suggested by the proposed definition of ubiquitous music research are grounded on two current approaches to educational practices: the dialogical perspective pioneered by Paulo Freire (1999) and the free circulation of know-how and material resources proposed by the open educational resources initiative [Lima et al. 2012, 2014]. This research agenda is based on a participatory, community-based, subject-centered view of education [Lima and Beyer 2010], targeting both formal and informal educational settings.

Paulo Freire's (1999) educational philosophy pushes the teacher's role beyond a mere conduit for technical-theoretical information and encourages active protagonism by the stakeholders of educational activities. Freire's dialogical conception sharply contrasts with views that see creativity as a purely mental, individual process. Through hands-on activity and social interaction among peers, students are stimulated to evaluate their work. Given the relevance of the local referents, participants are encouraged to reflect about their own processes and products during musical activities. While keeping tabs on the local reality, they develop a critical view on their products and creative processes. Through iterative cycles of exchanges, dialogical methods foster individual and collective reflections.

Converging trends in creative practice research, educational research and music education point to the local context as a key factor in shaping creativity in educational settings [Burnard 2007; Keller 2000; Loi and Dillon 2006; Keller et al. 2010]. Loi and Dillon (2006) propose that adaptive educational environments can be designed as creative spaces that foster interaction through situational and social dynamics. Technology becomes a key resource in this type of educational environments. Burnard (2007) applies this framework 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 enablers for creativity in educational settings, proposing practice, participation and collaborative networking as objectives of music education research.

These situated, socially informed approaches stand in stark contrast to the standard educational views on musical creativity. While standard 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' [Webster 2003], situated approaches bring socially acquired musical experience to the forefront of the research agenda. Thus, they highlight two aspects that need to be considered in creativity-centered design: the place factor and the mutual processes of adaptation that emerge through social interactions. Both aspects can be handled by methods proposed in the context of ecologically grounded creative practices.

### **1.3. Ecologically grounded creative practices**

Western art practices have usually focused on what to do with musical materials, rather than what to do to empower people as creative musicians. Arguably, music creation can only be carried out by well-prepared, creative individuals who are versed in the secrets of Euterpe [Euterpe – Εὐτέρπη – 'well delighting' from Indo-European 'ei', 'to go' and 'terp-', 'to satisfy oneself']. Special stress has been placed on the concept of the individual activity done for self-fulfilling purposes. The view on musical creativity as an individual activity has also been adopted by technologically based musical practice. As a result, the constraints formerly imposed by acoustic instrumental writing – such as working indoors – and the exclusion of the audience as active participant in the creative process were inherited by mainstream computer music practices (see Wishart 2009 for an example of this perspective). Sonic art remains an activity carried out in the isolation

of the studio. This gap between the organizational systems applied on the musical material and the context where the material resources are gathered enforces creative techniques based on the objectification of sound. The studio as a compositional environment follows the model of the physics or the biology lab. Sounds are isolated and dissected according to well-established protocols, giving the composer total control over his creative product. The studio-centered working methods enforce the idea that the creative process consists of abstract relationships among sound objects masterfully executed by a well-trained musician.

In the late 1990s, the application of embedded-embodied theories on cognition [Gibson 1979] laid out a path to an alternative view of musical creativity. Windsor (1995) and Keller (1999a; 2000) provided the initial coverage of the embedded-embodied approach to music making and music perception literature. Through an acute and highly critical essay, Windsor (1995) brought several ecological concepts into the realm of musical analysis. His proposal – although tuned to the demands of studio-centered electroacoustic practice – highlighted the close affinity between sonic art practices and ecologically oriented theoretical efforts. He attempted to establish a bridge between the concept of affordance and the triadic representational model proposed by Peirce (1991), arguing for a sign-oriented reinterpretation of affordances. Working independently from a complementary perspective, Keller and Truax (1998) proposed a Gibsonian approach to music making. Ecologically grounded synthesis techniques were presented as a proof of concept of the applicability of the embedded-embodied view on cognition within the context of creative music making. Two ecologically grounded works featured examples of natural synthetic textures and everyday sonic events: “... *soretas de punta*.” (Keller 1998; see [Basanta 2010] for a thorough analysis of this piece) and *touch'n'go* [Keller 2000].

After Windsor's and Keller's initial proposals, several artists embraced embedded-embodied cognition as a conceptual and methodological basis for their creative practice. Matthew Burtner (2005; 2011) realized a number of compositional experiences involving field recordings and interactive techniques. As a reference to early perceptual research [Vanderveer 1979], he labelled his work 'ecoacoustics.' Agostino Di Scipio (2002) expanded the palette of synthesis techniques by applying iterated functions to produce natural textures. His compositional work *Audible Ecosystemics* [Di Scipio 2008] featured the use of space as a key parameter for real-time creative practices. Natasha Barrett (2000) and Tim Opie proposed techniques for gathering acoustic field data produced by animals and physical agents [Opie and Brown 2006]. Barrett's compositional work included the use and implementation of spatialization techniques based on ambisonics. Davis (2008) and Basanta (2010) adopted ecologically oriented approaches to increase the participatory appeal of their sonic installations. And Nance (2007) and Lockhart introduced ecologically grounded practices into the realm of instrumental composition [Lockhart and Keller 2006].

A common denominator of ecologically grounded creative practices is the close integration of sound processes shaped after natural phenomena with perceptual and /or social factors wrought by everyday experience. The ecocompositional paradigm that has emerged from the multiple creative projects realized since 1997 encompasses two strategies: (1) the construction of a theoretical framework for creative practices supported by embedded-embodied cognitive mechanisms [Keller 2000; Keller and Capasso 2006; Keller 2012]; and (2) the concurrent development of design techniques coherent with this theoretical scaffolding, featuring participation and emergence as the two central creative driving forces [Keller et al. 2011a]. Soundscape composition brought real-world context into the musical work. Ecocomposition sought to place

music creativity into real-world contexts. During the last decade, two strategies were developed for this purpose. On the one hand, music making involved reenacting experiences in their original geographical milieu [Keller 2004]. On the other, musical works were co-composed with the public [Keller 2000; Keller et al. 2011a]. Thus, ecocomposition took the act of creation out of the realm of the studio. Techniques such as accumulation and enactive social interaction helped to lower the usability requirements of musical systems, bringing the audience into the creative act [Keller et al. 2002].

## **2. Social factors: communities of practice**

One of the objectives of ubiquitous music research is to gather insights on the relationships between the subjects' profiles and the strategies they use to handle the creative tasks. 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 ubiquitous music experiments have adopted a parsimonious method for increasing tool access without hindering reuse of previous knowledge [Lima et al. 2012; Keller et al. 2013]. Tools are presented as opportunities for interaction, but they are not given as requirements until a series of preliminary planning studies has been 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 predetermined condition.

Community-based methods are at the center of ubiquitous music practice [Pimenta et al. 2012]. 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 ubiquitous music research: the communities of practice [Wenger 2010]. A community of practice is a social system that arises out of learning and exchange processes. This type of community unfolds through practice, not prescription [Wenger 2010:192], so it can be seen as an extension of the dialogical perspective [Freire 1999; Lima et al. 2012]. Take as an example open-source communities. Communities that are nimble and flexible – consisting of volunteer developers who make contributions either individually or as part of temporary teams with shared governance – foster imagination, engagement and consensus [Pimenta et al. 2012]. Brown and Dillon (2007) and Bryan-Kinns (2004) network music experiments suggest that these characteristics afford increased levels of participation in musical activities. Therefore, communities of practice should constitute a fertile context for creativity-centered design.

Summing up how social factors have impacted ubimus research, this section has focused on the use of social resources at several levels: (a) ubimus planning studies have provided insights on the relationships between the subjects' profiles and the strategies they use to handle the creative tasks [Lima et al. 2012]; (b) community exchanges of material and social resources have been used to support learning activities; (c) communities of practice were employed as the social grounding for creativity-centered design activities; (d) social interactions were used as tools for design assessment and critical evaluation; (e) socially shared resources have served as a factor for growth and consolidation of a community of practice engaged in ubiquitous music research [Pimenta et al. 2012]. By fostering social exchanges among music practitioners, the activity of prototyping creative products has been incorporated into creativity-centered design. Design activities – involving negotiation among artistic, computational and educational perspectives – have helped to adjust the objectives and methods of the ubimus research agenda. And at the longest time span, the formation of a ubiquitous

music community of practice – encompassing both novice practitioners and experienced designers – has encouraged the circulation of material and social resources feeding the community’s sustainable growth.

### 3. Material factors: volatility and rivalry

Keller and coauthors (2011b) define the material dimension as the collection of resources available to the participants of a creative activity. In the case of ubiquitous music systems, the material dimension encompasses the sound sources and the tools used to generate creative musical products and the material results of the musical activity. 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 the material produced. The stage *putting the pieces together* may involve selection, grouping and disposal of material resources; therefore both objective and subjective assessments may be necessary. Objective assessment demands measurements of the resource yield and the resource consumption as a function of time [Ferraz and Keller 2012; Keller et al. 2011c]. Bennett’s (1976) model suggests that musical creative processes start from a single germinal idea. Collins (2005) also adopts this view but allows for several musical ideas (he calls them *themes* or *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. 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 creative musical activity begins by exploratory actions or by a well-defined procedural plan with an explicit material objective. When the musical materials are given by the experimenter, it is not possible to draw conclusions regarding how the material resources are collected. This methodological problem is called *early domain restriction* [Keller et al. 2011b].

Focusing on creative music making as an activity [Barreiro and Keller 2010] has several implications on the study of material resources. Ubiquitous music phenomena involve both the locally available objects and the remote materials accessible through technological infrastructure. Therefore, we need to consider at least two types of resources: 1. the resources present on site, defined in the creativity literature as the *place factor* (i.e., *collocated resources*), and 2. the materials accessed through creativity support tools [Shneiderman 2007] which may or may not be collocated (i.e., *distributed resources*). Iannis Xenakis (1971/1992) suggested that creative musical activities may occur in-time or out-of-time. This idea has been adopted by the human-computer interaction literature under the labels of synchronous and asynchronous activities [Miletto et al. 2011]. Applying this notion to material resources introduces a new target for experimental work. Some materials may only become available during the creative activity and cannot be recycled for future use. Other resources may be repeatedly used in the context of asynchronous creative work. An example of the former case are the improvisatory performances based on network infrastructure. Each participant's action depends on the sonic cues provided synchronously by the other participants. These sonic cues are only available in-time, therefore they can be classified as *volatile material resources*. Other resources can be incorporated in the context of iterative cycles of creative activity. A good example is provided by the concept of musical prototype

[Miletto et al. 2011]. A musical prototype is a data structure that supports actions by multiple users through a network infrastructure. A single creative product is shared by the participants collaborating throughout the creative cycle. Participants access the musical prototype remotely and cooperate by doing direct modifications and by providing comments on their actions and on their partners' actions. Creative decisions are the result of a cumulative process of material exchanges that can last from a few hours to several months. Hence, we can say that a musical prototype is a *non-volatile material resource*.

Recent theoretical proposals on creativity generally label the results of creative activity as 'products' [Kozbelt et al. 2010]. If we take into account the ongoing mutual adaptations among agents and objects during creative activities [Keller and Capasso 2006], a functionally oriented description of the material resources becomes necessary. Material results of creative activity may be either resources or products depending on their role within the context of the activity. For example, the sounds collected in San Francisco's Bart transportation system (metro or subway) served as material resources for the creative product *Metrophonie* [Keller 2005]. The same collection of sounds were expanded through ecological modeling techniques [Keller and Berger 2001; Keller and Truax 1998] to be employed as material resources within the multimedia installation *The Urban Corridor* [Capasso et al. 2001]. In *The Urban Corridor*, the action of the participants shape the organization of the sonic matter [Keller 2012; Keller et al. 2002]. Every instance of the piece produces a personalized creative product that is different each time the installation is visited. In this case, instead of being delivered as a single creative product, the sound sources of *The Urban Corridor* are available as material resources for the creative actions exerted by the audience. Hence, while the sound sources and creative products can be clearly separated in *Metrophonie*, this separation is not possible in *The Urban Corridor*. In the latter, sound sources remain as material resources and the creative product is equated to the emergent qualities of the interaction among multiple agents within the ubiquitous music ecosystem.

A group of perspectives that has direct application in ubiquitous music research comprises the psycho-economic theories of general creativity [Rubenson and Runco 1992, 1995; Sternberg and Lubart 1991]. The underlying assumption of this group of theories is that creative activity both demands and produces resources. Economically oriented approaches provide opportunities for observation and quantification of variables that are hard to assess within other creativity paradigms (for a comparison among creative theories see Kozbelt et al. 2010). Given that available resources for creative activity are finite, they may be quantified. By observing the flux of consumption and production of resources, quantitative predictions may be linked to specific environmental conditions. The effectiveness of the creative strategy can be assessed by comparing the use of resources with the creative yield. The type of creative outcomes could be predicted by identifying what resources are available and how they are used throughout the creative cycle. And the relationship between resource consumption and creative waste can be used to assess the sustainability of the creative ecosystem under observation. Consequently, creative potentials and creative performance become linked to specific variables that can be studied through empirical work. Observable resources become the focus of the experiments, opening a window to quantitative comparisons among different strategies for support of creative activities.

From an economy-oriented perspective, material resources may be *rival* or *non-rival*. Rival resources lose value when shared. Non-rival resources can be widely distributed without losing value. Information is a good example of a non-rival resource. Information can be freely shared without any impact on its social value. Contrastingly, if

a food stock is partitioned within a community its value is reduced proportionally to its depletion rate. An empty food stock has no social value.

There are some interesting observations to be gathered through the application of the quality of rivalry in creativity-centered design. Resources for creative activities can be characterized by their level of relevance and originality [Weisberg 1983]. In the context of group activities, these two factors constitute opposite forces [Ferraz and Keller 2012]. Creative resources that are unique and have not been shared among group members keep their creative potential and have a high level of originality. Through sharing, original resources lose their creative potential while they gain acceptance among group members. The most relevant resources are the ones most widely distributed with the highest social acceptance. Therefore since creative rival (*c-rival*) resources lose value through social acceptance, they can negatively impact originality. On the other hand, creative non-rival (*c-non-rival*) resources can be freely distributed without affecting originality. Given that *c-non-rival* resources can be widely shared, they can attain higher levels of relevance than the *c-rival* resources.

Sound samples can be classified as creative rival resources. The novelty of the creative products that use samples decrease proportionally to the number of copies of the original sound. Deterministic synthesis models generate the same sound for the same set of parameters, so they can also be classified as *c-rival* resources. Given that physical objects produce different sonic results each time they are excited, the events they produce can be classified as *c-non-rival* resources. On a similar vein, a stochastic synthesis algorithm can render multiple events without producing repeated instances [Keller and Truax 1998]. Timbre-based musical practices – such as the use of distorted guitar sounds – are also examples *c-non-rival* resources<sup>2</sup>. An example of a creative application of resource degradation is provided by [Fenerich et al. 2013]. The authors used an iterative network transmission process to emulate the sonic feedback mechanism proposed by Alvin Lucier (1969) in his piece *I am sitting in a room...* [Lucier and Simon 2012]. In Fenerich's and coauthors' piece the disruptive noises of the network transmission furnish new material as each copy of the sound is sent through the network. The sonic output is the result of multiple degraded copies of the original sound.

#### 4. Summary and implications for creativity-centered design

Taking as a point of departure the current definition of ubiquitous music – “a research field that deals with distributed systems of human agents and material resources that afford musical activities through sustainable creativity support tools” – I proposed the use of two design qualities in creativity-centered experimental work: volatility and rivalry. Ubiquitous music experiments need to assess their resource usage through observations of creative products and material resources. While some creative techniques provide a high product yield, other methods tend to produce high levels of creative waste. Therefore, creative waste assessments may furnish a window to the resource flow mechanics of ubiquitous music ecosystems. From a resource-flow perspective, the volatility of the material resources employed is a design quality that can be applied to gauge the level of support for asynchronous activities. Persistent resources, such as network-shared musical data allied to consistent metaphors for interaction, may prove useful to support creative activities across multiple devices, involving access by multiple stakeholders. Ubimus research carried out during the last seven years suggests that the resources' volatility should be taken into account when designing ubimus ecosystems. Creative rival resources do not add value to the creative product when

<sup>2</sup> This example was provided by an anonymous reviewer.

shared. Therefore, distribution of copies of creative rival resources among group members should be reduced to a minimum. This limitation does not apply to the case of creative non-rival resources, (e.g. synthesis techniques that generate new material for each iteration [Keller and Truax 1998]). These resources can be shared without imposing a steep reduction on the originality of the stakeholders' creative products.

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