Situating digital tools through ubiquitous virtuality: confluences of art, architecture, and activity in HCI

Romeu Luiz de Castro Bessa
Iowa State University

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Situating digital tools through ubiquitous virtuality: confluences of art, architecture, and activity in HCI

by

Romeu Luiz de Castro Bessa

A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Human-Computer Interaction

Program of Study Committee:
Mikesch Muecke, Co-major Professor
Jamie Horwitz, Co-major Professor
Michael Golec
Mark Rectanus
Ana-Paula Correia

Iowa State University
Ames, Iowa

2008

Copyright © Romeu Luiz de Castro Bessa, 2008. All rights reserved.
To Filipe, my son and best friend;

To Bia, Gui, and Dú for opening their hearts to me and embracing a life together;

To my parents, Pedro Parafita de Bessa (in memoriam) and Maria Célia de Castro Bessa, for their love and for setting the ethical standards that have guided me throughout my life;

To Tilei, Fátima, Gina, and Zilá (in memoriam), for their love and support.
"(...) Dias inteiros de calmaria, noites de ardentia, dedos no leme e olhos no horizonte, descobri a alegria de transformar distâncias em tempo. Um tempo em que aprendi a entender as coisas do mar, a conversar com as grandes ondas e não discutir com o mau tempo. A transformar o medo em respeito, o respeito em confiança. Descobri como é bom chegar, quando se tem paciência. E para se chegar, onde quer que seja, aprendi que não é preciso dominar a força, mas a razão. É preciso, antes de mais nada, querer."

[(…) Entire days of calmness, nights of ardency, fingers at the helm and eyes at the horizon, I discovered the happiness of being able to transform distance into time. A time in which I understood the things of the sea, in which I learned to talk with the big waves and to not discuss with the bad weather. To transform fear into respect, respect into confidence. I discovered how good it is to arrive, when we have patience. And to arrive, wherever it is, I learned that it is not necessary to dominate force, but reason. It is necessary, above all, to desire.”]

(Amyr Klink, *Cem Dias entre Céu e Mar / One Hundred Days between Sea and Sky*)
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I want to thank my advisors, Professors Mikesch Muecke and Jamie Horwitz from the Architecture Department and the Interdisciplinary Graduate Program in Human-Computer Interaction at Iowa State University, for their friendship and full support throughout the development of this dissertation. I would like to also thank the other three members of my committee, Professors Mike Golec (Art & Design), Mark Rectanus (World Languages and Cultures), and Ana-Paula Correia (Center for Technology in Learning and Teaching), for their careful reading of the dissertation and their comments. I want to extend my thanks to the staff of the Virtual Reality Applications Center (VRAC), in particular to Lynette Sherer, Beth Hageman, and Pam Schill, and to the staff of the Architecture Department, in particular to Jean Jonas, for going beyond their administrative duties and helping keep a high spirit at the workplace.

I also want to thank all the people that have come into my life in one way or another, and who have contributed to make it such a rich and fulfilling experience.
ABSTRACT

Over the last twenty years computer engineers introduced concepts such as “ubiquitous computing”, “embodied virtualization” (Weiser, 1991), “embodied interaction” (Harrison and Dourish 1996), “tangible bits” (Ishii and Ulmer, 1997), and “seamful interweaving” (Chalmers and Galani, 2004) in an attempt to describe and explain the increased embedding of computer technology into designed objects and environments, and to emphasize the crucial agency of the human mind and body in Human-Computer Interaction (HCI). Since the mid-1990s the apparent ‘dissolving’ of computers and sensors into ordinary and extraordinary environments is the focus of research and concern across the humanities, social sciences, and engineering as scholars attempt to understand how HCI influences the psychological, social, economic, aesthetic and ethical context in which we live (Castells, 1996, 1997, 1998; Smith, 2000; Hallnäs and Redström, 2002; Cuff, 2003; Bohn et al., 2004; McCullough, 2004; Hayles, 2005; Grudin, 2006).

Examples of how this understanding is being pursued can be found in Hayles’ argument that humans have evolved by using their cognitive powers to shape artifacts and technology, which, in turn, have been instrumental in shaping human cognition (Hayles, 1999). She calls this symbiotic relationship between humans and technology a “feedback loop” — new cognitive powers generate new technology, which in turn generate new cognitive resources then used to generate new technology. Coming from an art historical point of view, Summers argues that cognitive “notional operations” (i.e., referring to dimensional relations such as ratios, sizes, etc.) are a consequence of facture, i.e., of the actual making of artifacts. Bringing together insights drawn from working on the development of technology and looking at the social implications of such development, Brown and Duguid (1994) argue that besides the intended use that motivated the development of particular artifacts or of a particular technology, it is their “latent border resources” — resources that lay beyond their original intended uses — that support our shared use of them.

Building on a cross-disciplinary discourse, I outline in this dissertation a conceptual outlook — which I call ubiquitous virtuality — to address the changing conditions of HCI in the context of ‘smart’ technology and pervasive computing. Addressing a condition in which ‘smart’ tools are interwoven in the material fabric and structure of everyday environments this dissertation explores how new individual and collective subjectivities are being built at the turn of this new millennium by putting together elements drawn from the history, theory and practices of art, architecture, and HCI. A number of archival and field researches situate these elements within the context of ‘smart’ technology. Activity Theory, an analytical framework that has been proposed to support the study of context in human-computer interaction, is used in an evaluation to help clarify how this cross-disciplinary discourse can be applied to HCI.

Keywords

Human-Computer Interaction; Interaction Design; Ubiquitous Computing - Smart Environments; Handheld Devices - Mobile Computing; Information Architecture; Activity Theory; User-Centered Design - Human-Centered Design; Evaluation; Usability Research.
INTRODUCTION

The concept of ubiquitous virtuality developed in this dissertation has been motivated by a number of research interests and projects encompassing about twenty-five years of practice in art and in-depth reflection about its role in society. These interests and projects can be grouped into four main periods, with each one involving some major public outcome, either a significant solo exhibition or a graduate degree, and in some cases both. These four stages are: 1) *Quase-Arte* (Quasi-Art); 2) *riverflow*; 3) *Nonothing*; and 4) *Ubiquitous Virtuality*.

The first period, *Quase-Arte*, refers to a number of art projects produced between 1982 and 1988. It is also the title of a solo art exhibition held during that time period. *Quase-Arte* is a reference to “quase-cinema”, an art collaboration between Brazilian artist Hélio Oiticica and Brazilian filmmaker Neville D’Almeida. In “quase-cinema”, Oiticica and D’Almeida explored what they called “nãonarração” (non-narration, in English) by using non-linear, ‘non-naturalistic’ cinematic images blended in art installation environments in which the viewer/user was invited to fill in the blanks and construct his/her own significant sequence through free associations. The artists argued that “quase-cinema” was neither cinema nor installation in a strict sense, but something in between. Like Oiticica and D’Almeida’s “quase-cinema”, the projects I developed under *Quase-Arte* also explored what I refer in this dissertation as ‘latent border resources’. These projects challenged the use of standard art materials and supports and looked for resources within the ‘built’ and ‘natural’ environment.

For example, instead of canvas or paper, the two most common supports for painting and drawing, *Nights in the Highland* (“Noites no Sertão”), a series from this period, uses roof tiles common in the historical Baroque towns of Brazil. In this case, the usual ‘invisibility’ or
‘impartiality’ of canvas or paper — which as we will discuss later are not really invisible but specific formats that create certain ‘conditions of presentation’ — is denounced by the use of a support that has strong cultural significance for some communities. The tiles are recognized in Brazil as a sign of a particular urban environment associated with social-economical conditions that brought these communities into existence in the 17th and 18th centuries. These cities remain to this day strong cultural references in Brazil.

![Figure 1](image.png)

Figure 1. Images from the Quase-Arte period. On the left, Noites no Sertão / Nights in the Highland #1 (1983); on the right Noites no Sertão / Nights in the Highland #2 (1983). Both mixed media on roof tile.

The second period, riverflow\(^1\) refers to a period of about four years (1987-1991) during which time I explored what was at the time the beginning of the popularization of the computer. This popularization was a direct result of the introduction of desktop systems that were cheaper and

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\(^1\) riverflow started to be developed during my third year as an undergraduate at the School of Fine Arts, Federal University of Minas Gerais (Brazil), when I was invited by the school’s director to participate in an interdepartmental research group (fine arts, design, and computer science) to study possible collaborations between the departments. My interests at the time centered on the connection between fine arts (drawing/printmaking) and computers. These interests led me to pursue a Master’s at Illinois State University. riverflow: Visual Reflections on the Nature of Some Dynamic Systems is the title of that dissertation. At that time, the art program at Illinois State had among its faculty three outstanding professors teaching painting, drawing, and color theory, and an college-wide office dedicated to promoting the teaching, learning and use of digital technology (ORAT – Office of Research in Arts Technology). This combination made the school a very interesting place to study the possible transitions and resistances to digital technology ‘in the wild’. It also provided an interesting ground for observing the power dynamics that such ‘encounter’ still arises, and how they are carried over to the ‘commercial’, i.e., non-academic art world in general.
more accessible to non-experts. Although not much of the technology (software and hardware) being developed was specifically targeted at adding a digital component to painting and drawing languages, the projects targeted borderline resources of digital technology that could be transformed into a painting/digital painting discourse aimed at relating ‘traditional’ and digital media. This phase ended with a one-person show that was part of the requirements for a Master’s degree in studio arts — *riverflow: Visual Reflections on the Nature of Some Dynamic Systems*.

![Figure 2. Images from the *riverflow* period. On the right, *Circuit-Systems 101*, 1990, tempera on paper; on the left, *Systemic Image XXIX*, 1991, tempera on paper.](image)

The word *riverflow* is a reference to *riverrun*, the first word in James Joyce’s *Finnegans Wake*. Joyce’s novel has been very influential for its experimental use of ‘cycles’ to articulate new forms of narrative, and for its extraordinary exploration of the English language. The book starts with the word “riverrun” which is also the last word of the book’s last sentence. Completing this sentence requires a return to the beginning of the book. In *riverflow*, the idea of ‘cycle’ was used to relate the electrical flows running through computer circuit boards to paint flows running on paper and on canvas. *riverflow* explored this clash between these two very different forms of information processing, which are, nonetheless, intimately related. Image and text are forms of
codes that have been developed to expand real space with a virtual counterpart. The images on the previous page are examples from this period.

The third period, *Nonothing*, expanded the previous work relating traditional and digital painting media but with an emphasis on color-based pictorial space. In this type of space color is the driving element in the formal organization of the virtual space, in contrast to the more popular models of space representation based on a geometric organization, such as one or two-point perspective. In *Nonothing* models of color-based space — “hue contrast”, “tonal layer”, “luminosity”, etc. — provided a ‘platform’ from which to explore the internal dynamics of what I now refer to as ‘communities of practice’. The projects developed during this period attempted to check the verbal and/or written discourses used to set up the rules and norms for painting production against the actual perceptual responses that were generated by the color-based virtual spaces. The faculty and students of the department of art at the University of Illinois at Urbana-Champaign formed the primary ‘community of practice’, with additional communities encompassing other departments as well. That university has a long history of providing very sophisticated facilities and financial assets for research in engineering and computer science, some of which is devoted to digital visualization technology. Those facilities and technical resources were intended to create the conditions for multi-disciplinary collaborations through laboratories such as the Renaissance Lab, a sophisticated visualization facility at the Beckman Institute for Advanced Science and Technology.

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2 The title *Nonothing* comes from a free translation of ‘Nonada’, the opening word of *The Devil to Pay in the Backlands*, a novel by Brazilian writer Guimarães Rosa. *Grande Sertão: Veredas*, as it is known in Portuguese, is regarded as having done for Portuguese and Brazilian literature what James Joyce’s *Ulysses* and *Finnegans Wake* did for English. *Grande Sertão* has had an enormous impact in Brazilian popular culture as its characters and language have made their way into popular culture. This exchange in itself can be related to the concept of ‘cycle’ as much of the linguistic experiments in the novel originated in popular regional speech patterns.
The Beckman is a large “interdisciplinary research institute” founded on the premise “that reducing the barriers between traditional scientific and technological disciplines can yield research advances that more conventional approaches cannot.” Reducing this type of barrier requires a willingness from different ‘communities of practice’ to reach out to other communities. In the case of the Beckman Institute, it reached out to departments in the College of Fine and Applied Arts (Architecture, Art & Design, Theater, Music, etc.) and in the humanities (Anthropology, Psychology, Linguistics, Philosophy, etc.). The projects in Nonothing explored what I now refer to as “creativity, reflectivity, and resistances” to the cultural changes associated with technology. These are the terms used by Kaptelinin and Nardi as being “crucial to understanding technology” (2006).

The fourth period, Ubiquitous Virtuality, which includes this dissertation and for that reason shares its name with it, revisits the previous projects and addresses some more recent ones through the perspective of ‘activity’. This is being done within the broader context of HCI and interaction design. Ubiquitous Virtuality attempts to describe, evaluate, explain, and predict new individual and collective activities in the context of ‘smart’ technology by building on the history, theory and practices of art, architecture, and HCI.

Figure 3. Images from the Nonothing period. On the right, Modern Cave II, digital painting, 1992; on the right, Mirage, digital painting, 1996
This period started with my return to the US in 1998 and the five-year teaching experience I had at Illinois State University, two of which in the painting/drawing area and three in the Arts Technology Program, a new interdisciplinary program created by the Schools of Art, Theater, and Music. At the end of this five-year period I enrolled in the MFA Program in Electronic Visualization at the University of Illinois at Chicago, which has been run by the Electronic Visualization Laboratory (EVL), one of the first interdisciplinary labs set up to promote collaboration between computer science and the arts. However, after one year at EVL I decided to pursue a doctorate degree in human-computer interaction.

*Ubiquitous Virtuality* derives from these previous experiences, from the cultural and historical contexts in which they were created, including attempts to create context-driven multisensorial immersive virtual environments and mixed reality projects. The history, theory and practice of art and architecture played crucial roles in setting up those multisensorial contexts, of which *SoftSpots* is an example.

![Figure 4. Snapshots of SoftSpots, a VR Art project developed between 2004 and 2005 at the Electronic Visualization Laboratory (University of Illinois at Chicago) and at the Virtual Reality Applications Center (Iowa State University).](image)

With *Ubiquitous Virtuality* the issues related to virtual and real spaces and places that were being investigated to create immersive environments is brought out ‘in the wild’, i.e., into the everyday environments in which we live. These environments are increasingly a mixture of real and virtual spaces and places, and although this mixture has not started with the recent development of
digital technology, it has been dramatically impacted by it. With *Ubiquitous Virtuality* I intend to explore how art and architecture contribute and shape ‘activity’ in our everyday life and how their history, theory and practice need to be brought to light when developing conceptual tools and physical artifacts that shape activity in the context of ‘smart’ technology.
PART I - DISCOURSE
CHAPTER 1: INTRODUCTION TO DISCOURSE

Initial remarks

Over the last twenty years computer engineers introduced concepts such as “ubiquitous computing”, “embodied virtualization” (Weiser, 1991) and “embodied interaction” (Harrison and Dourish 1996) in an attempt to describe and explain the increased embedding of computer technology into designed objects and environments, and to emphasize the crucial agency of the human mind and body in Human-Computer Interaction (HCI). Since the mid-1990s the apparent ‘dissolving’ of computers and sensors into ordinary and extraordinary environments is the focus of research and concern across the humanities, social sciences, and engineering as scholars attempt to understand how HCI influences the psychological, social, economic, aesthetic and ethical context in which we live (Castells, 1996, 1997, 1998; Smith, 2000; Hallnäs & Redström, 2002; Cuff, 2003; Bohn et al., 2004; McCullough, 2004; Hayles, 2005; Grudin, 2006).

Scholars theorize the history of art and objects by bringing together diverse fields in social sciences, comparative literature, and history of science. Art historian George Kubler (1962), for example, argued that objects and ideas combine into “a visible portrait of the collective identity” and proposed the expression “history of things” to reunite the history of art with the history of science and technology. Coming from disciplines in science and literature, N. Katherine Hayles (1999) argues that this collective identity is the result of humans using their cognitive powers to shape artifacts and technology, which, in turn, have been instrumental in shaping human cognition. She calls this symbiotic relationship between humans and technology a “feedback loop” — new cognitive powers generate new technology, which in turn generate new cognitive resources then used to generate new technology. For Summers (2003), an art historian who has
been exploring art’s role in the structuring interaction and social spaces, this feedback loop is shaped by our ‘cardinality’, i.e., “the specific conditions of individual human real spatiality, defined by uprightness, size, facing, capacities for movement and actions.” He also contends that artifacts make “human purposes present to us” because by being ‘factured’, i.e., by actually being made, they record configurations of materials gathered, selected and processed in one way or another. Combining disciplinary theory and practice in technology and social sciences, Brown and Duguid (1994) argue that besides the intended use that motivates the development of particular artifacts or of a particular technology, it is their “latent border resources” — resources that lay beyond their original intended uses — that support our shared use of them. The mobilization of these resources plays an important role in stimulating the cognitive operations that support the feedback loops that Hayles talks about. However, for Brown and Duguid the fast pace of current innovations involving digital technology put these potential resources at risk of never being uncovered, resulting in missed opportunities of having them converted from latent states into new resources that can be shared by a community. For social scientists Lave & Wenger (1991), the transformation of latent resources into shared resources involves a process of “co-participation” among members of formal or informal communities. They argue that such co-participation is critical in any learning process and proposed the term ‘community of practice’ to situate learning within a context that encourages ‘social participation’. Communities of practice make possible the development of a “shared repertoire of communal resources (routines, sensibilities, artifacts, vocabulary, styles, etc.)”, which in turn are important in transforming latent resources into useful active ones.

In light of all this we can start to see why the need to interrogate and theorize the concept and the role of “context” in the midst of this rapidly changing technological environment has
informed several decades of applied research between the human, the social sciences, design, and computer engineering. Among the many frameworks that have been proposed to study context in HCI — situated actions, distributed cognition, etc. — Activity Theory is one of the latest and most promising of them (Nardi, 1996; Kuuti, 1996; Bødker, 1998; Engeström, 1999; Kaptelinin & Nardi, 2006). AT defines context as “the relations among individuals, artifacts, and social groups” and activity as “a purposeful interaction of the subject with the world” (Kaptelinin & Nardi, 2006). These concepts of context and activity are the foundation of a powerful analytical model that can be used to study any type of activity, including ones mediated by computers and ‘smart’ technology. In line with its interest in context, AT focuses on “the purposeful, mediated, human social activities” and looks at the use of technology as being significant at several levels and not just as “information processing” (idem). This focus makes it well suited to study contemporary trends of multitasking, i.e., managing simultaneous activities with the help of digital technology.

Kuuti (1996) argues that by including a “minimal meaningful context” in the analysis of a subject’s activity, AT offers a model that can take in consideration the fact that individuals participate in several activities simultaneously and that each activity “contains several artifacts (e.g., instruments, signs, procedures, machines, methods, laws, forms of work organization, etc.)”. Kuuti also argues that each mediating tool and artifact is “both enabling and limiting” and that any systematic analysis of the relations between an individual and his or her environment must include the community formed by those that share the same object, i.e., Lave & Wenger’s communities of practice. Kuuti’s discussion of AT relies on a model first proposed by Engeström, which is based on three “mutual relationships between subject, object, and community”: 1) subject-object mediated by tools and artifacts; 2) subject-community mediated
by rules; and 3) object-community mediated by division of labor (Kuuti, 1996). The fundamental structure of this model is shown in the figure below.

Figure 5. Engeström’s model showing the complex dynamics of the ‘mediating relationships’ between the three poles. (Source: Engeström, 1999)

Kuuti contends that “some potential features of an object remain ‘invisible’ to a subject because at the same time that he or she is “empowered” by the transformation processes that are “crystallized” in a tool and artifact, the subject is also “restricted” to the interactions made possible by that particular tool or artifact. Communities can function in similar fashion, as they provide rules that enable transformational processes aimed at producing outcomes recognized and validated by their members, while also providing “explicit and implicit norms, conventions, and social relations” that can equally limit how tools and artifacts are to be used. Objects — “prospective outcomes that motivate and direct activities, around which activities are coordinated, and in which activities are crystallized” (Kaptelinin & Nardi, 2006) — are not just “physical things” or “ideal objects” but also socially and culturally defined ‘objectives’. As such, objects are both “external and internal” and can be constrained by resistances and affordances provided by the environment as well as by ‘subjective’ counterparts incorporated by a subject as part of his or her constitutive values or values shared by a social group.
Building on a cross-disciplinary discourse, I propose to investigate the changing conditions of human-computer interaction in the context of ‘smart’ technology and pervasive computing. This investigation will be conducted through the construction of something like a ‘cultural observatory’, i.e., a place from where these changes can be observed. This observatory is built upon the history, theory, and practices of art, architecture, HCI and interaction design, and it will be used to address this condition in which digital tools are interwoven in the material fabric and structure of everyday environments. I call the context that emerges from these changes “ubiquitous virtuality”.

The ‘smart’ technology milieu

‘Smart’ technology is a term being used in HCI and interaction design to suggest the embedding of computing capabilities in materials, objects, homes, offices, schools and cities. ‘Smart’ objects are designed to be aware of one another and/or of their users by adding computing and sensor capabilities to otherwise regular objects. ‘Smart’ environments combine ‘smart’ materials with ‘smart’ objects and additional layers of computing and sensors embedded into the architectural setting. The term ‘smart’ is closely linked to ubiquitous and pervasive computing, both of which are movements that promote the integration of computers within objects in the context in which they are used. This integration makes computers ‘disappear’ into objects designed to enhance our activities within a particular context. A context is understood as entailing objects and architectural settings, humans acting within them, and information made tangible through interactions between subjects and between them and the environment.

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3 The term “disappearing computer” is often used in the European Union to promote an agenda similar to the one being advanced by ubiquitous computing.
<table>
<thead>
<tr>
<th>Categories of ‘smart’ technology</th>
<th>‘Smart’ systems</th>
<th>‘Active’ systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensors embedded in the structure</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>React to environmental or data stimuli</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Shape memory effect</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Example:</td>
<td>Smart textiles such as Philips’ <em>Lumalive</em></td>
<td>Active fabrics such as ESI’s HASCO fabrics</td>
</tr>
</tbody>
</table>


The push for the development of ‘smart’ technology has also deeply impacted materials science, in some cases by transforming the composition of materials that have been remarkably important throughout human history, as is the case of fabric and paper, for example. Under the general term of ‘smart’ materials there are two main categories: “smart” and “active”. The first category includes materials with sensors embedded in their structure, which preserves their tactility while adding a layer of digital information. The materials can “sense and react to environmental stimuli, such as those from mechanical, thermal, chemical, and magnetic sources” (Tao, 2001). Textiles with “power and data transmission” capabilities that can be transformed into “personal area networks” are examples of this category (idem). “Active systems”, on the other hand, refer to materials that retain a “shape memory effect” or can return to a previous structural state (Ji et al, 2006). They can be, for example, “self-healing”, which means that once scratched or deformed in some way they return to their original form. What is important in both cases is that the long-standing ‘facture’ of ordinary materials and objects is being radically altered with the incorporation of digital technology.
‘Smart’ technology is also changing objects even without changing their constitutive materials. For example, ClearBoard — a sharing ‘drawing board’ able to keep eye contact between participants in realtime in local and remote collaborations (Ishii and Kobayashi, 1992) — and the Conference Assistant — a complex context-aware conference setting capable of handling several people, multiple locations and diverse activities (Dey et al, 2001) — are among projects of ‘smart’ technology being developed for offices. The SmartKG (Smart Kindergarten) is an example of ‘smart’ technology used to enhance early childhood education (Steurer and Srivastava, 2003). A number of ‘smart’ houses, such as the Gator Tech Smart House at the University of Florida and the House_n at MIT use ‘smart’ technology to create a “secure residential environment” by developing, for example, sensor networks embedded under tiled floors to sense and map the residents’ movement, beds that monitor occupants’ sleep patterns, refrigerators that can monitor the residents’ food consumption and automatically prepare shopping lists that are sent to on-line grocery stores, and blinds that can automatically control ambient light (Helal et al, 2005).

‘Smart’ technology is also transforming the public urban environment by impacting the design and construction of buildings and other infrastructure that shape urban life. The impact of such transformations can be so significant that urban planner Dana Cuff (2003) has suggested the term “cyburg” to indicate new urban environments that are saturated with computing capacities. She emphasizes that this computation is “spatially embodied” in the environment and argues that ‘smart’ technology when used in urban space creates the need to move the discussion to the “public sphere”. Cuff uses this term to imply “not only physical space but also the metaphorical space of public discourse, social norms, interaction, and social sentiment” (idem). With the concept of ‘cyburg’ Cuff marks her opposition to the idea of ‘cyberspace’, which she defines,
based on William Gibson’s original term used in *Neuromancer*, as having “no physicality, no matter, and no Cartesian duality”.

However, despite the fact that art and architecture have always impacted the way we live and have played a crucial role in the facture, usage, and aesthetic value of everyday objects and environments, they have been only marginally integrated into the process of developing ‘smart’ technology. This situation reflects a larger trend in HCI to relegate non-technical areas to minor roles in formulating its theoretical framework and in shaping its practice. This situation is problematic, if not outright dangerous. Jürgen Bohn et al (2004), for example, warn that the ubiquitous distribution of ‘smart’ technology into everyday objects can create “fascinating possibilities” but because it will accompany us throughout our entire lives its impact will be far greater and further reaching than the Internet, which, needless to say, has had a tremendous impact in contemporary life. Summers (2003), speaking from an art historical perspective, contends that contemporary technology is changing some of the “millennial conditions of human conditionality making possible, for example, the actual experience of weightlessness, of high speed, of instantaneity and simultaneity”. ‘Smart’ technology is already influencing us individually by changing the tools and artifacts we use to achieve our objectives. It is also impacting and re-configuring our communities and changing the way we communicate with one another. The widespread use of cellular phones and their increasing technical features is a clear evidence of that. Therefore, it is argued in this dissertation that psychological, social, aesthetic and ethical concerns must be more assertively brought into HCI, so that the development of ‘smart’ technology can be shaped by a broader set of issues and not just ‘technical’, engineering and scientific considerations.
Prelude to linking art, architecture and Activity Theory

Although AT offers a robust model for the study of context, the model does not openly addresses the relationship between space and place. However, we cannot forget that a ‘subject’ as adopted by AT is an individual with a body and that, as argued by Casey (1993), body and place are “congruent counterparts” because each one needs the other at such a fundamental level that there is no body without a place. Communities, another pole in AT’s triangular model, cannot be dissociated from ‘place’ either as they are formed around “enclosures”, areas distinguished from their surroundings to include some people and exclude others according to social rules, divisions of labor, economic interests, etc. (Summers, 2003). Digital ‘enclosures’ add other layers to this association between ‘community’ and ‘place’. Furthermore, if we assume that ‘activity’ is “a purposeful interaction of [a] subject with the world”, as defined by Kaptelinin & Nardi (2006), then much has to be learned from the history, theory and practice of two areas that bring together scholars and practitioners deeply invested in issues related to space and place.

Art historian David Summers’ description of the plane as “the condition for what we regard as civilized order and activity, a new basis for activities from weaving to painting… for writing, tabulation and mathematics, for the planning of buildings and cities, and for mapping” (Summers, 2003) is an example of the kind of conceptual resources being brought from art and architecture to describe the context I am defining as ubiquitous virtuality. The development of the plane was critical for the development of virtual space — the representation of three-dimensions in two — and it also made possible what Summers calls “new conditions for social relations”. He argues that with the development of the plane, space became “an objective reality, subject to visual appreciation, analysis, theory, classification and management” (idem). Derrick de Kerckhove (2001) points out that the alphabet is among the new conditions created by the
plane. For de Kerckhove “the use of letters… introduced a new relationship to space among the cultures that practiced it”. He considers the alphabet a “core technology of human information-processing”, and argues that “the connection between the Greek alphabetic literacy [which added vowels to the Phoenician’s model] and city grids is neither fortuitous nor accidental, but direct”. He relates the alphabet to the development of perspective later on, because “the need to align objects in space in terms of their proportionate relationships is an effect of the practice of reading and writing, of how we make use of the optic chiasm.” These technologies created what de Kerckhove, Summers, and other authors refer to as a “visual bias” (Ong, 1982; Pallasmaa, 1996; de Kerckhove, 2001; Summers, 2003; McCullough, 2004; Malnar & Vodvarka, 2004), i.e., “a frontal relationship with the world”. For de Kerckhove, digital networks and virtual reality are challenging this relationship by creating a “surround quality” for information processing and cognitive explorations.

*Ubiquitous virtuality* is the term I am proposing for the context created by this surround quality as it is merged into the “cultural capital that is the built environment” (McCullough, 2004). The cultural observatory put together in this dissertation emerges from conceptual synergies such as the one between Casey’s (1993) assertion that “a building condenses a culture in one place” and McCullough’s argument that architecture provides “a fixed form for the flows engineered by pervasive computing”. From such synergies we can observe a context for interaction design aimed at triggering new individual and collective subjectivities.

These subjectivities are being made possible by new forms of information processing, which in turn are opening new cycles of cognitive explorations and generating new activities at a local and global scale. Because every community assigns different rules to its subjects and divides labor depending on which objectives its members deem relevant along gender, class, education and
ethnic background lines, for example. This dissertation explores some activities to disclose the
dynamics and in some cases the arbitrariness of some of these assignments. It does that by
investigating the context for representations and experiences of real and virtual spaces and
places, and for human activity with 'smart' technology, in what de Kerekhove calls a “connected
architecture”, i.e., an architecture aimed at managing physical, mental, and virtual spaces.

I believe that such investigation promotes collaboration among different communities of
practice and reflects the efforts already being made within the HCI community to move beyond
any limited vision of what is relevant in human interactions with computers. This limitation has
began to be questioned by computer scientists such as Jonathan Grudin (2005, 2006), Paul
They have argued that HCI should reach beyond its traditional, engineering-related concerns,
create new bridges with other areas in the humanities and the arts, and swirl HCI towards a
broader interdisciplinary and inter-cultural direction. Dourish, Chalmers, and Svanæs have done
that by using Merleau-Ponty’s arguments in favor of repositioning the body at the center of any
analysis of perception, mind and intelligence, thus opening HCI to phenomenology. Petersen,
Tractinsky, Udsen, and Fishwick have done the same in relation to aesthetics. Fishwick has gone
as far as proposing using aesthetics as a “catalyst” for modifying “the core components of
computer science, its areas of study, and its methodologies”. With ubiquitous virtuality, I make a
similar claim for a broader set of issues central to the history, theory and practice of art and
architecture.

It will be shown throughout this dissertation that art can be particularly helpful when, following
the interdisciplinary cultural perspective of philosopher and media theorist Vilém Flusser
(2002a), it is understood as “any human activity that aims at producing improbable situations”. This usefulness is due to the fact that improbable situations produce maximum information. Not all situations need to be improbable — after all, comfort zones are also important for everyday life. It is, nonetheless, important to understand how improbable situations emerge, and how they are transformed and assimilated. With this in mind, Flusser proposed a “cycle of aesthetics” because according to him, an aesthetic object is an object that is “capable of being experienced” and we can only fully experience what is “new”. The “new” can be experienced because “a ‘new’ situation is terrifying if seen from the context it emerges from, it is unexpected and therefore experienced as something hateful, ugly” (idem). Flusser claims that the novelty of his four-stage cycle — ugly-beautiful-pretty-kitsch — arises by using “habit” as the criteria for judging where something fits into it, because with habit as criteria the cycle “can no longer be linear” (Flusser, 2002a). Flusser’s use of “ugly” is supported by a similar idea put forward by art historian George Kubler — mentioned earlier for having coined the expression “history of things” to reunite the history of art with the history of science and technology — who argued that “the act of invention is distasteful to the majority” (1962).

The dissertation explores such conceptual synergies to promote interaction design aimed at triggering new individual and collective subjectivities, and to better contextualize representations and experiences of real/virtual spaces and places and human activity in the context of 'smart' technology and pervasive computing. Linking the history and practice of art and architecture with HCI research is a vital step towards understanding the historical antecedents of interaction design and towards recognizing the profound changes in human conditions and actions triggered by digital technology.
Structure of the dissertation

The chapters have been grouped into three parts. Part I — Discourse — includes this introduction and two additional chapters. Chapter 2 — The Contribution of Art and Architecture to Theorizing HCI as a Living Context — discusses how art and architecture can help structure a more robust representation of context in HCI and how they can enrich concepts such as ‘latent border resources’ and ‘communities of practice’. Chapter 3 — Concepts of Activity Theory and the Dynamics of Cultural Change — summarizes AT’s conceptual framework and prepares the ground for the case studies.

Part II — Case Studies and Field Research — is dedicated to detail a number of case studies and field research used to evaluate the concepts being coalesced into this cultural observatory. Chapter 4 — Evaluating Latent Border Resources: a case study of Logitech’s io2 Digital Writing System — evaluates the possibility of expanding the io2’s use as a digital drawing system. Chapter 5 — Exploring Art as Activity: a case study — discusses the development of Brazilian artist’s Lygia Clark’s oeuvre as an exploration of latent border resources in art. The focus of the study is on Clark’s transition from a position of “producer” of art towards that of a “proposer of conditions for the receiver to be able to let himself/herself set off into the undoing of forms… in favor of the new compositions of fluxes…” (Rolnik, 1997). Chapter 6 — The Built Environment and ‘Smart’ Technology: a comparative study — discusses two different approaches to the development of ‘smart’ environments. Chapter 7 — Evaluating Activity with ‘Smart’ Technology: a case study of four communities of practice — evaluates how four different groups of undergraduate students define activity when using a ‘smart’ object. The participants in this study were undergraduate students majoring in art and design, architecture, computer science / computer engineering, and creative writing.
Part III — Implications and Applications — contains the final chapter — Situating digital tools through ubiquitous virtuality — in which the final considerations of the implications and applications of *ubiquitous virtuality* are drawn.

Whenever possible, images, tables, and charts have been added to illustrate the points addressed in the text. Footnotes are added throughout the dissertation to provide additional information about the topics being addressed in the main text without disrupting the flow of the arguments. An extensive bibliography is included at the end of the dissertation.
CHAPTER 2: THE CONTRIBUTION OF ART AND ARCHITECTURE TO THEORIZING HCI AS A LIVING CONTEXT

Introduction

In an editorial for the journal Leonardo, Rudolf Arnheim argued that art is a “human need” as “essential” as biological needs (Arnheim, 1986). He contended that human beings “need” to make sense of their environments, and that science and art are the “two professionalized versions of the two ways our minds have developed to that end” (idem). According to Arnheim, science develops “intellectual principles” that are needed to understand observed events while art lets us “experience” what constitutes the world in a “clarified, orderly and impressive” way. For Arnheim we need the tools provided by both of these systems to handle our existence.

Following a similar line, Kubler argues that the ‘needs’ identified and grouped as ‘science’ and ‘art’ become ‘tools’, ‘instruments’, ‘artifacts’, ‘symbols’, and ‘expressions’ when they “pass through design into matter” (Kubler, 1962). As mentioned earlier, he called the combined history of all these results the “history of things”.

The complementary nature of art and science is also captured by N. Katherine Hayles’ expression “feedback loop” which she uses to explain the co-dependence and intersecting currents that take place between “technologies and perceptions, artifacts and ideas” (Hayles, 1999). She argues that this interplay between informational patterns and material objects occur in historically specific contexts and the feedback loop that occurs between them determines “shifting configurations” for the co-existence of “human” and “posthuman”. In How We Became Posthuman Hayles defines the posthuman as a view of the human that “privileges information patterns over material instantiation”, that “considers consciousness as the seat of human identity”, “thinks of the body as the original prosthesis we all learn to manipulate”, and that
“configures human being so that it can be seamlessly articulated with intelligent machines” (idem).

Hayles emphatically defends a position within the cybernetic tradition that recognizes “complex interplays between embodied forms of subjectivity” and “arguments for disembodiment” (idem). She describes three “waves” of development within cybernetics, the third one of which includes the time we are living now. According to Hayles, this third wave “highlights virtuality”. She defines virtuality as “the cultural perception that material objects are interpenetrated by information patters”, a definition that she contends “plays off the duality that is at the heart of the condition of virtuality — materiality on one hand, information on the other” (idem). Hayles’ develops in How We Became Posthuman a theoretical framework to integrate the ‘abstraction’ of information with embodiment within this ‘condition of virtuality’. I am borrowing Hayles’ definition of ‘virtuality’ to start a discussion of the condition that is being created by ‘smart’ technology. I will be exploring how this transformed, mediated condition is becoming ubiquitously present in our everyday life through the integration of thinking objects and environments. The ultimate goal of the resulting cultural observatory is to help structure a more robust understanding of HCI within a living context.

In addition to her concepts of ‘feedback loop’ and ‘condition of virtuality’, Hayles also draws a distinction between ‘body’ and ‘embodiment’ that can be useful when articulating art and architecture’s contribution to HCI and interaction design. For her, the ‘body’ is “normative” and “idealized”, while ‘embodiment’ is “contextual, enmeshed within the specifics of place, time,

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4 The Oxford English Dictionary defines cybernetics as “the theory or study of communication and control in living organisms or machines.”

5 According to Hayles, the ‘first wave’ (1945-1960) was centered on the concept of “homeostasis”, i.e., the property of an organism to regulate and stabilize its internal environment; the ‘second wave’ tried to incorporate “reflexivity” as one of cybernetics ‘fundamental concepts’. Reflexivity is “the movement whereby that which has been used to generate a system is made… to become part of the system it generates” (Hayles, 1999).
physiology, and culture”. Instead of idealized, embodiment is ‘enacted’. As it will be discussed in more details in the next chapter, Activity Theory seems to have been developed around an implied ‘body’, something that makes it harder to articulate ‘embodiment’ within its framework even when talking about biological needs. AT could become more robust if it openly addressed the difference pointed out by Hayles between an abstract, normative ‘body’ and a contextualized ‘embodiment’. As will be demonstrated throughout the rest of the dissertation, the history, theory, and practice of art and architecture can help in this endeavor. This chapter is an introduction as to how this can be accomplished.

**A historical account of ‘virtual’, ‘virtuality’, and virtualization processes**

Contemporary digital technology such as the Internet, wireless communication networks, and virtual reality has transformed the ‘virtual’ into a key concept of our time. Although often mentioned to reference this new technology, the virtual has a long and rich history that antecedes digital technology. It is usually associated with positive changes, an association closely linked to its etymological roots from the Latin *virtus* from which comes the modern virtue. The concept has been related to power, moral strength, and divine beings, and associated with rites of passage (Shields, 2003). It has also been associated with controversial meanings as was the case, for example, of its use during the religious crisis that took hold of 16th century Europe around the Christian Eucharist (idem). It has also retained an elusive character, as something intimately related to the real and actual without ever being grounded by the more tangible characteristics and implications of achieved goals associated with these concepts. For the most part, though, the virtual remains associated with forces capable of generating some kind of transformation, which explains in part why it has reemerged with such force as a social phenomenon associated with new technology.
The virtual now indicates multiple, alternative spaces made possible through the use of digital technology. These alternative virtual spaces are contemporary reenactments of the simulations and representations of other historical instances of virtual space articulated, for example, on irregular cave surfaces and through weaving, painting, writing, tabulation, computing, mapping, city planning, etc. (Ong, 1977; Kerckhove, 1987; Flusser, 1990, 2002; Summers, 2003). These plane-based articulations include many rounds of the ‘feedback loops’ that Hayles talks about, as new articulations of virtual space emerged with each new condition to represent three-dimensional form and other phenomena in two dimensions. Over time, humans have internalized these conditions to such a degree that they have become part of our ‘second nature’ (Summers, 2003). As a result, our experience of real space and place changes with each turn of this feedback loop referred to by Hayles.

In Activity Theory, explored in more details in the next chapter, this is explained as a process of ‘internalization-externalization’ that shapes and re-shapes the way we think and behave as operations are internalized and provide new ‘conditions of presentation’. The ‘co-dependence’ between internalization and externalization in Activity Theory is similar to a ‘co-dependence’ between what Summers describes as ‘notional’ and ‘facture’. In both cases, long strings of feedback loops are established.

Among other things, virtual space allows us to experientially flip between the horizontal plane onto which we stand and the vertical ones onto which we project possible representations of place or articulate virtualizations through maps, writing, calculation, tabulation, etc. In the built environment, this flipping between vertical and horizontal planes is useful to provide the body with a sense of safety and protection without overwhelming it with a sense of confinement and imprisonment. This happens because virtual spaces either projected onto surfaces, like in
paintings, or resulting from the articulation of real planes, like in architecture, can by-pass the physical restrictions created by the materiality of the wall. Openings (such as doors and windows) and the semi-occlusion created by partial walls can transform our experience of an enclosed place by emphasizing a back and forth alteration between real and virtual spaces. An example of this kind of articulation of real planes can be seen in the renovation of the Institute of Contemporary Art in Boston designed by Diller Scofidio + Renfro⁶. Someone visiting the building experience a large window placed on a wall facing the bay area as a screen. Diller and Scofidio also articulated a radical version of this alteration between real and virtual spaces in their Blur Building for the Swiss EXPO 2002. They describe the building as an attempt at ‘dematerialing’ architecture and at making ‘media’ (electronic screens, monitors, etc.) become “physically tangible” (Diller & Scofidio, 2005).

Humans have long nurtured this ability to transit between real and virtual spaces, and record such transitions by leaving traces on surfaces or by transforming them into rituals of passage that can be repeatedly reenacted. Weaving, painting, writing, tabulation, etc., are forms of traces and in some cases have common etymological roots (for example, text and texture from the Latin textus and textura). Although rituals can take many forms and have many meanings, they can also be considered customary and formal reenactments of transitions between virtual and real spaces. For Shields (2003) these reenactments depend on their ability to create “liminal zones”, which he defines as ambiguous zones made possible by the “suspension of everyday order” and their transformation into alternate orders. Shields argues that ‘liminal zones’ remain primarily as performative spaces, i.e., spaces where spoken utterances and actions create a “threshold between at least one immediate lived milieu and the distant ground of the other(s)” (idem).

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⁶ A review of this and other works by these architects can be found in Davidson, 2007. Other examples are going to be discussed in depth throughout the rest of the dissertation.
Synthetic virtual environments (SVE) and digital networks are the latest experiments with this kind of transitions. For Shields, digital networks, in particular, are transforming the world by shifting older, dualistic models that oppose the real to the virtual into hybrid systems that are best understood as intensities and flows that circulate through both spaces, a condition of ubiquitous virtuality.

These hybrid systems are being made possible by the pervasiveness of global digital telecommunication networks and a seemingly relentless advance towards a goal of connecting people all over the world in an instantaneous or quasi-instantaneous way. These digital telecommunication networks allow us to be simultaneously involved in multiple activities centered at different locales. For William Mitchell, although people were previously bounded by constrains set up by their particular cultures and surrounding places, they are now subjected to and users of what he calls “instruments of displacement” (Mitchell, 2005). These instruments “embed the virtual into the physical, and weave it seamlessly into the daily urban life” (idem).

‘Smart’ technology and ubiquitous computing dramatically increase the availability of such instruments of displacement. However, I will argue that they can be as much ‘instruments of replacement’ as they can be ‘instruments of displacement’. They make it possible to connect with distant places and keep in touch with relatives or establish or renew relationships that otherwise would be either very hard to keep or simply lost. In some cases, these instruments can take over architectural façades or entire walls and use them as new ‘conditions of presentation’ to communicate a continuous flow of information. Kas Oosterhuis’ Saltwater Pavilion built in 1997 at Neetje Jans (The Netherlands) is one example of how the built environment is transformed

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7 The Saltwater Pavilion by Oosterhuis and other works grouped under a general term of ‘Hyper-architecture’ are going to be discussed in more detail in Chapter 6.
into an instrument of displacement / replacement. The Pavilion is made with a flexible skin covering a “unibody” building, i.e., a building planned to retain the “structural integrity associated with the skull of an animal’s skull” (Oostehruis, 2002). A “bumpmap skin” of images generated from real-time data is projected on top of this flexible skin (idem). Other instruments of displacement such as cellular phones are being miniaturized and receiving additional digital technology intended to enhance the interconnectivity between their users without jeopardizing their mobility and independence. There is also significant research being done to make these instruments disappear into the threads of the fabrics used to make our garments, incorporated into new synthetic materials, and/or inserted into the built infrastructure that supports social life (Ishii & Ulmer, 1992; Barber et al, 1999; Edwards & Grinter, 2001; Lumelsky, 2001; Baurley, 2004; Plowman & Luckin, 2004; Stead et al, 2004; Berzowska, 2005; Addington & Schodek, 2005; Blacktrom et al, 2006; Vaughan, 2006). The rationale behind all this research is to enhance the connectivity between individuals by transforming them into link points within an immense global social network.

Despite the potential drawbacks caused by the development of such networks and ‘instruments’ — as for example the potential increase in surveillance mechanisms and their use in pervasive social control systems (Castells, 1997, 1998, 1999; Smith, 2001; Bohn et al, 2004) — they indicate a Western movement towards a negotiation between its own traditions and other non-Western ones, as well as between the West and its own foundational principles. The need for such negotiation is one of the main arguments developed by David Summers in Real Spaces – World Art History and the Rise of Western Modernism. One of Summers’ basic tenets is based on the substitution of “formalist notion of the visual arts’ by what he calls spatial arts. This substitution is aimed at reemphasizing the importance of all senses, and not just vision. He also suggests
making real and virtual the two basic categories of space. Sculpture and architecture would be the main instances of the first, while painting and graphic arts would be the ones of the last. In addition to these two categories he also proposes personal and social spaces (sculpture and architecture, respectively) as two sub-categories of real space. Global communication networks, smart environments, and other ‘instruments of displacement’ promote this negotiation by making profound changes in the ‘conditions of presentation’ and modes of representation prevalent on Western cultures. These conditions are making possible what de Kerckhove (2001) calls “total surround quality”, a quality that is altering social spaces and making them resemble the virtual spaces and ‘liminal zones’ created by rituals. These techno-rituals tend to challenge previously dominant forms of virtual space that depended on local conditions, and instead promote individuals’ mobility and their potential as links within this global network.

**Perspective and the organization of virtual and real space**

The laws of perspective first developed in the Renaissance aim at “arresting vision” (Shields, 2003), substituting real objects for their representations in two dimensions thus creating virtual objects and spaces, which look like real ones without actually being so. Perspective was made possible by the development of planar surfaces, something Schapiro suggests was ”an achievement of human art”. Summers argues that planar surface “has been conditional for vast, pervasive and multilayered institutions of the preservation of images and information, as well as social spatial order and practice” (Summers, 2003). However, the human experience of virtual spaces used to be restricted by the physical location of the supports upon which these

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8 Summers argues that “the phenomenological principle of ‘being-in-the world’ is an early ancestor of his concepts of ‘real space’ and ‘context’. This provides a direct connection with phenomenological approaches being developed in HCI through the initiative of a number of computer scientists like, for example, Harrison & Dourish (1996), Agre (2001), Dourish (2001, 2004), Chalmers (2004), and Svanæs (1999, 2001). Phenomenological approaches are among the first to argue for HCI to be based on ‘embodied’ interactions.
representations were executed. Photography made this virtual substitution easier and more accessible. ‘Arrested visions’ are now second nature to us, i.e., we ‘see’ the world through perspective. The pervasive distribution of such visions and their ubiquitous presence in our lives allows them to compete with real objects to define real space. We so ‘embrace these virtual substitutes’ that we now see them as viable alternatives to the real (idem).

Let us contrast the new context of “total surround quality” with one dictated by an approach to the world dominated by space and geometric alignment, which is the context created by the development of perspective (Ivens, 1938; Pallasmaa, 1996; Summers, 2003, Shields, 2003). For Ivens, the “rationalization of sight” through the laws of perspective was “the most important thing that happened during the Renaissance”, because perspective “secured a two-way, or reciprocal, metrical relationship between the shapes of objects as definitely located in space and their pictorial representation” (Ivens, 1938). Ivens argues that despite of its importance for “picturemaking”, perspective “is more important to general thought”, because based on “its logical recognition of internal invariances through all the transformations produced by changes in spatial location, [it] may be regarded as the application to pictorial purposes of the two basic assumptions underlying all the great scientific generalizations” (idem). Ivens argues that these two principles are “homogeneity of space” and “uniformity of nature”. For Summers, the special and geometric alignment made possible by perspective led to what he calls the “metaoptical”.

On the other hand the total surround quality created by global communication networks and other forms of digital technology is making real space become ‘liminally virtual’, i.e., constantly

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9 Painters working on what is called color-based pictorial space develop strategies to create virtual space that depend on color relationships instead of on perspective. See for example, the work of Cézanne, Kandinsky, Jackson Pollock, and Frank Stella.

10 The definition that Summers gives of metaoptical/metaopticality is: “If the universe is defined as visible, that is, in terms of the active economy of light, then the notional framework — a universal grid — relative to which this activity may be described is metaoptical” (Summers, 2003).
being pushed towards a new status (Shields, 2003). Similarly, virtual spaces are also becoming ‘liminally real’ as more and more supporting ‘smart’ technology and global digital communication networks are made accessible to a greater number of people. This technology transforms information into bits that can be easily stored and continuously circulate within digital systems. It thus changes the experience of real everyday life as well as disseminates new ways to simulate alternatives to the real world. Digital technology is creating ‘mixed’ realities and making it possible for the virtual to become once again “the domain of latency and potentiality” (Grosz, 2000). It is achieving this by breaking down any hard, well-defined division it may have had in relation to the real, a process of re-virtualization of reality. This re-virtualization is a new state in which “the ‘true’ reality itself is posited as a semblance of itself, as a pure symbolic construct” (Zizek, 1996).

Architecture and urban planning have always been deeply invested in the regulation of social space (including the division of labor) and play a significant role in enforcing the rules and norms set up by a community to its members. However, their impact in human activities often remains subconscious to most members of a community. Some authors, architects, and urban planners like William Mitchell (2005a, 2005b), Kas Oosterhuis (2002, 2005), Peter Weibel (2005), and Dana Cuff (2003), for example, are now advocating a new kind of architecture and urban design to address this new virtualization of reality. Mitchell (2005) argues that with the rapid development and greater accessibility and distribution of ‘smart’ technology, social space now involves much higher levels of complexity, while for Weibel (2005) social space is being “characterized by immateriality and nonlocality”. For Cuff (2003) this new situation challenges fundamental ideas about subjectivity and the distinction between public and private, and requires that we “reformulate our conception of the civic realm”. In order to deal with this, Oosterhuis
(2005) maintains that architecture needs to be “mass-customized” instead of “mass-produced”, while Bouman (2005) argues that what we need now is to build “hybrid environments” to support this new reality because such environments completely integrate the analog and digital worlds. These hybrid environments are conceived as “an object or a built environment and also as a computer and as an interface”. The re-emergence of the virtual can also be described as being established by what Johnson (1999) calls “machinic process” between the possible, the real, the virtual, and the actual. He defines a machinic process as “a type of working relationship among heterogeneous elements and relations defined by an assemblage”, where assemblage encompasses both “mechanical machines” and “organic bodies.” For Massumi (2002), machinic processes promote a co-dependency between “deterritorialization” and “reterritorialization”, making them particularly important in light of ‘smart’ technology and global communication networks. Through deterritorialization and reterritorialization machinic processes aim at capturing ‘movement’ or, as Massumi puts it, ‘qualitative transformations’. These transformations also create ‘liminal zones’ between hybrid systems, and set the conditions for what I am calling ubiquitous virtuality.

**Ubiquity and the experience of everyday life**

The late Mark Weiser, the former chief scientist at Xerox Park who first proposed the term ‘ubiquitous computing’ and pioneered many of the early developments in the area, stated that in order to build invisible technologies we need to “start from arts and humanities: Philosophy, Phenomenology, Anthropology, Psychology, Post-Modernism, Sociology of Science, Feminist Theory,” and our own experience (Weiser, 1997). Since then, there has been a growing awareness of the need to get design and human sciences involved early in the efforts initiated by engineering and computer science to advance ubiquitous and pervasive computing. Weiser also
offered the term “embodied virtuality” in an attempt to better represent the “virtuality of computer-readable data” being brought into the physical world (Weiser, 1991).

Since the late 90’s, there has been a second wave of calls in ubiquitous computing for a better understanding of the infrastructure upon which it is being added (Mitchell, 1996; Puglisi, 1999; Palumbo, 2000; Abowd and Mynatt, 2000; Cuff, 2003; McCullough, 2004; Kang & Cuff, 2005; Dourish and Bell, 2007). The main argument presented by all these authors is that the definition and design of an infrastructure to support ubiquitous computing cannot be based just on technological considerations, but needs to include how this infrastructure supports the way humans experience the world, how it serves as a repository for collective memory, and how it is the ground for all social-cultural negotiations. That means that the social and cultural organization of everyday experience and the built environment that reflects and supports such organizations have to be seriously considered whenever technology for ubiquitous computing is being developed.

This infrastructure must also include the aesthetic experience, which is important in shaping real, virtual, and social spaces. Aesthetics is the “process and as the science of sensitive knowledge” (Jacques, 2001), and as such complements other methods of inquiry. It is not surprising that as the HCI community becomes more attuned to the social impact of technology that it starts to address the aesthetic experience directly and consistently (Belloti et al, 2002; Hallnäs & Redström, 2002; Petersen et al, 2004; Tractinsky, 2004; Udsen & Jørgensen, 2005; Fishwick, 2006; Tractinsky & Zmiri, 2006).

Although the recognition of the role of aesthetics is somewhat recent in HCI, it is nonetheless attracting more and more interest from the HCI community. However, any effort to integrate aesthetics into HCI will not be successful without addressing art and architecture, as they are
fundamental channels for aesthetic experience, for preserving habitual cultural universes as well as for providing new ones. Philosopher Vilém Flusser, for example, defines art as “any human activity that aims at producing improbable situations” (Flusser, 2002a). He proposed a ‘cycle of aesthetics’ using ‘habit’ as criteria to define transitions between the cycle’s four poles or stages — ugly, beautiful, pretty, and kitsch. This cycle will be explored in more details at the end of the next chapter when we discuss the issue of cultural change. It will argued that combining Flusser’s cycle with Hayle’s concept of ‘feedback loop’ and with Summers concepts of ‘notional operations’ and ‘facture’ can help us understand “the social implications of continuous and widespread immersion in computation”, as called for by Abowd and Mynatt in a 2000 summary of the challenges in ubiquitous computing. As mentioned before, this computation has been made possible by a number of other activities, such as writing, coding, tabulation, drawing, etc., that rely on the plane and on virtual space for other types of ‘computation’. The interactions between humans and computers will be made more robust if we put the computer within the context created by these other cognitive apparatuses and incorporate into HCI research the issues that drive their development.

An example of how this interaction can be more robust can be found in an argument put forward by Flusser. He argued that the development of the photographic camera was the first sign of the type of cultural and technological change that would eventually lead to the computer and more recently the new ‘smart’ digital gadgets. Flusser looked into photography as “an allegory of post-industrial and post-historical thought” (Amelunxen, 2000). He argues that along with this new technological turn comes one of the most significant cultural

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11 This allegoric use of the photographic universe is clear, for example, in the essays of Pos-História – Vinte instantâneos e um modo de usar (Pos-History – Twenty snapshots and one way of using them), in which Flusser uses photography to discuss “the ground on which we stand”, i.e., culture.
transformations ever experienced by humans. Flusser contends that aesthetics and the history and politics of representation — in images and texts, including scientific ones — offer the best model for the study of the impact of contemporary technology on society (Flusser, 2000).

Flusser bases his argument on two key concepts: “technical image” and “apparatus”. He defines technical image as “a technological or mechanical image created by an apparatus” and argues that photography is the first instance of this type of image (Flusser, 2000). ‘Apparatus’, on the other hand, is any tool or artifact used to “simulate thought processes” (idem). The photographic camera, for instance, simulates space perception; its optical system is set up to capture images using perceptive principles. Apparatuses became ‘technical’ when “they grasped hold of scientific theories” (idem).12 The photographic camera produces ‘technical images’ because it got hold of theories in optics, chemistry, manufacturing processes, etc. Because, this ‘hold’ is unlike any previous moment in the symbiotic relationship between humans, tools and instruments, Flusser argues that photography marks a rupture in human history of such magnitude that it can only be compared to the invention of writing (Flusser, 2000).

Flusser further explains this position by arguing that images were developed as mediations between human subjects and the world (idem)13. However, for Flusser, instead of continuing to represent the world, images started to obscure it. This obscuring started to happen because although the significance of any image should be on its “surface”, i.e., its meaning should be easily available, they instead became increasingly difficult to be ‘de-coded’. At some point,

12 Hayles follows a similar line when she argues that “technical artifacts help make an information theoretic view a part of everyday life… Especially for users who may not know the material process involved, the impression is created that pattern is predominant over presence. From here it is a small step to perceive information as more mobile, more important, more essential than material forms. When this impression becomes part of [one’s] mindset, [one] has entered the condition of virtuality.” (Hayles, 1999)

13 As will be seen in the next chapter, in Activity Theory images would be tools produced by instruments to mediate the relationship between subject and objects. Images objectify needs, and thus generate activities, which are then used in the development of the subject and of the world.
images stopped being tools to help us situate ourselves in the world, and instead they became “screens” interposed between the world and us. Once images became screens we started to look for ourselves in them instead of using them to situate ourselves in the world. According to Flusser, this situation was unsustainable in the long run, and in order to return the image to its original function of “map”, humans had to “tear down the screens” used to show images (idem). Humans did that by rearranging “the elements of the image (pixels)… into lines”, thus inventing “linear writing” (idem).

Flusser is not alone in pointing out the importance of such invention (Ong, 1977, 1982; Kerckhove, 1987, 1991, 2001, 2002). In a well-known study on cognition and oral culture — *Orality and Literacy – The Technologizing of the World* — Walter Ong writes that “only about 106 of the many thousand languages spoken in the course of human history have ever had a written representation, and an even smaller number have produced literature” (Ong, 1988). Ong studies the “psychodynamics of primarily oral cultures” and writes that in such cultures words are equated exclusively with “sounds”. Until the advent of digital technology, human speech did not leave any “trace” or “trajectory”, which Ong argues are “visual metaphors” that depend on writing. With writing came literacy, i.e., the ability to write and read texts. Derrick de Kerckhove points out the importance of literacy by saying that it brought a “visual bias” to our experience of space (Kerckhove, 1987). He argues that this visual bias puts the literate person “in a perpetually frontal relationship with the world” and triggers a “bias of representation” because “readers must translate text into images that the world represents” (Kerckhove, 2001)\(^\text{14}\).

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\(^\text{14}\) This visual bias is ultimately realized in geometric perspective, the result of many turns in the feedback loop between images and texts and an expression of what Ivins calls the ‘rationalization of sight’ (Ivins, 1938).
Reinforcing this argument, Flusser argues that writing “implies a radical change of meaning” from the world of “magic” to the “historical” world (Flusser, 2002b). According to him, “magic” derives from our activity of scanning surfaces in order to decipher images. Scanning implies a world that is “structured by eternal return,” i.e., by a “reversibility of relations” in which all things are ordered by a “circular time” that demands the intervention of “gods” (idem). Images “mean the world” because they “reduce the four-dimensional situations of time and space to scenes” (idem). He also argues that the circularity of time associated with the 'magic' character of images is also behind a common past cultural practice of putting cities under the protection of a “god” or “goddess”. Rituals usually linked to celestial events were then offered to appease the god or goddess until when a new similar ritual had to be performed. For Flusser, the “historical” world is different because it is a consequence of eyes having to follow lines. Lines establish time-related sequences of episodes. Following similar steps, Jack Goody explains that texts are subject to “backward scanning”, which means that with text one can backtrack the sequence of events from present to past (Goody, 1968). Ong (1982) argues that spoken words, on the other hand, have to be considered “events,” because by not leaving “traces” they retain the temporality of a performance (idem).

For Lévy, what links all languages — spoken, visual, written, numeric, etc. — is that languages in general perform the virtualization of ‘real time’. This virtualization is bound to the here and now but it “breeds new spaces and times, new speeds” (Lévy, 2002). The ‘speeds’ are speeds of “learning” and “thinking”, and other speeds that can be associated with a “cultural evolution that is far quicker than biological evolution” (idem). For Lévy, technology is an “agent of virtualization” because the design of a new artifact is a virtualization of many actions, and this virtualization triggers a “shift from private to public and the mix between inside and outside”.

With ‘smart’ technology this shift and this mix are being exacerbated, changing the conditions in which we live, and thus changing the context in which HCI operates.
CHAPTER 3: ACTIVITY THEORY AND THE DYNAMICS OF CULTURAL CHANGE

Introduction

The bases for AT is the work of Russian psychologist Lev Vygotsky (1896-1934) on the cultural-historical influences on child development and on cognitive processes in general provided the foundation upon which Activity Theory was built. Vygotsky called these influences “mediation” because they occur through the use of tools, instruments, and physical artifacts. He argued that the use of such mediators “changes the structure of activity” (Kaptelinin & Nardi, 2006) as they are “internalized” through interpersonal communication and through individual elaborations about the different aspects that comprise a particular activity. Vygotsky called “internalization” the process in which “external” artifacts are substituted by internalized mediators that he called “psychological tools” because “they transform natural mental processes into instrumental acts, i.e., mental processes mediated by culturally developed means” (idem). Eventually, Vygotsky articulated a difference between the psychological tools that are “physical artifacts” and the ones that are “symbolic systems”. Kaptelinin & Nardi give “pieces of art, maps, diagrams, blueprints” as examples of ‘physical artifacts’, and “languages, numeric systems, algebraic notations” as examples of ‘symbolic systems’.

As seen from the discussion presented so far in this dissertation the history and theory of art and architecture have much to contribute to concepts such as “instrumental act”, “physical artifacts”, and “symbolic systems”. For example, Summer’s already mentioned concepts of the “notional” — referring to “generalized dimensional relations, usually ratios” (Summers, 2003) — and “facture” — referring to “the indications in an artifact of its having been made” (idem) — give another cultural-historical dimension to concepts such as “internalization”, “instrumental act”
and “physical artifacts”. Notional relations and facture feed a symbiotic relationship that humans have with technology as we shape and re-shape our place in the world. With this in mind, it is useful to revisit Vygotsky’s concepts in light of the importance attributed to the ‘plane’ by scholars such as Summers (2003), de Kerkhove (2001), and Ong (1982). Ong and de Kerkhove’s ideas support Summers’ assertion that the plane is a major “condition of presentation”, that it can be used as “quasi-substitute” to real planes (the actual surfaces on which we stand), and that this ‘substitution’ makes virtual space possible.

Although Vygotsky layed down AT’s foundation, it was his former disciple and colleague Aleksey Leontiev (1903-1979) the person responsible for formalizing his ideas into a structured framework. Leontiev’s structure of Activity Theory made it easier to verify AT’s emphases on the purposeful interaction of a subject with the world. He was also responsible for placing these interactions in the rich milieu of social-cultural contexts (Kaptelinin & Nardi, 2006).

What is bringing AT closer to HCI? This coherent structure along with AT’s assertion that human consciousness emerges from interactions between people and artifacts (idem). Along with “situated actions”, “distributed cognition”, phenomenology, ethnography, and others, AT is part of a postcognitivist revision of HCI basic concepts (Winograd & Flores, 1987; Suchman, 1987; Harrison & Dourish, 1996; Svanæs, 1999, 2001; Winograd, 2001; Chalmers, 2004; Garbarini & Adenzato, 2004; Dourish, 2006). The integration of these frameworks into HCI research is a relatively recent event, having started in the late eighties. According to Kaptelinin & Nardi (2006), it was Susanne Bødker, a Danish computer scientist, who first articulated the AT’s usefulness for HCI. She emphasized the “need to consider the human use of technology within a wider context of human interaction with the world”. AT’s focus on “purposeful, mediated, human social activities” has been hailed as being particularly useful in formative experiments in
which designers, social scientists, engineers, and computer scientists collaborate to develop new technology (Bødker, 1991; Nardi, 1996; Kuuti, 1996; Bødker et al, 2000; Crawford, 2004; Gay & Hembrooke, 2004; Kaptelinin & Nardi, 2006). By considering activity the basic unit of analysis and the fundamental means of development for subject and object, AT’s basic model already offers a sound approach to the difficult task of understanding human interaction with the world. In Kuuti’s (1996) words, activity “is the minimal meaningful context for understanding individual actions”. When AT researchers expanded this basic unit to include community as one of its basic poles they enhanced AT’s ability to address social-cultural contexts and turned it into one of the best frameworks to support the study of the interactions between people and computational devices.

The concepts that make up Activity Theory will be discussed in more details throughout the rest of this chapter. The relation between AT and the history and theory of art and architecture will start to be addressed more directly in the last sections and further explored through a number of case studies in Part II.

The three poles of activity: subject, object, and community

In Activity Theory, a subject doing something directed at an object defines an activity. The activity is motivated by the transformation of this object. The object of an activity and its transformation are what distinguishes one activity from another (Kuuti, 1996). Tools and artifacts used within a social-cultural context mediate these transformations. A tool is at the same time enabling and limiting: “it empowers the subject in the transformation process with the historically collected experience and skills “crystallized” [in]to it, but it also restricts the interaction to be from the perspective of that particular tool or instrument” (idem).

“Communities”, i.e., groups that share the same object or closely related ones, pass tools from
one subject to another, from one generation to the next. Therefore, subject, object, and community are considered the three poles of activity.

According to AT, there are “mutual relationships” between these poles. Just like “tools” mediate the relationship between subject and object, “rules” mediate the relationship between subject and community. Rules are “explicit or implicit norms, conventions, and social relations within a community” (Kuuti, 1996). As a result of these mediations there is also a “division of labor” in the relationship between community and object. Division of labor is how the community organizes itself to enact the transformations required by the object to achieve a particular outcome.

These ‘mutual relationships’ are the focus of many negotiations as subjects refine the object of an activity and decide which mediating tools should be used to achieve the desired outcome(s). These negotiations concur with other ones between subject and community about which rules need to be followed, along with negotiations taking place within the community about who does what to ensure the desired outcome. One outcome can involve many of these negotiations and involve different objects as is the case, for example, when the financial, marketing, design, and engineering groups involved in the development of one product (a software or a digital gadget, for example) handle different expectations as to what should be the final outcome, i.e., the product to be sold in the market.

These multiple negotiations can get even more complex when there are other communities affected by an outcome but that may or may not be involved in the activities leading to it. This is a common problem in HCI due in part to the history of the computer and the initial applications that shaped its design. In the early stages of its development, the computer was used in laboratory settings where there was certain homogeneity between the community of developers
and the community of users. The limitations of this approach became evident when more and more people started using computers and heterogeneity substituted this previously convenient homogeneity. The popularity of ‘smart’ gadgets such as the iPod or iPhone and the friendly interaction they provide is the result of communities of practice within large technology-driven groups (in this case, Apple) understanding and addressing the fact that developers and users usually do not use the same mediating tools to handle an object. I believe that there is much to be gained from looking into the dynamics that take place within communities of practice, the relationships between individual subjects and communities, as well as between one or more communities. This will be the focus of an evaluation described in chapter 7: “Evaluating Activity with ‘Smart’ Technology: a case study of four communities of practice”.

Activity Theory already has in place concepts that support this kind of inquiry. For example, it represents the hierarchical structure of subject-object interactions in three layers — “activity”, “actions”, and “operations” — and relates to each layer a certain kind of outcome based on its ‘level of intentionality’ — “motive”, “goals”, and “conditions”. It describes two classes of “needs” associated with a subject: “biological needs” and “psychological needs”. AT also defines three classes of object — “needs, motives”, and “objectives” — which hierarchically organized according to a scale of intensity (Kaptelinin & Nardi, 2006). These concepts are explained in the next sections of this chapter. At the end of this chapter, after an introduction to the issue of cultural change from AT’s perspective, Flusser’s ‘cycle of aesthetics’ will be brought into the discussion in preparation to the case studies. Concepts developed in art and architecture — such as Summer’s ‘notional relations’ and ‘facture’ — introduced in Chapter 2 will be explored in the case studies and revisited in the final chapter.
The hierarchical structure of activity

Activity Theory describes three layers within an activity — activity, actions, and operations\(^\text{15}\). To each of these layers there is an associated level of intentionality called motive, goals, and conditions. These levels of intentionality help explain the dynamic nature of activities. The top layer is activity proper, which is associated to and directed towards a motive. To a subject or a community, the motive is the object of the activity. According to Stetsenko & Arievitch (2004), the link between object and motive was introduced by Leontiev “to convey the idea that human activities are always driven by something objectively existing in the world, rather than by some events and occurrences in the hidden realm of mental processes or human soul.” Thus, motives have a push and pull effect on activities, sometimes resisting a subject’s intentions and sometimes directing them. The chart bellow summarizes these relationships.

![Diagram](image.png)

**Figure 6.** The hierarchical structure of an activity based on Kaptelinin and Nardi (2006).

Furthermore, by placing motives as objects (in the ‘outside’ world) Leontiev was emphasizing his view of human development based on a foundational principle about the primacy of the social material production of human life and about human needs, desires and motives as being derivative from this production” (idem). Therefore motives force a series of negotiations

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\(^{15}\) In AT what I am calling ‘layers’ is usually called ‘units’. ‘Layer’ is used because, in my opinion, it better captures the changing conditions taking place within an activity, while ‘units’ tend to demarcate discrete territories.
between subject and object. These negotiations are made through *actions*. Actions, on the other hand, are steps aimed at realizing the motive but they may not be immediately related to it. In AT, what links actions to motives are *goals*. Goals are “conscious” and provide “indirect evidence” of a motive associated to an activity (Kaptelinin & Nardi, 2006). Actions, on the other hand, can be decomposed into lower level layers, which are called *operations* (idem). Operations are “routine”, i.e., somewhat automatic or semi-conscious processes. Operations respond to *conditions*, the lowest level of intentionality (idem).

These layers can shift up or down as, for example, when an action becomes routine, automatic, and thus should be more properly considered an operation. Likewise, breaks in the conditions can turn an operation into an action, as it requires a conscious, goal-oriented intervention on the part of the subject. Similarly, a motive may become a goal within a larger-scale activity, or a goal becomes a motive when it turns out to be the center of the negotiations between subject and object. Figure 8 on the previous page better represents the possible shifts.

Although “community” was not included as one of the three poles of activity in Leontiev’s original model of AT, its role has always been considered crucial as the theory presupposes social, cultural, and historical dimensions in shaping human activity. Leontiev himself argued...
that there were three aspects of culture — tools, language, and division of labor — that have a fundamental impact on human “mind” (Kaptelinin & Nardi, 2006). However, although these aspects implied the existence of a “community”, the concept was not directly articulated in the original framework. Nonetheless, by making “the social material production of human life” a “foundational principle” of human development, AT eventually would have to include ‘community’ as one of the poles of activity.

This happened with Yrjö Engeström (1987) whom proposed a triangular model for AT and explicitly recognized the critical role of communities in the production of human needs, desires and motives (Engeström, 1987, 1999; Kuuti, 1996; Kaptelinin & Nardi, 2006). The rules and norms that mediate the relationship between subject and community and the division of labor that is negotiated within the community impact all the dynamic changes between the three layers of an activity and their corresponding levels of intentionality. Furthermore, the existence of communities implies arrangements of real places to attend to the biological and psychological needs of subjects. Although this new model improves the original one it still does not clearly addresses the impact of real places and the built environment in shaping human activity. This topic was addressed in the last chapter, will be further explored in the case studies discussed in Part II.

**Classes of subject needs: biological and psychological**

In Activity Theory, the “ultimate cause behind human activity” is a subject’s needs (Kaptelinin & Nardi, 2006). The theory describes two classes of needs: biological and psychological. Biological need is “an objective requirement of the organism” such as food, water, air, or shelter (idem). Despite of attending to a subject’s needs, biological needs are, nonetheless “produced and brought to life by human social practice” (Stetsenko & Arievitch, 2004). This kind of need has to
“first ‘enter’ into an activity and encounter their objects in order to then become transformed into motives” and only when they do that can they direct an activity (idem).

The second class of ‘need’ described by AT is “psychological”. Psychological need is motivated by “social necessity” (Leontiev, 2005). It is “a directedness of activities toward the world, toward bringing about desirable changes in the environment” (Kaptelinin & Nardi, 2006). “Behavior and subjective experiences” are the two main expressions of psychological need (idem).

Biological and psychological ‘needs’ must be “objectified”, i.e., they must find “a concrete object” (Kaptelinin & Nardi, 2006). Objectified needs indicate that an activity has emerged.

In discussing subjects’ ‘needs’ we must keep in mind that in AT “no properties of the subject and the object exist before and beyond activities” (Leontiev 1978). Therefore, both biological and psychological needs must be ‘objectified’ in order to generate an activity, since activity is regarded as a *unit of analysis* and “the key source of development of both the object and the subject” (Kaptelinin & Nardi, 2006). Including ‘community’ as a third pole, as proposed by Engeström, expands this ‘unit’ and highlights activity as the key source for the development of subject, object and community. This in turn, makes AT’s arguments in favor of a cultural-historical nature of activity even more robust.

The concept of ‘need’ was introduced in the last chapter when ‘activity’ was related to concepts that have been developed in the history and theory of art and architecture. As it was pointed out, the biological, psychological, cultural, and historical factors that shape human activity as discussed in AT are related to what Summers calls ‘social space’, i.e., a “condition of human existence” as “we find ourselves among others” and as we do so in “culturally specific circumstances (Summers, 2003). These conditions are determined by our “embodied ways” of being in places, spaces and times shared with others (idem).
Issues regarding the definition of objects in Activity Theory: Needs and Motives

Defining ‘object’ has been a contentious issue in AT literature despite of the concept’s importance to the framework (Leontiev 1978; Bannon, 1992; Kuuti, 1996; Nardi, 1996; Engeström, 1999; Davydov, 1999; Bannon & Griffin, 2001; Foot, 2002; Kaptelinin, 2005; Miettinen, 2005; Kaptelinin & Nardi, 2006). For Kaptelinin & Nardi (2006), the object of an activity is a “sense maker”, “anchoring and contextualizing subjective phenomena in the objective world”. Although this provides a solid foundation for the concept, AT has been inconsistent when this definition is further explored to account for how an object becomes a sense maker. Such inconsistency is already present in Leontiev’s original subject-object model, and in his use of the expression “true motive” to define the ‘object of activity’. Kaptelinin (2005) points out that, according to this definition, ‘motive’ and ‘activity’ would “basically mean the same thing” and the theory would have to deal with the problem of having to justify the use of two terms to mean the same thing. He also points out that mixing the two terms do not solve a contradiction regarding the ability or not of motive and/or object to “direct” or “just impel” an
activity (idem). Finally, he argues that ‘need’, ‘activity’, ‘motive’, and ‘object’, as defined by Leontiev, cannot be easily used when analyzing “poly-motivated activities”, a type of activity that had already been predicted by Leontiev himself (idem).

Figure 9. Kaptelinin’s model accounts for the possibility of a ‘poly-motivated’ activity. A subject’s needs become motives when seeking to be objectified. In the process of doing so, they are also shaped by the social context and the conditions and means that the subject has to transform each motive. One, and only one object must be identified in order for an activity to be defined. This model derives from Engeström’s model. (Kaptelinin, 2005; Kaptelinin & Nardi, 2006).

An alternative solution for the definition of ’object’ starts to emerge in Engeström’s three-pole model. In this model, the ‘object of activity’ is the result of negotiations involving an individual subject and a community, both of which make use of cultural-historical resources in the form of mediating tools, artifacts, symbolic systems, etc. Thus ‘subject’ and ‘community’ can be agents of an activity but neither one is ever completely independent of the other. A ‘subject’ has to be constantly negotiating the rules and norms he/she is expected to follow when objectifying his/her needs, while the community as a whole depends on the behavior of its subjects and on negotiations on how it will divide the tasks that their objectified needs require in order to produce the desired outcomes. In this model, the “dual status” of the ‘object of activity’ as “a projection of the human mind onto the world and [as] a projection of the world onto the mind”
is clearer. The object of activity is then characterized as a dynamic process. This feature is better illustrated in the next image.

Figure 10. A double pointed arrow represents the ‘dual-status’ of the object.

Kaptelinin (2005) calls the process of “constructing and reconstructing” the object of activity a “process of design”, and points out four “preliminary criteria” for such process to be qualified as being successful: ‘balance’, ‘inspiration’, ‘stability’, and ‘flexibility’. ‘Balance’ means that an effective motive must be “properly represented”; inspiration’ means that the object should not be only “rationally feasible”; ‘stability’ means too many changes can make the activity “disorganized”; and ‘flexibility’ means that the object should be “redefined” when the motives and means change (idem). Besides the subject’s ‘internal’ needs and motives, the social context also plays a very important role in defining these criteria.

\[16\] For Vilém Flusser (1999b), the word ‘design’ forms a bridge between “the world of the arts”, which he equates with “aesthetic, evaluative and ‘soft’”, and “the world of technology and machines”, which he equates with “scientific, quantifiable and ‘hard’”. He argues that there used to be an “internal cohesion” between terms like “design, machine, technology, art, and art”, but that this cohesion “has been denied for many centuries (at least since the Renaissance).” According to Flusser, design resolves what used to be seen as an “irreversible” split between these two worlds because design “is an expression of the internal connection between art and technology.” The four preliminary criteria proposed by Kaptelinin to construct and reconstruct the object of activity strive to fuse the two worlds described by Flusser.
The community’s roles in activity

Although any cultural-historical perspective, as is formulated in AT, requires acknowledging some sort of ‘community’ — after all, there is no history or culture without a community — the concept was only formally brought into AT in the late eighties. However, even though ‘community’ is approached in AT as a social, cultural, historical group of ‘subjects’, there is no articulation of the role of place and of real space in shaping the context in which this social, cultural, and historical community operates, acts, and places its activities. This is a significant lapse in Activity Theory that needs to be addressed, particularly if we want to effectively apply the theory to the context of ‘smart’ technology, and if when ‘smart’ technology includes both ‘smart’ gadgets and ‘smart’ environment. Chapter 2 explored concepts that help address this situation and the topic will be further explored in Parts II and III.

Part of the problem seems to be related to the use of the term ‘community’ to refer to what Lave and Wenger call “communities of practice” (Lave & Wenger, 1991; Wenger, 1998). They define communities of practice as informal groups of people that “are created over time by the sustained pursuit of a shared enterprise” (Wenger, 1998). These groups can also be formal, as for example in the case of professional associations, the designers or programmers of a company, etc. However, the real power of the term ‘communities of practice’ resides in them being, as Wenger puts it, “everywhere”. This means that we belong to many of such communities in the course of our lives. These communities “situate” the learning processes that are part of every activity in specific social, historical, and cultural circumstances (Lave & Wenger, 1991).

At the same time that Lage & Wenger were formulating their concept of situated learning and communities of practice, Liam Bannon, a Danish computer scientist, was arguing that HCI’s community should follow the efforts of other communities and promote “a new vision of
human beings as active actors and not only as collections of attributes of cognitive processors” (Bannon, 1991; Kuuti, 1996). Bannon argued that by referring to “human factors”, as was usually the case in HCI at the time, “reduced the human to being another system component with certain characteristics, such as limited attention span, faulty memory, etc., that need to be factored into the design equation for the overall human-machine system” (Bannon, 1991). He then argued that the alternative term “human actors” emphasizes “the person as an autonomous agent that has the capacity to regulate and coordinate his or her behavior, rather than being simply a passive element in a human-machine system” (idem).

Understanding the dynamics between different communities of practice is becoming an even more vital issue in the context of ‘smart’ technology as computing capabilities are ubiquitously spread throughout the environment. The development of such technology requires understanding social-cultural issues much more complex than when dealing with desktop applications. It is, for example, critically important to recognize the role that infrastructure plays in shaping communities decision-making. This complexity led Gay and Hembrooke (2004) to propose an adaptation of the model of Activity Theory to address the role of evaluation in promoting a shift from “computer-centered design” to “context-based design”. They argue that their proposal is ‘context-based’ because “the use, design, and evaluation of technology are socially co-constructed and mediated by human communication and interactions”, and place these interactions between users and mediating tools within the motives, the community, the rules, the history and the culture of those users (idem). In context-based design the use, design, and evaluation of a particular technology is recognized as being a never-ending process.
The previous chart illustrates Gay and Hembrooke’s model, which is based on Engeström’s triangular model shown in Figure 5 (page 12). In their model the concept of ‘community’ starts to be broken into smaller units. By using “community of practice” instead of the general term “community” they make it easier to study the mutual relationship between subject and a particular community. In this model, the ‘community of practice’ on the left-hand side of the chart above is in a relationship with ‘users’, while the one on the right-hand side is in one with ‘developers and evaluators’. Gay and Hembrooke make a special plea to have ‘developers and evaluators’ be treated as a “unit”. According to them, this would prop up the integration of AT in the developmental processes of interaction design.

Having community and communities of practice articulated in its theoretical framework and methodology re-enforces AT’s position among other postcognitivist theories (phenomenology, distributed cognition, and situated actions, etc.). They all share a commitment to move HCI beyond its original reliance on cognitive models in which the mind reigned supreme and the subject’s body was absent. All of them also try to take HCI out of controlled laboratory situations and seek to contextualize human interactions with technology. Among these theories,
AT’s hierarchical structure makes it particularly useful in evaluation studies of such interactions, something that will be explored in Part II.

The next section will cover the relationships between the three poles of an activity. This discussion will provide a direct link to concepts developed in art and architecture — such as Flusser’s ‘cycle of aesthetics’ and Summer’s ‘facture’ — that will be further explored in the case studies and in the final chapter.

**Mediation between the three poles of activity**

According to Engeström’s triangular model, “tools and artifacts” mediate the relationship between subject and object, the relationship between subject and community is mediated by “rules”, and the mediation between the community and the object is made through “division of labor”. Each one of the three poles influences and is influenced by the mediations primarily used by the other two poles. This organization accounts for the dynamics that determine an activity. It also ensures that when analyzing any pair of poles and their mutual relationships, the remaining pole and the elements responsible for its mediation with the other two must also be taken in consideration.

In AT, tools and artifacts are “anything that can be used in the transformation process, including both material tools and tools for thinking” (Kuuti, 1996). For Leontiev, ‘tools’ (which for him also includes ‘artifacts’) are essential to characterize labor and are fundamental in the process of influencing nature (2005). Therefore, tools are fundamental to the cultural-historical context in which activities take place. Coming from different theoretical positions, Kubler, Flusser, and Summers emphasize this by saying that tools are also a form of ‘memory’. Kubler, for example, proposed the term ‘history of things’ “to reunite ideas and objects under the rubric of visual
forms” (1962). This ‘history of things’ emerges from all the “materials worked by human hands
under the guidance of connected ideas developed in temporal sequence” and includes
“artifacts”, “works of art”, “tools”, and “artifacts” (idem). Together, all these things “shape”
the collective identity of a particular group at a particular time. Kubler called this collective
identity “shape of time” and argued that it serves as a “point of reference to the group for the
future” (idem).

For Flusser (1990), tools and artifacts form human’s “cultural memory”. He argues that initially,
such memory started to be stored in two ways: the human body (through “gestures” and
“airwaves” used in vocalization, for example) and “hard objects” (stones, hones, etc.). According
to Flusser, neither one of these two first methods was very “reliable”, because as they were used
they would wear out the information that they carried — they became “disinformed”. This
created an “ecological problem” because “disinformed objects constitute a pernicious type of
memory” (idem). This problem led to the creation of “monuments” and ‘memorials’, i.e., objects
“designed exclusively as memory devices” (idem). This situation eventually led to the invention
of other ways of storing memory, including the alphabet and more recently electronic memories.
All of these types of cultural memory need to be considered when addressing the creation of
communities and communities of practice.

For Summers (2003), “tools” are a consequence of the actual making of artifacts — a process
that he calls “facture” — and of the development of “geometric” and “real planes”. A geometric

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17 From now on and throughout the rest of this dissertation, unless otherwise explicitly stated the term ‘tool’ will be used to refer to ‘notional operations’ (Summers) or any symbolic mediating process; ‘artifact’ will be used when referring to ‘material’ objects.

18 “Disinformed” objects should not be necessarily equated with ‘useless’ objects as the loss of some information can be transformed into ‘new’ information. For example, a new brush brings with it the history of its design and manufacture which, in turn, enable certain ‘gestures’ to be recorded on a surface. However, as painters use a new brush he/she is also recording a history of his or her gestures. The brush that lost its original form — the ‘disinformed brush’ — is now ‘informed’ by the artist's “tools” and custom-made to produce certain gestures.
plane is “any surface of such nature that a straight line joining any two of its points lies wholly in the surface”; a real plane is an actual surface that lends itself to the presentation of equivalents to geometric planes (idem). ‘Planar surfaces’...“make possible the maximally clear planar arrangement of relations, proportions and ratios”, make “measure possible”, and “enable operations requiring regularity, such as writing and tabulation” (idem). Summers calls these arrangements and operations “cognitive notional operations” (idem). Geometric planes and its related notional operations make virtual space possible.

Summers argues that once agriculture was established it triggered a “cluster of systematic innovations” that “involved activities and skills presupposing developed notionality, and more specifically, planarity” (idem). The result was the emergence of cities, temples, and palaces, etc., all of which have to be “panned”, or in other words, “the order and ratios of their parts must be worked out beforehand on regular, planar surfaces” (idem). Similar planning needs motivated the development of writing, record keeping, tabulation, and computation. Together they created “institutions and practices” that made possible for us to articulate the kind of social space that still supports the organization of our communities. For Summers, these institutions and practices made it possible for us to conceive the world as a “notional land” (idem).

Cities and other built environments create definite and bounded places in which these institutions and practices are ubiquitously present. It is through these institutions and practices that the ‘rules’ used to mediate the relationship between a subject and a community are established. The same institutions and practices establish the ‘division of labor’ used by a community to mediate the relation of its subject members to an object. Thus, adding ‘place’ to Activity Theory would make it an even more robust framework to study ‘embodied’ mediations. By including the ‘place’ of activity, AT can attend to a much richer social-cultural context for
mediated transformations. Addressing place and embodied mediations are important in the context of ‘smart’ technology, as sensors and computing capabilities embedded into objects and environments dramatically impact the process of these transformations.

AT already describes a process of ‘internalization-externalization’ to explain how these transformations occur. Internalization is a process related to a “redistribution between external and internal components of activity” while externalization “transforms internal activities into external ones” (Kaptelinin & Nardi, 2006). The internalization-externalization process is a process of ‘co-dependence’, and it is similar to one existing between what Summers describes as ‘notional’ and ‘facture’. He argues that notional relations are “abstracted and generalized dimensional relations” and thus related to speculation and theory, while facture must be considered a “record” of something having been made (Summers, 2003).

Establishing a relationship between AT’s ‘internalization-externalization’ process and Summers’ ‘notional-facture’ concepts makes AT’s explanations about the structure and dynamics of activity more robust. For example, Summers’ idea of ‘notional relations’ includes and expands Vygotsky’s original “psychological tools”. For Vygotsky, these tools are the “internalized mediators” that “transform natural mental processes into instrumental acts, i.e., mental processes mediated by culturally developed means” (Kaptelinin and Nardi, 2006). The concepts of ‘notional’ and ‘facture’ provide a better distinction between “symbolic systems” and “physical artifacts”, which are, according to Vygotsky, the two categories of “psychological tools”. The connection between ‘internalization-externalization’ and ‘notional-facture’ is just one example of the impact that the history and theory of art and architecture can have in Activity Theory.
Activity Theory and cultural change

In trying to describe the cultural changes brought about by digital technology and interaction design, Kaptelinin and Nardi highlight three “fissures or disruptions” that would explain how they happen: creativity, reflexivity, and resistance. By creativity, they mean “imaginative activity directed toward an object in which an original product emerges” (Kaptelinin and Nardi, 2006). By reflexivity, they mean “reflection that lends to change in practice, or potentially can lead to such change when obstacles do not prevent it” (idem). By resistance, they mean “opposition to a technology, or to a practice associated with a technology” (idem). They argue that in order to account for “invention of technology” a theory would have to place creativity as something that “follows logically from basic principles” (idem). This position reflects the authors’ scientific background and a certain tendency to rely on logic to promote change.

Contrast this approach with Kubler’s position regarding change in art and technology as being “linked solutions” that take place in “open and closed sequences” (Kubler, 1962). Under linked solutions Kubler groups solutions within “a finite yet uncharted domain of mental forms”. These are the processes that lead towards what Summers calls notional and that are eventually materialized through facture. However, these solutions are not necessarily logically linked to one another. A certain degree of “arbitrariness” is also important in promoting change. By arbitrariness Summers means local variations of the shape of an artifact originally determined by its function. The same principle could be applied to ‘tools’ like language, that can be also shaped by local conditions, turned into dialects, and in some cases become a fully formed separate

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19 Resistances are greater whenever existing border resources are not addressed in a new artifact. See Chapter 7 for an evaluation of such resistances as they relate to an artifact’s ‘latent border resources’, i.e., resources that lay beyond their original intended use.

20 For example, Kubler points out that “the transparent animals and humans of Australian painting and the rhythmic figures of tribal African art correspond more closely to contemporaries theories of reality that the opaque and unequivocal body forms of Greek art.”
language. For Kubler, “formal sequences” formed by linked solutions are “historical networks of gradually altered repetitions of the same trait”. He argues that these networks are made of “prime” objects and “replicas”. Prime objects corresponds to “principal inventions” which “cannot be explained by their antecedents”. What makes an object a prime one is not its position in the historical sequence or its ‘size’; it is the impact it has upon the sequence and the consequences that it provokes. That means that a ‘principal invention’ may not be recognized at first as such. Replicas on the other hand correspond to reproductions or derivations of prime objects; they just carry on the ‘genetic’ material of the sequence (idem). Kubler argues that a prime object emerges when the technical conditions for the sequence’s “revival”, i.e., a break in the series of replications, become available or when the combinations and permutations of the elements until then on hand are exhausted. In either case, producing prime objects demand a great amount of energy and risk because “the very act of invention is distasteful to the majority” (idem). Nonetheless, prime objects and replicas are linked in a sequence in which they are recognized as being the “early and late versions of the same kind of action” (idem).

Although Kubler’s discussion of *sequence* was originally developed in relation to art works as *objects*, it can be extended to address *object* as it is used in Activity Theory. Kubler’s rationale and Kaptelinin and Nardi’s description of fissures in cultural change find common ground when both point out how difficulty it is to create a prime object. AT recognizes the importance of a subject’s motives in determining how he or she will set up goals, act upon them by playing with the local conditions, and objectify the needs that will lead towards an activity. As mentioned before, in AT, tools and artifacts — an assorted set of prime ones and replicas — mediate purposeful interactions of a subject with the world. This interaction is also shaped by that

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21 This would be the case, for example, of the invention of the photography.
subject’s community, by the rules and norms that it puts in place through texts, images, and the built environment, and by a division of labor that impacts how a subject will objectify his/her needs.

Ruptures that promote cultural change such as creativity, reflexivity, and resistance, depend on one another to realize such changes. I don’t agree with Kaptelinin and Nardi’s position that resistance is “a rupture in the smooth flow of routine collective activity” (2006). On the contrary, resistance is usually related to attempts to prevent such ruptures. Resistance is part of a negotiation that takes place within culture, a negotiation that stimulates reflexivity, i.e., “the rise of consciousness” (Leontiev quoted by Kaptelinin and Nardi, 2006), within that culture. It is often based on the memory of how past accomplishments were realized. The resistance to give up a known artifact for a new ‘smart’ gadget, for example, is based on the knowledge of the tools associated with that artifact (oil painting, for instance), the sequence of replicas but also of the prime objects that have been realized with them, and the objects that a community still expects to realize with them in the future. An example of this situation would be the use of the brush made of natural or synthetic bristles in painting. Brown and Duguid (1994) use the expression “social inertia of objects” to refer to their contribution to authority, which is critical in determining the rules and norms that regulate a community or a number of communities of practice. They argue that as material form change “designers and users need to look for new means to reconstitute authority” (idem). This would be the case with the tools and artifacts that are being developed to support ubiquitous computing.

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22 How communities regulate the biological and psychological needs of its subjects should not be, by any means, considered irrelevant. See for example Michel de Certeau’s The Practice of Everyday Life (1988).

23 The subject of resistance its relation to an artifact’s ‘latent border resources’ is the subject of an evaluation study conducted with Logitech’s io2Digital writing System and described in Chapter 7.
Reflexivity is the process one has to go through to evaluate if the known tools and artifacts can still be used to create prime objects that will be recognized as such by the community, and even to define which community that is. Under these conditions, one may realize that even though prime objects are still possible, they are irrelevant in the larger cultural context. Such ‘rise of consciousness’ can lead towards greater resistance or towards creative responses to generate a ‘prime’ artifact, develop a ‘prime’ tool, or both. The danger, in either case, is to end up with a situation in which latent border resources of ‘old’ artifacts and/or tools are not explored, thus interrupting processes that could lead to the development of different prime artifacts.

Another way of analyzing the conditions that lead to the fissures or ruptures that exert pressure towards cultural changes is through Flusser’s cycle of aesthetics. He proposed this cycle because according to him aesthetics offers models to capture unusual, ‘un-habitual’ phenomena. ‘Smart’ technology is one of such contexts. Flusser defines aesthetics as “capable of being experienced” and habitual means whatever can no longer be experienced. He calls what cannot be experienced “anaesthetics” (Flusser, 2002a).

Flusser represents his cycle of aesthetics in an Möbius strip to, according to him, avoid any suggestion that values are ‘provisional’ or ‘historical’, a suggestion that according to him can be associated with linear scales. By representing the cycle in a Möbius strip Flusser hopes to emphasize that this is a “dynamic scale” in which value zones can slide along the scale in order to capture the aesthetic phenomena (idem). He argues that a dynamic cycle of aesthetics can also show that aesthetic values are not “eternal”, and that they gravitate towards habit.
The *cycle of aesthetics* has four zones: *ugly*, *beautiful*, *pretty*, and *kitsch*. Flusser equates ugly with “new” or “any situation that makes us tremble because it is unexpected” (Flusser, 2002a). The ‘un-habitual’ is perceived as ugly, because it disturbs one’s familiar ambient (Flusser, 2002c). The ugly is experienced as beautiful when it is used to “create information”. Flusser argues that the transformation of ugly into beautiful is a “painful process” because it requires significant effort and laborious negotiations (Flusser, 1983a). On the other hand, the transformation of beautiful into pretty and kitsch happens “spontaneously” (idem). The habitual is experienced as ‘pretty’ because it goes on without actually being ‘perceived’, and the less perceived it is, the more it is experienced as kitsch, i.e., tasteless.

**Activity in the context of ‘smart’ technology**

‘Smart’ technology is changing the infrastructure that supports the interactions between subjects, objects and communities and thus changing the cultural context in which they take place.

Architecture and urban planning are traditionally invested in any negotiation about infrastructure, and along with artifacts, they provide the cultural capital that supports the development of ‘smart’ technology. Advocating a deeper understanding of these areas, Malcolm McCullough argues that HCI and interaction design need to become “more sophisticated about environmental perception” because architecture provides a fixed form for the informational
flows engineered by ubiquitous computing (McCullough, 2005). He argues that a similar process will need to happen with architecture, as it too will need to become more sophisticated about the flows taking place in virtual space and learn to negotiate the needs that emerge from them. He argues that by fusing computing capabilities into artifacts and the built environment ubiquitous computing is changing the “ambient social infrastructure” and is directly impacting the cultural memory that they carry (idem).

For Suchman, transformation of “material and social circumstances” entails changes in human actions (Suchman, 1987). Dourish and Bell (2007) follow similar approach by stressing that infrastructure involves “social-political” aspects because it reflects “crystallizations of institutional relations” as well as “experiential” aspects related to how it shapes individual actions. Therefore, by catalyzing artifactual and infrastructural changes digital technology is radically affecting our conception of the civic domain and of human activity as well.

It is, thus, necessary to keep in mind the importance of the built environment in defining the social infrastructure and establishing collective memory, and to understand that such importance cuts across cultures and times. McCullough argues that ubiquitous computing has searched for a “universalist” model and has disregarded the thousands of years of human experiments and conventions with different kinds of built environments. These environments have been transformed over and over again by waves of new technologies and have remained the site for embodied social activities and social learning. The built environment demarcates the grounds for the kind of negotiation that sets off the feedback loops between cognition and technology described by Hayles. As pointed out by Summers, Kubler, Flusser, and McCullough, artifacts and buildings are as important for supporting performative actions as they are for representing social practices. In other words, they are as important as memory devices as they are for their
intended uses. Therefore they constitute the context for specific technology and related social interactions.

The social practices associated with artifacts and buildings, the performative actions and activities that they entail, and how they are changed by ‘smart’ technology will be the subject of four case studies discussed in Part II. In two of these case studies, Activity Theory is brought together with more traditional usability and evaluation methodologies, while in the other two it helps guide the investigation of activity in art and architecture as well as of art and architecture as activity.
PART II – CASE STUDIES AND FIELD RESEARCH
INTRODUCTION TO CASE STUDIES AND FIELD RESEARCH

The four case studies discussed in Part II explore some of the concepts discussed in Part I. Each case starts with an Introduction section that is used to summarize the main concepts related to that particular study. These introductions provide an initial link between each study and the rest of the dissertation. Furthermore, additional concepts pertinent to each case are brought in as needed to support the specific topics of each case. A conclusion at end of each study reviews the concepts presented in the introductions in light of the material explored in that particular study and prepares the discussion that will take place in the final chapter.

In the first case study — Evaluating Latent Border Resources: a research study of Logitech’s io2 Digital Writing System — Summers’ concept of ‘notionality’ and its materialization through ‘facture’ form the basic conceptual substrate to study how analogue and digital artifacts relate to one another. Brown and Duguid’s discussion of artifacts’ border resources, some of which can remain latent for some time but are nonetheless important to create communities of practice, is used here to examine the links between brush, pen, and digital pen.

The second case study — Exploring Art as Activity: a case study — looks into the internal dynamics of an artist’s oeuvre to highlight art as an activity. Lygia Clark’s work is a good example of how latent forces within an activity can challenge its status quo and demand changes. By looking at Clark’s work in reverse, we can gain insights into the current challenges of situating digital tools.

The third study — The Built Environment and ‘Smart’ Technology: a comparative study — compares different approaches of how to build ‘smart’ environments. These approaches are anchored in different priorities of different communities of practice.
The fourth and last study — Evaluating Activity with ‘Smart’ Technology: a case study of four communities of practice — uses Activity Theory to structure an evaluation of four groups of students: architecture, art and design, computer engineering and computer science, and creative writing. These groups are approached as being at the periphery of well-established communities of practice. Logitech’s io2 digital Writing System is used to prop an evaluation of how each group conceptualizes its activity.
CHAPTER 4: EVALUATING LATENT BORDER RESOURCES: A CASE STUDY WITH LOGITECH’S IO2 DIGITAL WRITING SYSTEM

Introduction

This case study explores a combination of Summers’ argument that cognitive “dimensional operations” are a consequence of the actual making of artifacts, which he calls facture, with Brown and Duguid’s argument that besides the intended use that motivated the development of particular artifacts or of a particular technology, it is their “latent border resources” — resources that lay beyond their original intended uses — that support our shared use of them. These two arguments are explored through an evaluation of Logitech’s io2 Digital Writing System (DWS) described in this chapter.

Logitech developed the io2 primarily as a handwriting tool. Its software saves the digital marks and translates them into digital text that can be edited with common word processors like MS Word. However, the io2 can also be used for sketching and drawing. The same software is used to save the digital marks and translate them into images that can also be edited (selected, moved, rotated, etc.). By using the same base technology for handwriting and drawing, the io2 preserves a deep-rooted link between text and image. To evaluate this subsidiary capability, the case study expands traditional evaluation methods by integrating art and design needs in the evaluation process. It does that by exploring border resources in the io2 system that could be particularly important to a community of practice formed around painting and drawing.

Logitech’s io2 DWS adds a digital layer to pen and paper, which are two relatively recent examples of a long history of styluses used to make marks on surfaces. Many communities of practice emerged by articulating different sets of marks into symbolic systems and by
conceptualizing surfaces as ‘planes’ (Summers, 2003). A need to make clean and efficient mark-making artifacts emerged from these articulations. Pens and pencils evolved from the brush to address this need. The technological link between them can also be seen in the etymology of these words. According to Petroski (1990), the word pencil comes from *penicillum* a Latin word used to describe a fine-pointed brush. He adds that the pencil brings together two desirable qualities: dryness (important to keep the user’s hands clean) and darkness (important for effective mark-making) in a single instrument. A pen uses hollow metal ‘reeds’ to encase wet ink for similar reasons.

Paper has evolved into one of the primary surfaces used for mark making because “its physical properties (thinness, lightness, texture, opacity, flexibility) afford [i.e., facilitate] a large variety of human actions (grasping, manipulation, folding, writing, drawing, etc.)” (Sellen & Harper, 2002). These characteristics have made the paper into one of the primary substrates for creating knowledge and for storing information. It remains so even in the wake of digital technology. But paper has also limitations. Sellen & Harper mention three different “classes of problems”: “symbolic”, “cost”, and “interactional”. A ‘symbolic’ problem would be for paper to be seen as part of “the old-fashioned past and a failure to progress to a modern, high-tech world.” Paper’s ‘cost’ is related to its “delivery, storage, and retrieval”. Regarding ‘interactional’ problems the authors mention that paper “must be used locally”, it “requires physical delivery”, it “can be used by only one person at a time”, and it “cannot be easily revised, reformatted, and incorporated into other documents.” However, different communities of practice see these classes of “problems” in different ways. According to Sellen & Harper, “one of the concerns for any investigation into paper” would be to separate the “symbolic”, i.e., ‘old-fashion’ aspect from real and quantifiable concerns. For some communities separating this symbolic aspect of paper
is not a matter of quantifying paper’s affordances. For the art community working with drawing, symbolic and interactional issues are so intertwined with its activities that any potential digital substitute must take them in consideration.

Problem statement

Brown and Duguid (1994) proposed the term “latent border resources” to describe resources that lay beyond the original intended uses of an artifact. They argue that communities are often formed around the exploration of such resources. These communities usually start small and grow overtime as members incorporate new resources and new members join in. For Lave & Wenger (1991), this expansion happens because learning how to incorporate these resources into a language shared by many requires a process of “co-participation”. This process of co-participation galvanizes groups into “communities of practice”, which Lave & Wenger consider to be formal or informal contexts for the “social participation” of active members, the attraction of new ones, and for the development of a “shared repertoire of communal resources (routines, sensibilities, artifacts, vocabulary, styles, etc.).”

Although the io2 DWS was not primarily developed for drawing, it can be used as a drawing tool because writing and drawing often share the same styluses to make marks on a surface (usually paper). This case study expands the io2 resources originally developed to improve the ‘legibility’ of handwritten text by using strategies such as substituting the pen’s original ballpoint stylus for other types of nibs or seeking different processes to disturb the ‘smart’ paper’s dot pattern. The study explores the mark-making capabilities of Logitech’s io2 DWS and the system’s potential use as a digital catalyst for current members of communities of practice formed around painting and drawing. The evaluation is meant to be formative, i.e., intended to be part of a developmental process, and uses the “Expertise-Oriented Evaluation Approach” described in
Fitzpatrick et al. (2004). According to these authors, this approach “depends primarily on professional expertise to judge an institution, program, product, or activity”. Jeffrey Rubin adds that this kind of evaluation is more effective when conducted by a “double specialist”, i.e., a “specialist that is also an expert in the particular technology employed by the product” (Rubin, 1994), which is the case of this dissertation’s author.

Description of the artifact’s prototype

The io2 DWS fits into the ubiquitous computing framework as it embeds computing capabilities into an otherwise regular pen. The system is made up of four components — a digital pen, a cradle, smart paper, and software — and has been designed to be an alternative input device. The pen has a regular ballpoint stylus used for writing or drawing, pressure sensor, a micro camera, and an advanced optical and storage system used to capture and store what has been written on the ‘smart’ paper. The ‘smart’ paper uses Anoto functionality technology. This technology adds a dot pattern mapped over a coordinate system to an otherwise regular paper. Anoto’s original dot pattern could cover an area equivalent to Europe and Asia without repetition. This makes it possible to have a unique dot pattern on each sheet of paper. The optical system includes a micro camera, advanced optical sensor, image processing software, and USB storage unit. As the pen moves over the paper it disturbs the dot pattern; the displacement of the dots is mapped and compared with the original pattern. Since each area of the dot pattern is unique, this system allows the displacement of dots to be tracked independently of when they occurred. The user can work on many sheets at the same time before downloading the digital documents to a computer. The system stores up to 40 documents before having to be

24 All technical information regarding the io2 DWS where obtained from Logitech io2 Datasheet retrieved from http://www.logitech.com/

25 http://www.anotofunctionality.com
downloaded to a computer. The pen’s battery handles up to 25 documents between charges. The cradle is used for recharging the battery and for downloading the files from the pen to a computer.

Figure 13. Logitech io2 Digital Writing System. Image A, the io2 Pen and Anoto ‘smart’ paper; image B, pen’s interior; image C, io2 Pen on the recharging and downloading cradle.

Once downloaded to a computer, the handwritten document can be converted to editable digital text using a combination of Logitech MyScript software and Microsoft Word, Outlook, Journal and OneNote. Drawings and sketches can be saved as bitmap digital images and edited with image processing software such as Photoshop. Logitech has also created special pre-defined symbols and lines — called ioTags — that can be used to by-pass some steps. A capital E within a circle, for example, tells the system that the text is an email. MyScript Trainer can be used to improve how io2 software handles the specific writing style of each user.

Description of the evaluation’s goals

According to Logitech, its io2 DWS was developed for “mobile professionals, office workers, or any organization looking for easy mobile data capture.” The digital pen was primarily designed for writing but the focus of the evaluation was on how it could be used for drawing. The pen
includes a 66mm-long ink cartridge that once pressed activates optical sensors. This study was limited to changing the point of contact between the pen and the smart paper. No other changes were made on the system’s hardware or software.

The study focused on the affordances of Logitech’s io2 DWS for drawing, and indirectly also to painting. This is justified by the fact that painting and drawing have been intertwined in the exploration of virtual space (i.e., of space represented on two dimensions). However, painting and drawing have been profoundly challenged by digital technology even though sketching and drawing are still widely used as part of design processes. Both used to have central roles in the investigation of virtual space, but are now considered inadequately instrumentalized to address the social context being reshaped by digital media.

Although the io2 can be used for drawing and sketching, the system’s original mark making capacity is restricted to what can be done with a ballpoint stylus. In the same way that handwriting and drawing have shared many other mark making tools — plumes, brushes, pencils, etc. — the io2 is a digital drawing tool as well. Evaluating its latent border resources can be achieved by exchanging the original ballpoint stylus for other mark making tools, for example. A formative evaluation helps define under which circumstances different styluses would still disturb the original dot pattern and what kind of marks left by these alternative styluses would be registered by the io2 system. The problem statement can be summarized through the following research question:

• Can an art-based evaluation reveal ‘latent border resources’ in ‘smart’ technology?
Cultural context of the io2 ‘smart’ technology

The ideas discussed in the previous sections support an approach to design focused on user experience in which developers working on technological innovations would nurture a strong connection between what they intend to develop and the needs and interests of the communities targeted by what they are doing. Unfortunately, this is not always the case. When pressed to modify an artifact, or motivated to develop a particular technology because of a recent breakthrough in a related area, designers and engineers can overlook important aspects or characteristics of that artifact or technology. They may be tempted to ‘define’ the use of that artifact or technology by singling out one aspect, based on a different set of priorities associated with another field of expertise — and another community of practice. Technological challenges, costs, and marketing considerations can put additional pressure for simpler solutions that can be quickly marketed as something new. However, by caving in to these pressures developers risk alienating the community of practice to which they intend to target their product(s). Feeling alienated, communities can put up defenses to resist what they feel is an outside intrusion into their collective learning processes, avoid direct involvement in the development of artifacts and technology, thus missing crucial opportunities to shape and re-new their own practice.

The relationship between the painting community and commercial digital painting software is a good example of this situation. For a long time, painting had a prominent role in the development of virtual space in Western culture. Art movements started to consistently challenge this role in the 1960’s, and despite occasional revivals painting kept losing its previous position. Digital technology has further exacerbated this decline.

Military, industrial, and commercial interests directed the development of digital technology for image processing that served primarily the areas of photography, graphic design and industrial
design. Early digital technology for image processing was funded by the military, which were more interested in photo-realistic techniques that could be used in surveillance, missile guiding systems, etc. Architecture, advertising, and industrial design were interested in digital tools that could be used in precision drafting techniques that were better attended by vector graphics either for 2D imagery or for 3D modeling. This technology could be used with a desktop computer without completely disturbing the traditional drafting methods used in these areas. However, for painting the technology had some serious drawbacks: painters had to give up all of their traditional interaction devices — brushes, paints, palette, their bodies, etc. But painting practice is so intertwined with these tools that giving them up was deemed unacceptable by most painters. In order to better understand the rationale behind this case study we must explore a little more how these tools shape the painting activity.

Brush design and manufacturing has evolved throughout a long period of time by bundling together materials such as the natural hair of different animals and by giving these bundles different shapes and sizes. Brights, flats, and filberts are some of the most common shapes, with sizes usually varying from very small (a few millimeters wide) to large ones (3 centimeters wide, or more). Synthetic materials have used as a substitute to natural animal hair but they are bundled in similar shapes and sizes as their predecessors. Using a brush made with synthetic hair does not disturb the use of the brush. This secures an easy transition from natural to synthetic bristle, and vice-versa, as choosing between brush types causes no disruption in the painting process. The material, shape and size of each brush make different strokes possible and the community practicing painting as an art form has made these differences an integral part of the painting language. Brushes are so integrated into the painting process that even when they are
set aside — as in the case of Jackson Pollock’s ‘drip’ paintings, for example — they still remain as the de facto reference.

The situation is similar with paint. The quality of pigments and binders used to make it malleable and stick to a surface produce paints with very different physical and chemical qualities regarding hue strength, translucence, light reflection, adhesion, etc. These qualities make each paint more suitable for different supports like canvas, wood board, paper, etc. A painter will take all these factors in consideration when evaluating the perceptual responses he/she intendeds to achieve and the context in which the work is going to be experienced. These decisions are so important that the collective learning involved in them have shaped smaller communities of practice, sub-groups of the larger painting community. Some are bound together because of their choice of paint (watercolorists, oil painters, etc.) and some because of how they use one or more material to shape alternative modes of pictorial space (‘non-representational’ or figurative painters, for example).

Despite of the fact that the contact between brush and paint is an intrinsic aspect of the painting process, this interaction is ignored in most digital painting software. In digital painting the brush has been substituted by mouse or stylus, which retain few, if any, of the brush’s characteristics. The palette, which is the surface where different colors are mixed, is considered a crucial aspect of the painting process, but in digital software it is substituted by a digital counterpart that does not emulate the characteristics of the traditional method. For the most part, digital models of different paints attempt to create the ‘effects’ of their traditional counterparts, but fail to provide any viable alternative to their physical characteristics. Other aspects of the painting practice

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26 For a good summary of the role of the palette on the painting process, see “The Palette: ‘Mother of all Colours” in John Gage’s *Color and Culture: Practice and Meaning from Antiquity to Abstraction.*
important to its community, such as the relation between the painter's body and the surface being painted, or the haptic feedback that the painter receives from touching the brush over the surface are completely absent from the digital process. As a result, the painting community has resisted adopting technological innovations associated with digital devices. With so many changes in its traditional methods, this community has, for the most part, avoided integrating digital painting software into its practice. It was much easier for photographers to do this kind of integration because digital cameras retained much of the modes of interaction associated with previous film-oriented apparatus.

The traditional combination of brush and palette form a simple but flexible apparatus, the result of extensive developmental processes that were adapted to diverse local cultural conditions. This flexibility facilitated the exploration of latent resources in painting artifacts and the facture of new ones that could advance the notional operations being elaborated by different communities responding to the specific conditions of their cultural context. Communities practicing painting and drawing have been formed and evolved around shared interests of what was initially considered latent resources at the fringes of mark-making styluses. Other equally specialized communities were formed around interests in other aspects of the same apparatuses and technologies. At different times, these shared interests were also considered latent and at the 'border', and only later were they turned into the core of a different set of interests and made central by a community.

Needless to say, the visible portrait of our contemporary collective identity is intricately related to digital technology. The issue being investigated here is how effective can Logitech’s io2 DWS be used as a base artifact for painting and drawing. The purpose of this case study is to
investigate ‘latent border resources’ of Logitech’s io2 DWS in the context of needs associated with painting and drawing.

**Case study’s methodology**

As already mentioned, the study uses the “Expertise-Oriented” evaluation model, which according to Fitzpatrick et al (2004) “depends primarily on professional expertise to judge an institution, program, product, or activity”. Every model has advantages and disadvantages in how it uses concepts to support its methodology, and this is also the case with the “Expertise-Oriented” model. Fitzpatrick et al. (2004) list among its contributions the “legitimization of subjective criticism and self-study with outside verification”. Among the methods’ limitations they list its difficult “replicability”, its “vulnerability to personal bias”, the “scarcity of supporting documentation to support conclusions”, and its “superficial look at context”.

These limitations suggest some of the reasons for what sometimes is perceived to be a problematic relationship between design and evaluation. Wania, Atwood & McCain (2006), for example, argue that there has been a focus on “design and evaluation methods that are used outside of the real context of use” and that “we need to see more and more methods and techniques that focus on taking in account the context of use or methods that are intended to be used in the real context of use”. To mitigate these problems in the present study the “Expertise-Oriented” method was combined with Activity Theory (AT) methodology. According to Engeström (2000), AT offers a “coherent new theoretical framework… to overcome the aged dichotomies between micro- and macro-, mental and material, qualitative and quantitative, observation and intervention…”
Gay & Hembrooke (2004) also proposed a model for the mediating role of evaluation in technology design based on AT (see Figure 11 on page 54). The authors argue that approaching activities such as the development of digital technology as “dynamic processes” instead of “static structured entities” would create new conditions for collaboration between evaluators and designers. They use Lave & Wenger’s concept of ‘communities of practice’ to emphasize continuous negotiations that dynamically shape this collaboration. One of the most important contributions of art to evaluation and design will come from understanding how the community formed around art defines its ‘rules and norms’. Many clusters are formed as members redefine the object of their activity by playing with the community’s tools and artifacts, and by manipulating their formal and informal rules and norms. These clusters end up affecting the internal dynamics of the entire community.

Also supporting the case study’s methodology is the definition of art offered by Flusser as “any human activity that aims at producing improbable situations” (Flusser, 2002a). Latent border resources of the io2/Anoto paper system were sought after in this evaluation by departing from the usual modes of interaction between artist and artifacts, more specifically of drawing on paper. This approach was motivated by the many 20th Century art movements that challenged then prevalent methods of visual representation and models of pictorial space that seemed to restrict cognitive (intellectual and multisensorial) explorations of virtual space. Artists like Picasso and Klee, for example, used different materials to change the physical texture of the surface they were using, and along with that developed different methods of creating virtual space.

Exercises proposed by Klee on his Pedagogical Sketchbook were used to guide many of the experiments in this case study. There were two main reasons for this: first, the Sketchbook was
written by Klee during his time as an instructor at the Bauhaus, a school that proposed a radically different approach to art instruction. Klee argued that the function of art is not to reproduce the visible but to make the invisible visible. However, in most art schools, drawing instruction still starts with an emphasis on “reproduction” and “representation” of objects. This is still a contentious issue in art with part of its community defining the “object” of its activity one way or another. Without trying to over simplify this complicated issue, for the most part drawing and painting that focus on “reproduction” is considered ‘academic’ because it follows rules and norms set up by the community aimed at sustaining a certain concept of beauty. For this reason, it was assumed here that latent border resources would be likely to be found by submitting the io2 system to situations aimed at “ugly” results. The second reason for using the Sketchbook is that using the exercises attends to some of the limitations of the “Expertise-Oriented” method, more specifically its difficult “replicability”, its “vulnerability to personal bias”, the “scarcey of supporting documentation to support conclusions”, and its “superficial look at context” (Fitzpatrick et al., 2004).

Evaluation procedures

This investigation is guided by the qualitative, “expressive” affordances of the io2 system, not a search for the system’s effective as a handwriting tool. In other words, motivated to explore the range, nuances and diversity of marks allowed by the original system or that could be added to it without changing its software or its hardware. The evaluation was limited to finding border resources of the original system and by changing the ink cartridge for other mark making tools. The initial assessment was that it would be necessary to find out if the length of the ink cartridge could be changed, if there was a way to expand the number of points of contact between the pen and the smart paper, and if the optical system could register marks or textures made by
other means. Knowing that the system is activated when the ink cartridge is pressed, one initial question was if other similar devices with one or more different tips (or “pens”) could substitute the cartridge. It was necessary to find out if the manufacturer had calibrated the system for a particular distance from the paper (taking in consideration the ‘legibility’ of handwritten text). But since the investigation was motivated not by ‘legibility’ but by ‘expressivity’ it was assumed at the beginning that there would be some room to modify the system and still have it able to register the changes within a limited area.

<table>
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Table 2: The three evaluations conducted for this case study

The first two evaluations (described in sub-sections A and B, and in figures 14 to 20 on pages 83-86) were conducted using the original io2 system without any modification, then repeated with the original ink cartridge/ballpoint being substituted by a metal rod of the same length and similar thickness but with an uneven ‘nib’. The coordination between eyes and hand were compromised by the use of an ink-less stylus. However, the use of an uneven nib was meant to decrease the predictability of the system, and therefore produce unexpected situations. This solution is similar to using a piece of charcoal left over from burned log (irregular by nature) instead of a drawing vine charcoal (a fairly even drawing tool). The evaluation described in the sub-section C (pages 86-89) compares three versions of the same drawing, one made with felt pen, one made with painting/drawing software, and one made with Logitech’s io2 DWS.
A- Evaluation using value scales

A value scale is a chart with the gradual sequence from light to dark tones. The chart is usually made of eight or ten squares, starting from white (usually the natural color of the paper) moving gradually through grays and ending in black. It helps someone learn how a particular material.

With tools suited to create line — such as pencil and pen — the scale is created by cross hatching the lines. Drawing a “value scale” is a standard exercise used in beginning drawing classes (Ensticce & Peters, 1996; Betti & Sale, 1997; Goldstein, 1999).

Figure 14. This figure shows how the io2 system registers the value scale created with the original pen. The system did not register lines when it was not pressed hard enough (squares 2, 3, and 4). The crosshatched lines remain very linear for the most part but start registering some mid-values towards the end of the scale. This is particularly visible in square 8. This is an indication of resources that could be further expanded to transform the io2 system into a digital drawing system.

Figure 15. This figure is a scanned image of the value scale shown in Figure 14. The scanned image is closer to how we visually register the scale with softer transitions between tones created with crosshatched lines made with the io2 pen. These transitions are softer in part because the ink left at the border of the pen’s ballpoint nib is spread over the paper filling the space between lines without disturbing the dot pattern.

Figure 16. This figure shows how the io2 system registered a value scale created with the original ink cartridge being substituted by a metal rod of similar size and thickness. Since the metal rod does not leave ink marks, the only visual cues are given by the way the ‘smart’ paper responds to the pressure applied with the modified pen.
Figure 17. This figure is the scanned image of the value scale shown in Figure 16. The scanner only partially registers the soft transitions created by the movements of the dot pattern and by ink being scraped from the printed dot pattern. The naked eyes can register even softer but more pronounced transitions.

B- Evaluation using exercises from Paul Klee’s *Pedagogical Sketchbook*

The *Sketchbook* is a compilation of exercises devised by Klee while teaching at the Bauhaus. In the introductory notes to the American edition, Moholy-Nagy argues that Klee had replaced the “academic” cannon of “deduction” — “based on the Aristotelian principle of deduction, meaning that all representation was deduced from the broad general principles of absolute beauty…” — for a principle of “induction” (Moholy-Nagy, 1968). Induction was the result of “observation of the smallest manifestations of form and interrelationship” from which Klee would be able to “conclude about the magnitude of natural order” (idem). Moholy-Nagy also argues that with this principle of induction Klee ‘fused’ science and art because a phenomenon “perceived and analyzed was investigated until its significance was beyond doubt”. However, “exactitude” was “winged by intuition” (idem). Klee’s approach is based on setting conditions that maximize the likelihood of improbable situations based on his idea that “art does not reproduce the visible, but makes the invisible visible” (Klee, 1979).

Three of the exercises from the *Sketchbook* were used in the evaluation (1, 2, and 12). The explanation provided for each exercise was taken directly from the *Sketchbook*.

• Exercise #1: “An active line on a walk, moving freely, without a goal. A walk for a walk’s sake. The mobility agent is a point shifting its position forward.”
Figure 18. Image A shows exercise #1 created with the original pen as it was registered by the io2 system. Image B shows a scanned image of the same exercise. Image C shows exercise #1 created with the metal rod instead of the original ink cartridge/ballpoint as it was registered by the io2 system.

- Exercise #2: “The same line, accompanied by complementary forms.”

Figure 19. Image A shows exercise #2 created with the original pen as it was registered by the io2 system. Image B shows a scanned image of the same exercise. Image C shows exercise #2 created with the metal rod instead of the original ink cartridge/ballpoint as it was registered by the io2 system.

- Exercise #12a: Waterwheel and Hammer. This exercise is based on “Trichotomy”, i.e., three “organs”: first organ is “active (brain)”; second one is “medial (muscle)”; and third is “passive (bones)”’. In this exercise the waterfall (represented by the lines that follow the direction of the top arrow) is the “active” element; the wheels (circles following the movement indicated by the
left arrow) are the “medial” element; and the hammer (activated by the movement indicated by the lower-center arrow) is the “passive” element.

Figure 20. Image A shows exercise #12 created with the original pen as it was registered by the io2 system. Image B shows exercise #12 created with the metal rod instead of the original ink cartridge/ballpoint as it was registered by the io2 system. Image C shows a scanned image of the exercise #12 created with the original pen.

C- Evaluation using a drawing comparison

This evaluation compared sketches made with three different mark-making devices: a Sanford Calligraphic pen, the Wacom Intuos 2 system (tablet and pen), and Logitech’s io2 DWS. These
three devices are shown on Figure 21 below. The Sanford calligraphic pen is an adaptation of traditional calligraphic pens that have interchangeable nibs. These nibs have different shapes that leave different traces when transferring ink from the pen to paper. The Sanford pen has a flat point that can easily produce marks as thin as its thickness and as thick as its width. The device, the Wacom system, is an alternative input device. The system’s tablet can trace the movements of a mouse and of a special pen-like stylus with a hard nib. The tablet includes controls for the pressure sensitivity of the pen with the user being able to easily control how soft or how firm the system should record the pressure being applied to the stylus. The use of this pressure control allows the system to emulate the mark-making variations of traditional drawings styluses (pencils, charcoal sticks, etc.) and traditional brushes. The third device used in this comparison was Logitech’s io2 DWS.

![Figure 21](image-url)
Figure 22. This is a scanned version of the sketch that was made using a Sanford Calligraphic pen.

Figure 23. The same elements sketched with the Wacom system using the Felt Pen of Corel Painter IX.
Among the three artifacts – Sanford Calligraphic pen, Wacom stylus, and the pen in the io2 DWS, the calligraphic pen is the lightest and thinnest, followed by the Wacom pen and the io2 pen. Being lighter and thinner makes the calligraphic pen the most comfortable to use. The Wacom pen and the io2 pen have round nibs, while the calligraphic pen has a flat nib. This flat tip makes it easy to explore a wide range of marks by just flipping the pen. In the Wacom system this range of marks is emulated through a number of settings in drawing/painting software made to maximize its characteristics. The io2 DWS can be improved by adapting the ink cartridge to an exchangeable nib system similar to the most traditional calligraphic pens. In order to re-design the ink cartridge the io2’s sensors and optical system would also have to be adjusted something beyond the technical conditions of the present study.
Discussion of the study

The Exercises explained in the previous section show that although the io2 DWS still does not register all the nuances created by the pen’s movement over the paper at different pressures, it comes close. The interaction made possible by the io2’s use of pen and paper is a step forward, and will be discussed shortly. It is also important to make a qualitative comparison between the io2’s graphic mark and that provided by other drawing tools because such quality, or lack of it, is one of the arguments that can be used against its wider acceptance by the drawing community.

The qualitative difference between io2 marks and the other drawing tools can be seen, for example, in Exercise #2 (Figure 19 on page 83). In image B the paper is registering line modulations due to different pressures applied to the pen; image A shows how the io2 translates this modulation into a single line weight. Image B has a richer graphic quality than image A because the paper registered nuances that are missing in the io2’s translation. The system also has some problems registering dark marks made by moving the pen many times over in one place. This can be seen on Image A of same Exercise #12. The system translated the single slight diagonal on the leftmost circle into two lines. The pen gives a buzzing sound when too many lines are drawn on top of each other, indicating that it is not being able to follow step by step the disturbance in the dot pattern. The metal rod creates a thinner mark than the ballpoint stylus, but the io2 does not seem to pick up the difference. This could be resolved by tightening the space between the dots in the dot pattern.

The evaluation discussed in this chapter was limited to finding out if the io2 DWS could register nuanced graphic marks created with the original ballpoint ink cartridge and with one alternative mark making tool. Other possibilities offered by the system, such as tightening the dot pattern or printing it on different papers, were not part of the study. Even within this limited evaluation,
some conclusions can be drawn about latent resources in the io2 DWS. The io2 relies on a common and well-known interaction between stylus and paper. The Wacom pen, on the other hand, requires a different adjustment of eye-hand coordination, because the hand moves over the tablet but the eyes are directed at the monitor. The Anoto functionality used by the io2 DWS offers an interesting solution to the “symbolic” problem of paper pointed out by Sellen and Harper (2002). By adding its dot pattern to an otherwise regular sheet of paper this functionality preserves all of the paper’s symbolic qualities, while establishing a direct link between paper and a digital drawing artifact. With the paper’s symbolic qualities preserved, this link establishes a necessary common ground between drawing and digital drawing. By creating a diverse set of nibs for the io2 pen, Logitech’s DWS can make this link even stronger.

The io2 DWS can also represent the first in a series of artifacts intended to solving paper’s ‘interactional’ problem, which was defined by Sellen and Harper (2002) as having to do with its need to be used “locally” and to have it delivered physically, its difficulty in being simultaneously shared by many users, and its difficulty in updating itself into a clean document once it has been revised, reformatted, and merged into other documents. The io2 DWS intermediates this interaction between papers. However, such intermediation could be greatly improved if it did not depend so much on the cradle, the system’s component used to re-charge the pen’s battery and to download files from the pen to the computer. The system’s dependency on such connection prevents its direct integration to networks that are already being established to support communication via other mobile devices such as regular cellular phones and other ‘smart’ artifacts used for text messaging and data transmission. The integration of the io2 DWS

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27 Wacom manufactures a version its tablet that is also a monitor. This solves the eye/hand coordination issue. However, this monitor/tablet product (Cintiq) costs ten times the price of a regular tablet of similar size.
to this kind of network would be an important technical innovation and a significant step towards the creation of digital drawing tools that could reshape the drawing activity.

The io2 DWS already addresses the third of paper’s problems as listed by Sellen and Harper (2002), “cost”. According to them, most of the cost of paper documents is in its “delivery, storage, and retrieval”. The io2 addresses this problem by directly translating the paper document into a digital file that can then be delivered, stored, and retrieved as any other electronic file.

This case study focused on the mark-making capability of the io2 DWS. The qualitative aspects of the marks made by a stylus — of any kind of stylus — are too important for the activities that make up the practice of drawing and painting to be side-stepped as it has been occurring in most digital systems aimed at the related communities. Even though io2 DWS still does not register well nuances in line weight, its integration of paper, pen and digital media point in the right direction when considering needs and concerns of the community working with drawing. The io2 should also serve as a model for the development of similar digital painting systems that combine canvas, brush, and digital media. Such links create conditions for painting and drawing to exist as activities within digital communication networks. Instead of having such networks be used just for the distribution of reproductions of paintings and drawings, digital systems based on the io2 DWS can potentially re-establish them as culturally relevant activities and renew their possible use as one more instrument that can be used to shape everyday life. The development of such systems does not guarantee that this renewal will happen, a subject that is explored in the next chapter’s study. Nonetheless, their availability provides more adequate conditions to bring the multisensorial aspects of pictorial explorations into the virtualization of real space and place and their integration into the digital fabric that supports contemporary life.
CHAPTER 5: EXPLORING ART AS ACTIVITY: A CASE STUDY

Introduction

Art and architecture are vehicles for a catalytic action of the poetic function towards new subjectivations. That is one of the main reasons why when developing ‘smart’ technology, its ‘smartness’ cannot be located only in complex sensor networks and computational grids but must also be designed to support multiple cross-pollinations between such environments and humans acting within them. The case discussed in this chapter evaluates art as an activity that breeds such cross-pollinations.

This study is motivated by the need to understand how to infuse everyday activities with an aesthetic sensibility that could re-virtualize the real space of social interactions mediated by any kind of technology, including ‘smart’ ones. It extends the case study discussed in the previous chapter, in which drawing was approached as an activity, and not just as the final result of one. That study was centered on the mediating tools between subject (in this case, artists working with drawing languages), object (the group of materials and conceptual elements that make up a drawing), and the community of practice that has been formed around them. This chapter looks into the internal dynamics of an art project initiated in painting and turned in new directions when its operational level, the somewhat automatic or routine process of putting paint on a surface, was interrupted by changing in what in AT is known as its levels of intentionality.

The case discussed here looks into the work of Brazilian artist Lygia Clark (1920-1988), a work in which all three intentionality levels of an activity — its conditions, goals, and motive — were changed. An interruption in the use of brush and paint, for example, forced a modification in the operational level, which changed the projects’ conditions, its lowest level of intentionality.
Such interruption triggered new actions and a reassessment of the previous goals associated with that activity. While this was going on, the artist reconsidered the motives associated with the activity and engaged in new negotiations with its object. Initially focused on representations in virtual space, for which she used brushes as mark-making tools and canvas as surface/plane of representation, she then progressively moved away from such representations, and became increasingly concerned with the reintegration of virtualizations into the social infrastructure. As she transitioned from one stage to the next, Lygia Clark was questioning the ‘need’ for art, both in the sense of need as defined by AT as the “ultimate cause behind human activity” as well as by how Arnheim framed it as a basic human necessity to make sense of our environment.

The changing conditions of this need have been the subject of debate in the arts for quite some time (Kubler, 1962; Summers, 2003). I am proposing that this kind of discussion can help the HCI community extend its understanding of the changing conditions brought by ‘smart’ technology as well. Dourish and Bell, for example, the first a computer scientist and the second a social scientist, both engaged in HCI research, argue that with ubiquitous computing we are forced to understand the practical and cultural logics of the spaces into which this technology is being placed (Dourish and Bell, 2007). For them, the organization of space as “the infrastructure for the collective production and enactment of cultural meaning” is as important as the physical substrate that supports this organization. These issues are discussed in this chapter and on the next one through case studies centered on art and architecture, respectively.

As mentioned before, Summers (2003) has argued that the organization of space as we know it today could not have happened without the ‘notion’ of planarity. He claims that as a concept the plane is a consequence “of making places and artifacts”, and a groundwork for the development of real and virtual spaces. However, such condition for “civilized order and activity”, as
Summers puts it, has come with a price, particularly in the form of a ‘visual bias’ and an emphasis on ‘a frontal relationship with the world’. This relationship has been criticized by authors like Ong (1982), Pallasmaa (1996), de Certeau (1998), de Kerckhove (2001), McCullough (2004), and Malnar & Vodvarka (2004), as well as by Summers. Michel de Certeau (1998) has put forward some of the strongest criticisms by arguing that “our society is characterized by a cancerous growth of vision, measuring everything by its ability to show or be shown and transmuting communication into a visual journey”. It is in order to emphasize the need to address this bias that Summers has proposed changing the term ‘visual arts’ for ‘spatial arts’, a change that, according to him, would facilitate a kind of “negotiation” between Western and non-Western traditions and between Western art and its own roots (Summers, 2003).

The case study discussed in this chapter examines the work of Brazilian artist Lygia Clark (1920-1988) as an example of this kind of negotiation. Clark challenged this visual bias during her career, starting in painting as an image-producing activity and moving towards what she called the “re-structuration of the self”. In the process, she explored multisensorial interactions and worked towards the dissolution of pre-defined roles between “producers” and “consumers” of art to achieve this. Clark’s work is well suited to support a discussion about art’s role in the re-spatialization of place through everyday activities that are motivated by aesthetics, the process and the science of sensitive knowledge as defined by Jacques (2001). In chapter 6 another case study will focus on projects generated within architecture aimed at similar efforts, more specifically, the re-spatialization of place and how the built environment can support activity in the context of ‘smart’ technology.

28 Lygia Clark’s and her close friend fellow Brazilian artist Hélio Oiticica (1937-1980) were motivated by the multisensorial emphases of Afro-Brazilian and other “native” Brazilian cultures. They explored latent resources in what Silviano Santiago calls a “culture in-between” (Gazzola and Miranda, 2001). For Santiago a culture in-between seeks to insert a “native culture” into “the universal totality” through processes of “differentiated repetitions”. These repetitions take performative aspects of native rituals and re-place them in different contexts.
The rest of the study is structured as following: the next section discusses theoretical aspects that clarify Clark’s endeavor and help connect it to the topics explored in Part I. The trajectory of Clark’s work is presented in the following three sections: the next one covers her first steps, followed by one discussing *Caminhando/Walking* (1964), a turning point in Clark’s career; the third one covers her proposals that combine of art, architecture, and activity. The last section presents a discussion of the case and further connects its material with what was presented in Part I.

**Theoretical considerations: the crisis of cartography**

In this section, additional concepts originally articulated in psychology, psychoanalysis, geography, cognitive science, anthropology, sociology and computer science, are weaved together with the concepts discussed in the previous chapters to build a theoretical foundation for the discussion of Lygia Clark’s work. This interdisciplinary theoretical base is necessary and justified by Clark’s own motivations as she developed her oeuvre. It also provides a substantive theoretical ground to discuss art as activity, and to place such discussion within the context created by ‘smart’ technology.

Among all the areas listed in the previous paragraph, psychoanalysis played a particularly important role in shaping Clark’s trajectory, so much so that towards the end of her career she even borrowed terms and concepts from it, and even stopped calling herself “therapist”.

Psychoanalyst Félix Guattari gives some possible links between the artist’s endeavors and psychoanalysis. He argues that the only acceptable objective of all human activity is the production of a subjectivity that continuously enriches our relation with the world. In his opinion such subjectivity can be produced through “dispositives” that can be found at the scale of urban environments, objects, and individuals, and one of art’s main objectives would be to
reveal them (Guattari, 1992a). An example of such dispositives is what Clark called “relational objects”, objects that had “physical specificities” due to the combination of easily available materials like plastic bags, stones, etc., but that had no “specific nature” (Clark, 1997). As these objects were manipulated they would create “relationships” between the person manipulating and his/her inner self, thus generating the kind of subjectivity called for by Guattari. Reinforcing the relevance of Clark’s project, Guattari argues that the “poetic function” is better equipped to “restore universes of subjectivity” because the “extraction… of aesthetic subjectivities” can provide “cuts” that make possible new and unexpected “existential harmonies, polyphonies, counterpoints, rhythms, and orchestrations” that support human action in the everyday life. He calls these existential results “complexity of subjectivization”.

Suely Rolnik, a former assistant to Lygia Clark whom later became a psychoanalyst, calls this complexity a “cartography of human existence” (Rolnik, 2000). She argues that a “crisis” in such cartography was already under way when Western industrialization started in the late 18th and early 19th centuries but that it has been exacerbated by more recent technological developments. According to Rolnik, some of the factors reflecting the social-cultural context of such crisis are the “exile of artistic practice into a specialized domain” and the consequent confinement of “processes of subjectivization” to the activity and experience of the artist and other “experts” (idem). Clark addressed this artistic exile through works that were increasingly more dependent of the participation of the ‘viewer’, whom in the process would become a co-producer of the work.

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29 Rolnik contends that art is a semiotic activity that supports the surfacing of the human experience and that when we delegate this experience to others, the social-cultural context becomes “unaesthetic” and a crisis takes over. A subsequent “terror” is experienced “pathologically” through “fantasizing interpretations” and “neurotic defenses” aimed at preserving some of the processes of subjectivization. These processes are revived through the vibrating body, i.e., the embodiment of the corporeal reality of the affects created from everyday contacts between human subjects and objects (Rolnik, 2000). These objects can be either human or non-human, but in either case the everyday life can be qualitatively improved through this corporeal reality.
Following a similar line of thought regarding human experience, Paul Harrison, a geographer, argues that we make sense of everyday life through experiences that are “at the edge of ourselves”, and that these experiences are only liminally “semantically” available (Harrison, 2000). He calls these experiences the “unthought” and the “unseen” because other than being “representations” they are “processes operating through our distracted, tactile knowing” (idem).

For Harrison, the lived present is “an open-ended generative process” and he uses the term “emergence” to capture the “fluidity” and “contingency” of everyday experiences. In the 1960’s Clark created works like *Draw with your fingers* (1966) (made of a plastic bag with just a little bit of water inside) and *Sensorial Gloves* (1968) (thick oversized rubber gloves) to call attention to this tactile knowing. In the next sections other multisensorial projects also by Clark will be discussed.

Following Deleuze, Harrison argues that emergence “demands a new spacing of knowledge” based on the “minor circumstances of everyday life” and on the “whatever surfaces of the everyday”, and contends that what carries us through these circumstances and surfaces is “habit” and “embodiment”. He quotes Taussig’s definition of habit as that region where “the unconscious strata of culture are built into the social routines as bodily dispositions”. However, both of them argue that these routines have occasional “breakdowns”, i.e., “moments in-between stimulus and responses”. These are the ‘aha!’ moments when in the midst of some ordinary situation we realize something extra-ordinary. Harrison calls these moments “intervals” and argues that they are full of potential because they interrupt the habitual. He argues that what keeps us moving through intervals is “embodiment”, which he defines as active and generative reconfigurations of cognitive structures, affects and sensations (idem). Clark explores these intervals and aims at triggering such ‘aha!’ moments in works like *Living Structures* (1969) and *Living Structures: Dialogues* (1969). In the first one of them, a web is created by attaching rubber
bands to one of the feet of four people lying down and to one of the hands of four people standing up; the people’s gestures create a flow of reconfigurations and therefore a number of moments in between stimulus and responses (Clark, 1997). On the second one, two intertwined rubber bands attached to the ankles of two participants form the starting point for a dialogue (idem).

N. Katherine Hayles corroborates Harrison’s arguments by calling attention to a distinction between embodiment and the body. She argues that the body is “normative” in relation to some general criteria, while embodiment is “contextual, enmeshed within the specifics of place, time, physiology, and culture” (Hayles, 1999). Embodiment is thus “performative, subject to individual enactments, and… improvisational”, while the body can “disappear into information” and be “independent of any particular manifestation” (idem). Clark’s Living Structures, as well as Biological Architectures of the same period, depend on this performative, improvisational aspect of embodiment.

Supported by a position articulated by Dreyfus in What Computers Can’t Do, Hayles also argues that embodiment is neither “essentialist” nor “algorithmic”. By essentialist they mean something that is indicative of “qualities or attributes shared by all human beings”, and by algorithmic they mean something that can be “formalized in a heuristic program for a digital

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30 Hayles argues that we could “enrich the tension between embodiment and the body” by juxtaposing a distinction between inscription and incorporation. By inscription she means systems of signs that operate independently of manifestations; like the body they are “abstract” and “normalized”. Incorporation, on the other hand, “cannot be separated from its embodied medium” (idem). She argues that there is an “interplay” between incorporation and inscription that is similar to what goes on between embodiment and the body.

Hayles then proposes the term incorporating practice to define actions that are encoded into bodily memories by performances that are repeated until they become habitual (Hayles, 1999). Therefore, incorporating practices are “performative”, while their juxtaposed inscribing practices “correct and modulate the performance” (idem). Together they create “cultural constructs” such as gender, consumer, user, etc. These cultural constructs “flow” from the body into the environment and vice-versa through performance and modulation. These flows are improvisational, often ‘unthought’ and ‘unseen’, but nonetheless they create knowledge, which is embodied and experiential.

31 In What Computers Can’t Do, Dreyfus argues that “embodiment means that humans have available to them a mode of learning, and hence of intellection, different from that deriving from cognition alone”.
computer” (idem). They argue that embodiment makes available “modes of learning” and of “intellection” that are different from those attributed to cognition alone (idem). These modes of learning are critical in the context of ‘smart’ technology because the integration of such technology in everyday activities must be based on embodiment, as most everyday activities also are.

Because ‘smart’ objects and environments are subject to individual enactments and improvisations, the development and implementation of ubiquitous computing should then be based on serious negotiations between its “producers” and its “consumers”. Michel de Certeau has centered his analysis of everyday life on these two entities. For him, technological and political forces shaping the social apparatus are turning consumers into “immigrants” in a system that is too complex to be grasped, a system that tends to imprison them in a tightly knit web of forces (de Certeau, 1984). He argues, though, that the everyday struggles offer “tactical” opportunities that consumers use to transform this web of “social codes” into “individual articulations of cultural appropriations”, i.e., the transformation of cultural precepts into instruments used in individual struggles in everyday life. Or the transformation of a rigid structure into a living one, just like Clark’s proposals attempt to do. De Certeau calls attention to the “status of the individual in technical systems” and argues that the individuals cannot escape “technocratic frameworks”; they can only “try to outwit them, to pull tricks on them, to rediscover, within an electronicized and computerized megalopolis, the “art” of the hunters and rural folks of earlier days” (idem). Individuals achieve this through the way they use “imposed systems”. This includes linguistic ones in which everyday language is used to “manifest logical

32 The field research described in Chapter 7 - Evaluating Activity with ‘Smart’ Technology: a case study with four communities of practice” explores the grounds for such negotiation.

33 This negotiation is the subject of a field research discussed in Chapter 7.
complexities unnoticed by scientific formalizations’” (idem). What keeps these linguistic systems alive is their continuous adaptation to contemporary situations, an adaptation integrated into the embodied interactions of everyday life.

New subjectivizations are enacted, performed and embodied through these operations, working as counterpoints to the informational fluxes that endanger former existential territories. Among these operations the ‘poetic’ ones work as “catalyst[s] for existential operators” that give consistency and persistency to new subjectivizations. Art and architecture are important vehicles for this catalytic action of the poetic function. That is one of the main reasons why when developing ‘smart’ technology, its ‘smartness’ cannot be located only in complex sensor networks and computational grids but must also be designed to support multiple cross-pollinations between such environments and the humans acting within them, and must include art and architecture in the process.

**Lygia Clark’s trajectory: first steps**

Mário Pedrosa, a well-known Brazilian art critic and a contemporary of Clark and Oiticica, referred to their work as “the experimental exercise of freedom” because they “reformulated and liberated the aesthetic act so that it could give itself up to completely unfamiliar transactions” (Carvajal, 2000). In this sub-section I discuss the initial development of Clark’s ideas until a proposition she called *Caminhando* (*Walking*, 1964; see Figure 26 on page 104), which is considered a turning point in her work (Clark, 1997; Herkenhoff, 1997; Rolnik, 2000).

Clark started her trajectory in 1947 working with the Brazilian landscape architect Burle Max (1909-1994), who was also a painter. She moved to Paris in 1950 to study with Fernand Léger, a
painter with close ties to Brazilian modernist movement. She returned to Brazil a few years later and joined a group of experimental artists from Rio de Janeiro and São Paulo. The group worked primarily with geometric forms but in the late 1950’s split into two groups because of disagreements regarding the future development of their artistic program. In São Paulo, the Concretists argued for a more formal and rigorously geometric agenda, while in Rio de Janeiro the Neo-Concretists pushed for softer exploration of geometric forms. Lygia Clark (and Oiticica) belonged to the Neo-Concretist movement (also known as Grupo Frente), but she only stayed with the group for about two years before deciding to pursue a different path. Her last works as member of the Neo-Concretist group were paintings with geometric forms that “flipped” back and forth as if they were doors held to walls by hinges (Gullar, 1997; Bessa, 2005).

In 1960, already out of the Neo-Concretist group, Clark declared the “death of the plane”. In a text written at the time, she argued that human beings created the plane as a concept for “practical reasons, to satisfy their need for equilibrium” but that it also contributes to a “false and rational sense of our reality” (Clark, 1980a). She argues that in order to regain a sense of ourselves as “alive and organic unities” we need to break down the plane “as the support of our expression”. At around this time, Clark took the geometric forms that had been flipping around perceptual “hinges” and transposed them to real space. This is the beginning of her Bichos (Animals, 1960-1964), probably her best-known work. This was the first series to question her previous reliance on visual elements and propose a different relationship between “producer” and “consumer” of art.

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34 Before Clark, among other artists Tarsila do Amaral, one of the leaders of the Modernist movement in the 1920's, had also studied with Léger. It was after her stay in Paris and after her return to Brazil that Tarsila do Amaral painted, among other works, the Abaporu (1928) considered a turning point in Brazilian art for addressing a “native” thematic and for forging a local pictorial language.
The *Bichos* are “spatial-temporal constructions” (Pedrosa, 1980) that invite the “spectator” to establish “dialogues” by manipulating the parts of the art “organism” (Clark, 1980b). With the *Bichos*, what used to be a relationship between artwork and spectator in the realm of virtual space, via painting, becomes “effective” (idem). Through the manipulation of this artwork-organism the relationship between “producer” and “spectator” now creates “spatial-temporal virtualities” (Pedrosa, 1980). Pedrosa argues that as the series evolved, the space created by the work became increasingly more “architectural” than “sculptural” because not just the spectator moves but so does the *Bichos*. Art is revealed as an activity through the interactivity required by the *Bichos* just like in Activity Theory, where subject and object also form a basic unit.

**Lygia Clark’s trajectory: Caminhando/Walking (1964)**

*Walking*, a proposition from 1964, marks a definite transition in Clark’s work. “From this point on”, she wrote, “I give absolute importance to the immanent act realized by the participant” (Clark, 1980c). She considered *Walking* as a proposition that allowed the participant to make choices, to explore the “unpredictable”, and to experience “the transformation of a virtuality into a concrete endeavor”. The object that supports *Walking* possible is a Moebius strip made of any kind of paper. The participant then uses a pair of scissors to make an incision and starts
cutting the paper lengthwise. Clark describes *Walking* as starting as just a “potentiality” that is transformed into a “unique, total, existential reality” by the “fusion” between participant and object. She argues that there is no separation between subject and object, just this fusion between the two, and that there is nothing before, and nothing after, just the act of cutting the strip itself. The actual cutting of the Moebius strip and the related symbolic “walking” are fused into an activity. Whomever experiments with *Walking* should be able to experience the “empty-full”, and the result of such activity is a “mysterious germination”. Rolnik describes this germination as “the experience of the vibrating body at the moment in which the exhaustion of a cartography is processed when the silent incubation of a new reality of feeling is under way, that incubation being the manifestation of the fullness of life in its power of differentiation” (Rolnik, 2000).

![Figure 26. Caminhando / Walking (1964)](image)

Clark’s use of the Moebius strip offers a unique juxtaposition to Flusser’s cycle of aesthetics, which is represented by putting the cycle’s four poles also on a Moebius strip. In the last section of this study will use this juxtaposition, to explore some key issues related to the re-spatialization of place and the virtualization of everyday life with ‘smart’ objects.
Lygia Clark’s trajectory: art and architecture as activities

After proposing Walking, Clark went through a very serious personal crisis that lasted a couple of years. During this crisis she continued to devise other experiments to challenge the separation between subject and object in art. In Longing for the Body (Nostalgia do Corpo), a series developed at this time, objects were still “indispensable” in triggering sensations in the participant. In Sensorial Masks (Máscaras Sensoriais), for example, a series developed mostly in 1967 and 1968, she creates olfactory stimuli by placing seeds and herbs in small pockets close to where the nose would be when the masks were in use. In Goggles (Óculos - 1968) and Dialogue: Goggles (Diálogo: Óculos - 1968), double-sided mirrors and springs were used to modify goggles normally used for diving. Those using the goggles could manipulate the mirrors and springs and by doing that “fragment the perception of the surrounding space” (Clark, 2000). The Sensorial Gloves (Luvas Sensoriais - 1968) were oversized gloves made of different materials used to manipulate balls of different sizes and textures. The experience of using the gloves was meant to help its users “rediscover touch” (idem).

Figure 27. On the left, Óculos / Goggles (1968); on the right, Óculos Diálogo / Dialogue Goggles (1969)

35 For a good explanation of the significance of these “crisis” in Clark’s life and work, see Rolnik, 2000.
In the following few years Clark developed two other series — *The body is the house* (*O corpo é a casa*) made for the 1968 Venice Biennale, and *The house is the body* (*A casa é o corpo*) — in which she investigated a link between body and architecture through the structure of the labyrinth (Brett, 1997). In *The body is the house* Clark set up the labyrinth, dark and full of objects and textures. Participants had to go through its four “cells” — penetration, ovulation, germination, and expulsion — blindfolded and would come out to a bright tent intended to emulate the experience of birth. In *The house is the body*, on the other hand, the labyrinth’s ‘architecture’ depended entirely on the participants’ bodies. Clark intended to make the separation between subject and object “disappear”. Participants became “the living structure of a cellular architecture, the mesh of an infinite tissue, and what remains of the object (some elastic bands, plastic sheets, jute sacks and threads) are quite empty of meaning and can only be brought to life by human support” (Clark, 1997b).

![Image](image.png)

**Figure 28. Biological Architecture: Egg shroud (1968).**
Between these series and the last period of her work, Lygia Clark spent some time off formulating what she called *Mute Thought (Pensamento Mudo)* through which she wanted to “relocate the real in terms of life” (Clark, 1980d). Through mute thoughts Clark wanted to quiet herself and bring up the “consciousness of other realities”, or as Rolnik (2000) describes it free “the act of thought from its yoke of representation, to place it fully at the service of the vibrating body”. The result is “the germination of new states of sensation no longer needs works of art, for now the mats are produced directly from life” (Rolnik, 2000).

In the last stage of her work, called *Structuring the Self (Estruturação do Self)*, Clark made a radical turn moving even farther away from the art world of studios, galleries, museums, etc. During this period she developed a number of “relational objects”, objects that according to her had “physical specificities” but “no specific nature”. Their ‘nature’ depended on the “relationship established with the fantasy of the subject” (Clark, 1997c). Using the “objective reality” of these objects Clark would work with each ‘participant’36 to structure a new mode of subjectivization “in which ‘at-homeness’ was no longer the neurotic ego of the modern subject but a living structure in a process of becoming, engendering itself through impregnation by the world, which Clark called ‘self’” (Rolnik, 2000). Rolnik, who collaborated with Clark in these experiments and later became a clinical psychoanalyst, argues that this subjectivization does not provide an “identity”, but is in fact “the definitive deterritorializing of the subject as spectator”. Clark claimed that the use of the Relational Objects in the Structuring the Self provided “a ritual without myth” (Clark, 1997c). Rolnik argues that this is the kind of ritual that is needed now in the context of new technology and globalization, a ritual that is not a “transference of myths”, but a ritual to “constitute an “at-homenes” within deterritorialization itself” (Rolnik, 2000). The

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36 Clark in fact adopted a psychoanalytic vocabulary and would call participants “clients”.

Relational Objects, arrays of simple materials, as used by Clark “provoked the dissolution of the disjunction of the aesthetic plane in its process of subjectivization” and liberated it “from its confinement in the artist’s subjectivity” (idem). No more confined to pre-defined roles, former spectators of aesthetic objects devised by others, “consumers” could then juxtapose aesthetics to their own everyday life, imbue ordinary objects of ‘relational’ qualities, and set off to do their own ‘experimental exercises of freedom’.

**Discussion of the case**

The development of Clark’s work is a compelling example of how the concept of virtualization can move to interactions with everyday life objects, including ones modified by ‘smart’ technology. Virtualization may still depend on the ‘conditional availability of surfaces’ as argued by Summers, but the information onto them can now be dynamically modified in real-time. In this context of a ubiquitous virtuality, virtual space does not depend on a capacity to represent three-dimensions in two but on a capacity to trace, process, record, and communicate anything taking place in real space. Surfaces now serve to a different kind of translation of three-dimension into two.

The discussion of this case departs from a superimposition of Flusser’s use of the Møbius strip to represent his *cycle of aesthetics* and Lygia Clark’s use of the same strip in *Walking* 37. Clark’s development happened by moving repeatedly into that un-habitual territory that Flusser calls “ugly”. In the first steps of her work, Clark was exploring ideas in virtual space within the

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37 As far as I know, there are no written references to any encounter between Flusser and Clark, but they probably knew about each other. In the early 60’s Flusser started writing a weekly column in the Fôlha de São Paulo daily newspaper, and Clark was one of the best-known artists working in Brazil at the time. An important but indirect connection between them may have taken place through the art critic Mário Pedrosa and the physicist Mário Schemberg, close friends of both. Pedrosa lived in Rio de Janeiro and Schemberg in São Paulo. In an unpublished manuscript, Clark wrote that all the “culture” she had she got it from “spending time with Mário Pedrosa and Mário Schemberg” (quoted in Rolnik, 2000). “They impregnated my ears with all that was interesting and good”, she wrote (idem).
general framework of “abstraction”. This framework was still somewhat fresh at the time, but not shockingly new anymore. The initial “terror” that it had caused decades earlier had by then been transformed into something “beautiful” and was making its way towards “pretty” and “kitsch”. With her *Animals* Clark started to move away from representations and towards objects that required to be manipulated by ‘spectators’. Through this manipulation of objects, spectators also had to move into unfamiliar territory. They had to move towards into the “ugly” and become themselves part producers.

The initial resistances to dynamic interactional possibilities opened by these objects were minimized by the fact that they could be placed in a certain position and viewed as sculptures. Placing them a sculpture, which is how they usually have been shown after Clarks’ death, tame the resistances to interact with an object and make it easier to treat them as “beautiful” art objects. *Walking* breaks down this escape gap. According to Clark, the moment she proposed *Walking* was a terrifying one, because *Walking* had to be treated as a “proposal” and could never be treated just as an art object. Such radical step was hard to take even for Clark and as a result she went through an acute personal crisis. She knew she had crossed a threshold, a point of no return. From then on, her work became progressively more directed at finding ways to help the spectator become user, than performer, so that he/she could experience the “empty-full”, and link it with his/her subjectivity. In doing so, they would create new conditions for their everyday life. At this point of her work, art objects seized to exist as the result of art activities (a painting on the wall, a sculpture, etc.); instead, simple mundane objects were transformed into instruments mediating the relation between subject and object in activities designed to “leave behind various shelters constructed from a priori representations” (Rolnik, 2000), and construct
in its place a new “at-homeness”. This new “at-homeness” was achieved through active embodiments that would potentially open a new reality.

Through collective experiences of the empty-full, the normative characteristics that Hayles associate with the body are transformed and “the body, in its relation to objects… becomes poetic again” (Rolnik, 2000). A new platform, or ‘plane of subjectivity’, is thus established, from which revitalized psychological as well as biological needs can seek objectification. These needs are objectified through what Guattari calls “dispositives” — everyday objects, fellow citizens, the urban environment, etc.

Clark’s exploration takes place at what Massumi calls the “edge of the virtual, where it leaks into the actual” (Massumi, 2004). We could describe this edge as a border zone between virtual and actual where latent resources from each side transit from one another. Clark’s work developed from a initial concept of virtualization described by Summers (2003) as a process “rooted in the capacity to see three dimensions into two, and in the conditional availability of surfaces upon which this capacity may be brought into play” to one in which virtuality is considered “the dynamic part of human reality” (Lévy, 2002). In the last phase of her work Clark devised aimed at triggering this dynamic part by devising objects made of simple and inexpensive materials, objects that could be made by anyone. She called these objects “relational”, and used them in private sessions with one participant at a time38. The sessions were held in Clark’s apartment because she wanted to avoid having them being confused with some sort of art project, something that could have happened had she used the space of galleries or museums.

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38 Clark called the process “therapeutic”, called herself “therapist” and called the participant “client”. For a in-depth discussion of the reasons behind this vocabulary and its implications for the future understanding of Clark’s work, see Rolnik (2000).
Overlapping Clark’s work with Flusser’s *cycle of aesthetics* we can gain additional insights into the kind of consideration that should take place in the development of ‘smart’ technology, because as Michel de Certeau puts it “technocratic frameworks” are not designed for their “consumers”\(^{39}\). Outwitting technocratic frameworks requires ‘playing’ with the apparatus and increasing one’s chance of moving from being a ‘functionary’ to being a ‘photographer’ (Flusser, 1999a). To pull “tricks” on apparatuses is one of the main applications of art, argues Flusser\(^{40}\).

It is my thesis that when working on ‘smart’ technology developers must treat artifacts and environments as being “relational”, in the sense that objects and the infrastructure should aim at enhancing ‘the dynamic part of human reality’. When computational capabilities are added to artifacts and environments to highlight and enhance their latent border resources, they provide “consumers” with additional leverage to transform space into a practiced place, as argued by de Certeau. The capacity to send text messages through cellular phones — an apparatus originally developed for oral communication — is an example of successful use of this approach. ‘Smart’ relational objects raise the quality of the activities mediated by them, create new opportunities for the re-spatialization of place, and transform the infrastructure available for the collective production and enactment of cultural meaning in everyday life.

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\(^{39}\) De Certeau argues that although consumers cannot escape the grip of apparatuses they can “try to outwit them, to pull tricks on them” (de Certeau, 1984). They do that through “spatial practices”, everyday tactics that transform space into a “practiced place” (idem). De Certeau gives the example of “the street geometrically defined by urban planning” being transformed into such space by the people that walk on them (the “walkers”). Another example is “the written text”, which de Certeau describes as “a place constituted by a system of signs”, which is transformed into a spatial practice through the “act of reading” (idem).

\(^{40}\) Flusser departs from the etymology of the word art, from the Latin *ars*, “the ability to turn something to one’s advantage”, and *artifex*, those that use such ability, he argues that in order to outwit technocratic frameworks one must be an “artist” or a “trickster”.
CHAPTER 6: THE BUILT ENVIRONMENT AND ‘SMART’ TECHNOLOGY: A COMPARATIVE STUDY

Introduction

Over the past decade, researchers have promoted the ubiquitous and pervasive computing agenda by integrating ‘smart’ technology into the built environment under concepts such as “smart house” (Aldrich, 2003; Harper, 2003; Tolmie et al, 2003; Frohlich & Kraut, 2003; Roy et al, 2003; Helal et al, 2005), “ambient intelligence” (Brumitt et al, 2000; Aarts, 2004; Friedwald, 2005; Markopoulos et al, 2005; Remagnino & Foresti, 2005), “intelligent environment” (Holmquist et al, 2004; Bullivant, 2005), and “programmable architecture” (Oosterhuis, 2002a, 2005; Bouman 2005). These different approaches attempt to capture essential changes in how the physical infrastructure will support everyday life as sensors, actuators, and computing devices are added to it. The comparative study discussed in this chapter explores some of the core issues related to how the built environment is being transformed by ‘smart’ technology.

As pointed out by Aarts (2004), Saggio (2005), Tscheligi (2005), Dourish and Bell (2007), and Bell and Dourish (2007), the integration of such technology into the built environment has been motivated by different concepts of “infrastructure”. This case study discusses some of these differences. At one end, in projects such as the GatorTech Smarthouse led by a group of computer scientists, the focus is to have a “programmable pervasive space” that is “scalable” and “cost-effective” (Helal et al, 2005). This approach adds a “smart” layer to an otherwise ‘regular’ house, meaning that it accepts commonly held tenets of stability and tradition associated with existing architectural plans and construction methods. As a result, from the outside the GatorTech looks just like any other house in the neighborhood. On the other end, projects such as Trans-ports and
the *Saltwater Pavilion* by the Dutch ONL architecture studio challenge those principles, approaches architecture as a “game to be played by its users”, and subjects “planning, construction, interior design, and landscape to forces of real-time calculation” (Oosterhuis, 2002). In the first case, sensors, actuators, and computing devices are used to track the inhabitant’s movements and support daily activities; in the second case, although they are also used to track the user’s movements and support daily activities, the focus is on having the space serve as a mediation between the user/inhabitant and a networked society at large. In the case of the *GatorTech Smarthouse*, moving computation off the desktop as promoted by ubiquitous computing is done without changing the cultural and psychological implications of a particular environment, while for projects such as *Trans-ports* and the *SaltWater Pavilion* such changes are a key aspect of the design process. These two “extremes” of habitats demarcate striking differences regarding how far architecture and ‘smart’ technology will change one another as they morph into ‘smart’ environments. Using Flusser’s *cycle of aesthetics* as scale, the *GatorTech Smarthouse* uses sensors, actuators, and computing devices in a habitat that falls onto the “kitsch” section of the scale — habitual and predictable — while the *Trans-ports* blends them into a habitat that falls into the “ugly” section of the scale — non-habitual and unpredictable.

The next section outlines the main theoretical considerations regarding ‘smart’ environments as computer scientists, architects and social scientists have addressed them. The following section describes the *GatorTech Smarthouse*, followed by a section that describes examples of “programmable architecture”, such as the *Saltwater Pavilion* and *Trans-ports*. In the last section of this chapter these projects will be compared as I revisit some of the theoretical issues discussed earlier and further address some of the challenges involved in the development of ‘smart’ environments.
Theoretical considerations

With terms such as “ambient intelligence”, “intelligent environment”, and “programmable architecture” researchers attempt to encapsulate concepts elaborated by different communities of practice in alternative frameworks that can be used to support the design of ‘smart’ environments. Although using the same technology, the two approaches discussed in this study demarcate striking differences regarding how architecture and computing devices will change one another as they are blended into such environments. Derrick de Kerckhove (2001) calls this new kind of space “connected architecture” because it is a space that “supports the physical and mental interconnectivity of bodies and minds”. He warns that connected architecture is not the same as web architecture or information architecture, because although all three are concerned with “connections”, only the first “tackles the management of thresholds and infrastructures between… the physical and virtual spaces”.

Designing this kind of interconnected space requires equal attention in managing networks and psychological impacts of the built environment. It does also require a qualitative improvement in managing “screens” as new “connectors and accelerators for connected minds”. De Kerckhove goes even farther by arguing that the main purpose of this “screen-based information exchange” is to challenge the “eye dominance” of all previous technology used to support virtual spaces. For him this happens because there is an “interval” — an area of “flexibility and interpretation” — between the screen and the eye that brings about a “multisensorial process of thinking”, that allows an externalization of “content and processes of our thinking both in terms of images and of words”. This externalization makes it possible for us to examine, interpret, correct, and reformulate what appears on the screen in a “psychotechnical way”, i.e., by choosing which links to follow among those appearing on the screen. Combining de Kerckhove’s concept of ‘interval’
with Harrison’s makes the ‘aha!’ moments, when we realize something extra-ordinary in the midst of some ordinary situation, a multisensorial experience. The cases discussed later in this chapter will show how widely different the approaches to these possibilities can be.

Determining the role and extent of screens in a ‘smart’ environment is central to defining which design path to follow and what kind of experience will be supported by the built infrastructure.

For Alicia Imperiale (2000), screen is related to “skin” and to “surface”, and they form a new kind of “flatness”. Imperiale argues that the skin is the “surface through which a body experiences the world” and that skins are now becoming “programmable surfaces, photosensitive membranes that narrate, design and inform the spatial organization of the volumes and interpret their functions” (idem). Surfaces are always interfaces between real and virtual spaces, but by being programmable these new electronic skins make possible new experiences of space and place. The widespread use of these skins in objects and in the built environment make computing ubiquitous, and create the conditions for an ubiquitous virtuality.

For Maria Palumbo (2000), this ubiquitous and surrounding media space created by the pervasive use of screens forms a new kind of “womb”, because this technology reverses visual, perspective-based experiences of space and creates a “new convergence between body and architecture”. This convergence makes it possible to treat the form and the structure of the built environment as a “living system”41. For Palumbo, electronics is pushing the built environment to “disappear” within a network of “interconnections”, thus creating “a new in-between zone between nature and artifice”. In this zone, the surface is “the limit of space” and the “hypersurface” is a “window onto the world of interactions”. This in turn creates a new “logic of

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41 Out of curiosity, when searching the Internet for scholarly articles about ‘wall in architecture’ the first pages returned results about ‘wall in cell architecture’ and other similar medical/biological topics. (Search using Google Scholar, 31 January 2008)
complexity” that pushes the “sensitization of space” towards “intelligent spaces” by changing the information paradigm “from the mechanical and computational logic of the abstract machine into a logic of visual and metaphorical complexity”, which according to Palumbo is the logic “that underlies the physical or corporeal basis of living systems”.

This new emphasis on skin, surface, and womb in architecture, as pointed out by Imperiale and Palumbo, finds a noteworthy repercussion in Oosterhuis’ proposals regarding architecture, which can also be linked to Lygia Clark’s work (see Figure 29 on page 126). Exploring similar issues regarding the relation between architecture and living systems, Pallasmaa (1996) argues that what separates architecture from other forms of art is the “bodily reaction” to the objects that surround us. Pallasmaa argues that besides the prevailing “architecture of the eye”, there is also a “haptic architecture of the muscles and the skin” and an architecture that “recognizes the realms of hearing, smell and taste.” For Pallasmaa the task of architecture is to create “embodied existential metaphors” and to make human experience concrete and structural.

The link between architecture and these embodied metaphors is so strong that it served as the basis for a mnemonic system widely used in Europe for almost two thousand years, from as early as 50 B.C. up until the 1700’s (Yates, 1992). Francis Yates describes this ‘art of memory’ as a set of techniques used to impress ‘places’ and ‘images’ on memory by transforming architectural settings into “memory palaces” (idem). These mental palaces where imbued with additional objects related to the specific needs of what had to be memorized. To recover the memory associated with those objects the processional space of the building was later mentally

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42 He argues that these “other architectures” are architectures of and for the senses, and gives as example the work of Erich Mendelsohn (1887-1953), Hans Scharoun (1983-1972), Alvar Aalto (1898-1976), and Frank Gehry (1929) as evoking muscular, kinesthetic and haptic sensations (Pallasmaa, 1996). In the case of Aalto, for example, he describes the work as being based on “sensory realism” and considers his buildings “sensory agglomerations”.

43 For more on this, see The Art of Memory by Francis Yates. For an example of the impact of such mnemonic device on international relations, see The Memory Palace of Matteo Ricci by Jonathan Spence.
revisited. The ideas behind the memory palaces were also used in the design of real buildings, as for example in the Globe Theater used by Shakespeare’s company. Yates argues that the different systems devised to create such palaces were also fundamental for the development of scientific revolution in the 1700’s and 1800’s. She describes a “transformation” that occurred in the art of memory at that time from being a “method of memorizing the encyclopedia of knowledge” and “of reflecting the world in memory” to one of “an aid for investigating the encyclopedia and the world with the object of discovering new knowledge” (idem).

Although the idea of memory palaces was mostly used in Europe, architecture’s aptitude to create “embodied existential metaphors”, as Pallasmaa put it, has been widely recognized. Summers, for example, argues that architecture is the art of “social spaces” because “it both encloses and includes institutions”, and it is how “human groups are set in their actual arrangements” (Summers, 2003). He argues that architecture ‘shapes’ places and give them their distinctive character no matter whether we are talking about Mayan, Chinese, or contemporary American suburban architecture. The reason is that the built environment always weaves together cognition, memory, and social practices.

Moving outside of these better-known cases, Bahamón (2004) describes the tents of the Tuareg people as a literal example of such weaving. The Tuareg, a nomadic group from Niger, uses a variety of local materials to make their tents, and use colors and patterns to indicate “different social and family affiliations” (Bahamón, 2004). Representing social and family affiliations is important because the Tuareg men often go on trading expeditions that can last up to seven months while women stay behind in semi-nomadic camps taking care of family and herds (Rasmussen, 1998). “Local” and “global” forces are negotiated within the home space of their tent through the actual construction of the tent, the interior distribution of space, song and
conversation. The Tuareg are a nomadic group but their tents provide a constant pattern for their collective identity and quite literally work as mnemonic devices for the social life of the group.

The programmable architecture of contemporary architect Kas Oosterhuis discussed in one of the next sections approaches such weaving of cognition, memory, and social practices, by using present-day material and digital technology. Oosterhuis accomplishes such weaving through the use of ‘smart’ materials and through the incorporation of global communication networks into the fabric of the buildings. The GatorTech Smarthouse, on the other hand, explores architecture’s predisposition to function as a mnemonic device to support the integration of ‘smart’ technology into the infrastructure of a house to be used by senior citizens. The age-in-place concept as it is used to support the GatorTech project indicates a different approach to the construction of personal and collective identities and of the social life of a group. These two approaches will be discussed throughout the rest of this chapter.

‘Smart’ houses: the GatorTech Smarthouse project

The GatorTech Smarthouse is a programmable pervasive domestic space specifically designed for the elderly and the disabled (Helal et al, 2005). The project’s objective is to “create assistive environments such as homes that can sense themselves and their residents and enact mappings between the physical world and remote monitoring and intervention services” (idem). It is part of an on-going effort in pervasive computing to help assisted living providers design smart environments based on a model called “aging in place”. The objective of this model is to help

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44 As part of the dissertation research, I intended to spend a week as a resident of the GatorTech Smarthouse to evaluate my framework and this domestic smart environment. The project had to be cancelled due to logistical problems and funding issues as the GatorTech shifts its financing sources. Therefore, the information discussed in this chapter was gathered from academic journals.
adults keep on living in their own homes for as long as they can care for themselves (Marek & Rantz, 2000; Mynatt et al., 2004; Tomika et al., 2007). In addition, the GatorTech Smarthouse is meant to be “scalable”, which means that it is being developed to “automatically integrate systems components” making it easier for experts in assisted living “to develop and deploy… new applications for users” (Helal et al, 2005).

Although sensors, actuators, and computing devices are used in the GatorTech to provide senior citizens conditions for independent living by easing their physical limitations, the same technology is being developed for general use as, for example, in the House_n project at the MIT (Intile, 2002) and the EasyLiving one being developed by Microsoft (Brumitt et al, 2000). There are a number of smart systems being developed for these domestic spaces, among them:

- **Smart floors**: sensors under the floor track the position of the resident. In the case of the GatorTech it will eventually detect when a resident falls.

- **Smart beds**: sensors monitor how resident sleeps. It can be used to establish sleeping patterns, which can help tracking the overall health of the resident.

- **Smart bathroom**: sensors and actuators control the temperature of water, deliver automatic toilet water flushing, track toilet paper, and control soap dispenser.

- **Smart display used for entertainment, gathering information, and for communication.**

- **Cognitive assistant**: “guides residents through various tasks” (Helal et al, 2005).

- **Smart refrigerator/pantry**: keeps track of an inventory of the food stored in the refrigerator and kitchen cabinets. It can be connected to grocery stores for home delivery as needed.
• Other systems include smart closet, laundry facility, microwave, stove, social-distant dining, thermostats, phones, plugs, and security monitoring.

In order to make their system ‘scalable” and adaptable to different built environments, the developers of the GatorTech project created six layers — “physical”, “sensor platform”, “service”, “knowledge”, “context management”, and “application”. These six layers are organized in a generic reference software library and form the project’s middleware architecture. The “physical” layer consists of all the appliances, furniture, and devices typically found in an American residence (chairs, tables, lamps, TV set, clock radio, heating thermostat, smoke detector, etc.), as well as other new technology such as a keyless entry system and a ‘smart’ microwave — called smartwave — that can “automatically adjust the time and power settings for any frozen food package” (Helal et al, 2005). The sensor platform layer “defines the boundary of a pervasive space within the Smarthouse”, senses the presence of any object “attached” to it, and converts any sensor or actuator placed in the physical layer to a “software service that can be programmed or composed into other services” (idem). The service layer is made of basic, standard, and composite services, and include “voice recognition, text-to-speech conversation, scheduling, and media streaming” or any number of combinations between them (idem). The knowledge layer contains a list of services offered by a particular configuration of the Smarthouse and of which appliances and devices are connected to the system. It can also be used to translate information between services and devices. The context layer is used to define and/or restrict a particular application under certain conditions. The application layer is the top-most layer from where developers can manage, activate, and/or deactivate services, appliances and devices. In order to make the system open to any new device a “smartplug” has also been developed. This
plug helps the system locate the new device in the physical environment of the *Smarthouse*, which in turn allows it to be managed through the different layers of the middleware (idem).

**Table 3: GatorTech Smarthouse: Publications by year and by community of practice**

<table>
<thead>
<tr>
<th>Year</th>
<th>Computer Science / Engineering</th>
<th>Rehabilitation / Occupational Therapy</th>
<th>Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2001</td>
<td>10</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2002</td>
<td>13</td>
<td>1</td>
<td>0</td>
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<tr>
<td>2003</td>
<td>29</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2004</td>
<td>9</td>
<td>1</td>
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<td>2006</td>
<td>16</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2007</td>
<td>12</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>108</td>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

*Table 3.* Number of articles written by faculty and students involved in the development of the *GatorTech Smarthouse* between 1999 and 2007. Source: [http://www.icta.ufl.edu/publications.htm](http://www.icta.ufl.edu/publications.htm) (accessed at October 10, 2007).

The development of the *GatorTech Smarthouse* has been geared towards creating a scalable technological substrate that can be added to any architectural setting. The studies related to the project have been primarily motivated by computer science and engineering concerns and produced by members of communities of practice associated with these areas. The table in the previous page shows the number of articles that have been written between 1999 and 2007 by faculty and students involved in the development of the *GatorTech Smarthouse*. The articles were counted according to year of publication and the community of practice of main author. The authors were divided into three groups: one group is made of faculty and students from computer science and engineering and associated with the University of Florida’s Mobile and Pervasive Computing Laboratory; the second group is made of faculty and students from rehabilitation and occupational therapy, most of them associated with the University of Florida’s Rehabilitation Engineering Research Center on Technology for Successful Aging. The third
group was meant to include faculty and students from any architecture program involved in the project. The project was initiated in the Mobile and Pervasive Computing Laboratory and in 2004 transferred to a house in a retirement community. Although GatorTech is not just a lab but a lab in a house or a house-lab there are no public records of any preliminary research conducted by the developers to evaluate the needs of the target population — senior citizens looking for ways to remain in their homes despite of increasing physical constrains — nor of any research about the optimal architectural setting for the project.

The “aging-in-place” concept started to be used by GatorTech developers at around the time that the International Center on Technology for Successful Aging (ICTA) was established at the University of Florida (Mann & Helal, 2002). Two evaluations were conducted once the system was moved out of the laboratory and installed in its current location in the retirement community. In one of these evaluations, a 78-year old woman spent 24 hours at the house (Davenport et al, 2007). She was asked to “treat her stay in the smarthouse as if she were spending a typical day in her home” (idem). This houseguest had a mixed review of her stay, but ranked her overall experience as “satisfying”. The second study (Johnson et al, 2007), involved three focus groups with 6 participants each. Each focus group session lasted about 2 hours (idem). The participants were “older adults with mobility impairments”, “older adults with visual deficits”, and “older adults without a significant impairment” (idem). The study aimed at gaining “an initial understanding of older adult’s perceptions and reactions to the technology and applications” at the GatorTech Smarthouse. The authors of this study recommended “more input from potential users” in order to attain “more beneficial and usable applications” (idem).

A review of the articles listed in the GatorTech Smarthouse’s website, indicates that the authors were motivated to develop technology for smart environments without much consideration for
how such technology would impact the built environment’s infrastructure and how this modified infrastructure would “shape individual actions and experience”, what Dourish and Bell (2007) call the “experience of infrastructure”\textsuperscript{45}. In McCullough’s opinion (2004), the need to address this experience is that architecture’s “deep knowledge of environmental perception” may be its biggest contribution to interaction design and HCI. The publications listed in the Smarthouse’s website also do not indicate any notable concern with how the design of the space could impact the development of the technology.

This approach to pervasive computing moves the computer off the desk or from our laps and distributes it into the architectural setting, but risks doing it by simply transferring to a building the same limitations of the desktop concept. Developing a “smart” house without consideration of the environmental perception and knowledge afforded by the built environment and the experiences derived from them narrows the problems that must be taken in consideration when designing the technology, but risks developing inappropriate tools and ineffective devices. In the next section, I discuss some ‘smart’ environments in which the environmental perception and knowledge and experience of the infrastructure are the primary motivations.

**Soft architecture: transformations in the built environment**

For the architect Kas Oosterhuis (2002), placing the experience of the infrastructure at the core of the design of ‘smart’ environments requires a significant revision of architecture’s theory and practice. He argues that digital technology turns architecture, urban planning, construction, interior design and landscape design into a “realtime transaction space” or “game” to be played in real time by their users (Oosterhuis, 2003). In the case of ‘smart’ buildings, its shape and

\textsuperscript{45} The authors were interested in the ‘experience of technology’ as shown in the studies by Davenport et al (2007) and Johnson et al (2007).
behavior would change as sensors, actuators, and computing devices capture any reaction to what the designers had pre-programmed, as users/visitors interact with the built environment and with one another, and to data collected from the natural environment (weather conditions, wind patterns, etc.). Oosterhuis describes such buildings as behaving like a “swarm” because its programmable elements (sensors, actuators, joints, etc.) will show “flocking behavior, always keeping an eye on the neighboring actor, always ready to act and react” (idem). The result is what Oosterhuis calls “swarm architecture” or an architecture that is “at the same time e-motive, transactive, interactive and collaborative” (idem). Architects creating such architecture are “designers of intelligent vehicles”, “sculptors of information” involved in “e-motive styling”.

An example of such architecture is the Saltwater Pavilion developed by ONL (Oosterhuis_Lénárd) in 1997, and built at Neeltje Jans Zeeland (The Netherlands). This pavilion approaches the built environment as “data carriers”. ONL also explored the concept of a building being a “unibody”, associating its “structural integrity” to that of “the skull of an animal’s head” (Oosterhuis, 2002). Oosterhuis argues that although the animal’s skull is complex and hard it is also “wrapped in a flexible skin, protecting the nervous wiring and allowing it to follow the movements of the jaw and sense organs” (idem). In the Saltwater Pavilion, ONL wrapped a structural unibody with a flexible, seamless, continuous and soft “elastomere skin” that worked as a protective layer as well as a projection screen.

The Pavilion is divided in two areas: the Sensorium and the WetLab. Access to the Pavilion is made through the WetLab, where real water drips from the walls and floods the floor making everything wet and slippery (Oosterhuis, 2002). The water runs on the floor making “waves” requiring that users negotiate with the building how and when to move from place to place. Dimmed lights of different colors reflected on the walls and the running water creates “an
immersive underwater experience”. From the WetLab the user walks into the Sensorium where there are virtual representations of water. The Sensorium is a mixture of ‘color-scape’ and ‘sound-scape’ controlled by sensors and actuators that can process data gathered from the environment outside the building, the Internet, and from interaction between the users and the building.

Connecting the WetLab to the Sensorium there is a continues twisted object called Hydra, which ONL considers a semi-independent ‘data-carrier’.

Following the Saltwater Pavilion, the ONL (Oosterhuis_Lénárd) studio added to the concepts of “realtime transaction space” and “swarm architecture” the idea of flexible structure in projects like the Trans-ports Programmable Pavilion. Created in 2001, the Trans-ports Pavilion “changes shape and content in realtime” as it responds to “local information content” and to information retrieved from the Internet (Oosterhuis, 2002). It has an “active” structure that responds to a program, which means that it can “relax” its rubber exterior skin when external and internal conditions are light or “tighten” it when these conditions are strong. These light and/or strong conditions could be linked to wind speed around the building, for example, or respond to actions by audience/users. Oosterhuis (2003) describes the building as an “input-output machine”. His studio proposed to construct a number of these pavilions in different places to connect different ‘ports’ in a single ‘trans-portation’ system. An early version of one of the Trans-ports was installed at the 2002 Venice Architecture Biennale.

ONL followed the Trans-ports Programmable Pavilion by proposing an E-motive House, i.e., a “fully programmable muscular construct” with a broad range of “moods and modes’ (idem). The E-motive House uses a rubber skin similar to the used in the Trans-ports Pavilions, as well as some of their principles. The house can either respond “to needs and wishes of its inhabitants” or act by itself to “surprise” its users, or to “play games” with them. The E-motive House can also switch
between “modes” — entertainment mode, relax mode, educational mode, etc. — and works as “a social semi-independent extension of the human bodies of the inhabitants” (Oosterhuis, 2003).

*MUSCLE*, another of ONL’s project, constructed and installed in 2004 at the Non-Standard Architecture exhibition at the Pompidou Center in Paris, is another application of the theoretical principles supporting the *Trans-ports Pavilions* and the *E-motive House*. This work consists of 72 pneumatic muscles connected to each other and forming a consistent mesh wrapped around a blue inflated bubble” (Oosterhuis, 2005a). The ‘muscles’ react to information input via varying air pressure that can be sent to each one of them. Adding air pressure makes the ‘muscles’ thicker and shorter; releasing air pressure makes them thinner and longer. The changes in the muscles transform the inflated bubble in realtime. Oosterhuis argues that the nodes controlling each individual muscle move “like the birds in the swarm” and that the MUSCLE is a prototype for a new kind of building.

![Figure 29. On the left, Oosterhuis’ MUSCLE (Source: http://www.oosterhuis.nl/quickstart/index.php?id=347, retrieved on 21Feb2008); on the right, Lygia Clark’s Tunel, 1973). Clark’s series of ‘biological architectures’ anticipates the kind of organic architecture proposed by Oosterhuis.](image)

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46 It is interesting to point out a link between the hinges in Lygia Clark’s *Bichos* and the pneumatic valves used in Oosterhuis’ muscles.
As stated before, the emphases of ONL’s projects is on a social space experienced through infrastructure constructed and programmed based “on the idea that all building elements operate as intelligent agents, as data-carriers and data-processors, and that they are active members of a swarm”. The difference between this approach to a ‘smart’ environment and the one used in the *GatorTech Smarthouse* will be the subject of the next and final section of this chapter.

As stated before, the emphases of ONL’s projects is on the experience of an infrastructure constructed and programmed based “on the idea that all building elements operate as intelligent agents, as data-carriers and data-processors, and that they are active members of a swarm”. The next and final section of this chapter will be used to discuss the differences between this approach to a ‘smart’ environment and the one used in the *GatorTech Smarthouse*.

**Discussion of the case**

The two approaches discussed in this chapter show striking differences in how developers use sensors, actuators, and computing devices to realize their vision of ‘smart’ environment. In the case of the GatorTech, they are driven by an interest in adding ‘smart’ technology without disturbing what they assume to be a standard architectural setting, thus preserving the social and emotional experiences provided by it. The concept of ‘aging-in-place’ is here used to justify the preservation of familiar experiences provided by such settings. The developers of this model take the house to be a stand-alone unit linked to the outside world for basic utilities; additional functional support such as the ‘smart’ refrigerator and mail delivery system, for example, keep to a minimum the resident’s needs to venture outside the house for basic daily tasks. This technology is seen as providing a service that enhances the quality of life of the smarthouse’s residents.
However, as these systems have been designed, they also keep the possibility of social interactions with the outside world to a minimum. The social-distant dining is the only attempt to provide some sort of interaction between the GatorTech resident and people outside it. Although GatorTech’s altruistic model intends to provide a comfortable environment for senior citizens, its emphases on just adding ‘smart’ layers to otherwise regular domestic space seems too directed at extending the resident’s life without tackling the more difficult task of re-designing the domestic space and the activities afforded by it to make aging be also a time of continuing personal growth. An alternative model could be investigated in which the lives of the Smarthouse’s residents could be substantially improved by taking in consideration the physical and the social environments when defining the context of use. While taking into account “the contribution of existing information embedded in [the] environment to people’s experience of it and to their situated interactions”, as pointed by Paay (2005), and as it is literally enforced by the GatorTech project, the re-design of the architectural setting could also qualitatively improve the resident’s lives without just trying to make up for the loss of mental and physical capabilities associated with aging. For example, a ‘cognitive assistant system’ could be much more than a system to remind residents when to take a medicine or direct residents through some tasks; it could instead stimulate cognitive operations and sociability.

Oosterhuis’ ‘programmable architecture’, on the other hand, defines the context of use by making information technology a defining factor in the design of the physical and the social environments. The focus here is not so much on the existing information that is embedded in the environment and its role in shaping people’s lives, but in letting the embedding of information in real time define the architectural setting and situate the interactions within it. In this context, the resident does not seek to preserve social and emotional experiences provided by
a familiar environment; instead, he/she recognizes being part of a human ‘swarm’ and seeks to go through social and emotional experiences that reflect such condition.

The merging of the two conditions exemplified by the GatorTech Smarthouse and by Oosterhuis’ programmable architecture — the first focusing on preserving standing stances, the second on responding to new networked ones — will eventually re-shape the built environment to reflect the changing needs and motivations of contemporary societies. The challenge is in finding ways to gradually merge these two conditions while addressing the social, economical, and environmental concerns of our time.

Meeting this challenge requires extensive collaboration between people working in different fields. Such collaboration is often hindered by misunderstandings regarding what the other groups can bring to the table. A field research was designed to get insights into how such misunderstandings occur by looking into how four professional groups define and construct their activity. This case study is discussed in the next chapter.
Chapter 7: Evaluating Activity with ‘Smart’ technology: a case study with four communities of practice

Introduction

This chapter describes an evaluation of how four communities of practice define and construct their activity and how such activity is being shaped by the development of digital technology. The evaluation was triggered by the use of Logitech’s io2 Digital Writing System47 already described in Chapter 4. This artifact was used as a prop to help participants define the object of their activity and as a bridge between communities of ‘developers’ and ‘users’. The communities of practice covered in this study were made of undergraduate students in their sophomore, junior and senior years in one of the following four departments and/or programs at Iowa State University: architecture, art and design, computer science / computer engineering, and creative writing.

The reason for relating each of these four programs with one community of practice is that undergraduate programs are designed to prepare students to become members of a professional community. Most students are considered to be at the ‘periphery’ of one of these communities — even more so in the case of undergraduates — but academic departments expect that what they teach these students prepares them to negotiate their full membership into a community of practice as they move up towards the end of their program. The io2 DWS was used as an object of reference to evaluate how the students expect to negotiate their way to the center of their chosen community. The study evaluates how they define the community of practice into which they anticipate getting full membership, and how they intend on using the tools, artifacts, and

47 See Chapter 4 for a description of the technical characteristics of Logitech’s io2 Digital Writing System. While the focus there was on border resources associated with io2’s mark making capabilities, the focus here is on how the four communities of practice construct their activity.
knowledge that they are acquiring at the university. The study also evaluated if each group anticipates the need to collaborate when engaged in their professional activities, what kind of collaboration that would be, and how they expect to negotiate this collaboration.

**Description of evaluation’s target audience**

The target audience for this evaluation was made of undergraduate students comfortable using computers and familiar with ‘smart’ objects, such as cellular phones, for example. The definition of the audience was based on the objectives of the evaluation and on Logitech’s claim that its io2 Digital Writing System was developed for “mobile professionals, office workers, or any organization looking for easy mobile data capture.” In order to participate, the student had to have had already declared to be majoring in one of the four programs. A total of thirty-two students, eight from each area, were expected to participate in the evaluation. All potential participants were screened regarding previous experience using digital writing systems. Age, gender, education background, computer experience, general attitude towards computers, and other relevant information were obtained from each participant through a questionnaire at the beginning of the evaluation.

The charts in the next two pages show the expected profile of the target groups and the profile of the participants. Table 4 on the next page shows the expected and actual distribution group by group. Despite of an intensive recruiting effort no students from the creative writing program contacted the researcher; this group was kept as a group with zero participants. Table 5 (pages 132-135) tabulates all the participants according to their personal history, and educational, computer and product experience.
Table 4: Expected and actual distribution of participants

<table>
<thead>
<tr>
<th>Group</th>
<th>Expected # of participants</th>
<th>Number of Applicants</th>
<th>Actual # of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>08</td>
<td></td>
<td>08</td>
</tr>
<tr>
<td>Art and Design</td>
<td>08</td>
<td></td>
<td>08</td>
</tr>
<tr>
<td>Computer Science / Computer Engineering</td>
<td>08</td>
<td></td>
<td>09</td>
</tr>
<tr>
<td>Creative Writing</td>
<td>08</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4. Table showing the expected and actual distribution of each group of participants.

Table 5: Profile of participants in the study

**Personal History**

<table>
<thead>
<tr>
<th>Category</th>
<th>Expected profile</th>
<th>Frequency Distribution Expected</th>
<th>Frequency Distribution Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male/Female</td>
<td>50% male / 50% female</td>
<td>84% male / 16% female</td>
</tr>
<tr>
<td>Learning Style</td>
<td>Need written instructions before doing new task on the computer / experiment with different ways of doing any new task on the computer even before having read any instruction</td>
<td>20% need written instructions</td>
<td>12% need written instructions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80% experiment with different ways of doing any new task</td>
<td>88% experiment with different ways of doing any new task</td>
</tr>
</tbody>
</table>

**Education History**

<table>
<thead>
<tr>
<th>Category</th>
<th>Expected profile</th>
<th>Frequency Distribution Expected</th>
<th>Frequency Distribution Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>College Undergraduate</td>
<td>Sophomore</td>
<td>30% of participants</td>
<td>16%</td>
</tr>
<tr>
<td>College Undergraduate</td>
<td>Junior</td>
<td>30% of participants</td>
<td>24%</td>
</tr>
<tr>
<td>College Undergraduate</td>
<td>Senior</td>
<td>40% of participants</td>
<td>60%</td>
</tr>
</tbody>
</table>

**Computer Experience**

<table>
<thead>
<tr>
<th>Category</th>
<th>Expected profile</th>
<th>Frequency Distribution Expected</th>
<th>Frequency Distribution Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years of experience</td>
<td>From 1 to more than 4 years</td>
<td>5% 1 year or less 5% between 1 and 2 years 5% between 2 and 4 years 85% more than 4 years</td>
<td>8% &lt; 8 years 24% = 8 years 68% &gt; 8 years</td>
</tr>
<tr>
<td>Type of computer</td>
<td>Desktop/Laptop</td>
<td>50% desktop 50% laptop</td>
<td>24% Desktop 72% Laptop 4% equal use</td>
</tr>
<tr>
<td>Frequency of daily use</td>
<td>From rarely to all the time</td>
<td>5% Rarely</td>
<td>25% Sometimes</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------</td>
<td>-----------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Architecture</td>
<td>Less than 4hrs: 25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Art &amp; Design</td>
<td>Less than 4hrs: 12.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comp. Engineering/Comp. Science</td>
<td>Less than 4hrs: 11.1%</td>
</tr>
<tr>
<td>Types of software used</td>
<td>Use one or more of the following: word processing, design, desktop publishing, database, spreadsheet, other</td>
<td>100% Word processing (Average of years by group)</td>
<td>Architecture: 9.4 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60% Design/Publishing (Average of years by group. When students reported more than one software, the one used the longest was used for the average)</td>
<td>Architecture: 3.6 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25% Database</td>
<td>Architecture: 4.1 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20% Spreadsheet</td>
<td>25% Compilers</td>
</tr>
</tbody>
</table>
### Input Devices
(Scale 1-5 from rarely used to used it daily)

<table>
<thead>
<tr>
<th>Device</th>
<th>Expected profile</th>
<th>Actual profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% have used keyboard</td>
<td></td>
<td>100% marked 5</td>
</tr>
<tr>
<td>100% have used a mouse</td>
<td></td>
<td>100% marked 5</td>
</tr>
<tr>
<td>70% have used a digital camera</td>
<td></td>
<td>Architecture:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: 0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2: 12.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3: 37.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4: 37.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5: 12.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Art &amp; Design:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: 0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2: 12.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3: 12.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4: 75%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5: 0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comp Eng. / Comp. Sci.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: 0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2: 22.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3: 55.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4: 22.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5: 0%</td>
</tr>
<tr>
<td>70% have used a scanner</td>
<td></td>
<td>Architecture:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: 0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2: 25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3: 62.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4: 12.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5: 0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Art &amp; Design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1 did not report):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: 0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2: 25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3: 25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4: 12.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5: 0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comp Eng. / Comp. Sci.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: 22.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2: 66.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3: 0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4: 11.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5: 0%</td>
</tr>
</tbody>
</table>
Table 5 (continued)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10% have used drawing a tablet</td>
<td>1: 87.5% 2: 12.5% 3: 0% 4: 0% 5: 0%</td>
<td>1: 37.5% 2: 25% 3: 12.5% 4: 12.5% 5: 12.5%</td>
<td>1: 78.8% 2: 22.2%</td>
</tr>
<tr>
<td>5% have used a digital pen</td>
<td>100% never used</td>
<td>100% never used</td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Table summarizing the profile of the participants. The information in the “Frequency Distribution – Actual” column was obtained through a Background Questionnaire filled out by each participant at the beginning of each session.

**Description of evaluation methods**

The method used in this study combines the evaluation method developed by Kaptelinin, Nardi, and Macaulay (1999) in the “Activity Checklist” with the “Expertise-Oriented” model used in the study described in Chapter 4. Fitzpatrick et al (2004) describe the “Expertise-Oriented” method as a method that “depends primarily on professional expertise to judge an institution, program, product, or activity”. Since university programs are expected to prepare capable professionals for different communities of practice, the method is used here to evaluate how the future professionals objectify their motives and goals to construct a concept of their activity. The same advantages and disadvantages of the “Expertise-Oriented” model depicted by Fitzpatrick et al (2004) and already described in Chapter 4 apply here. Undergraduate and graduate programs are designed to give their students the conceptual tools and technical knowledge that they need to become members of their respective professional communities. The development of a critical stance towards a field of expertise and the possibility of having an expert’s
knowledge be questioned by others is one of the positive aspects of the “Expertise-Oriented” model. It is necessary to instill in the students a critical stance towards what they learn in order to promote qualitative changes in these communities. These positive aspects of the “Expertise-Oriented” model are related to what in Activity theory is called internalization/externalization processes, and to what Summers calls ‘notional operations’. According to AT, internalization happens when internal signs and cognitive operations substitute artifacts previously required to solve certain tasks. These internalized processes are then used by an individual in his/her interaction with the world, a process AT calls ‘externalization’. What AT describes as externalization can also find its way to new artifacts through what Summers calls ‘facture’.

As already mentioned in Chapter 4, there are also limitations to the “Expertise-Oriented” model. Fitzpatrick et al (2004) list among them its difficult “replicability”, its “vulnerability to personal bias”, the “scarcity of supporting documentation to support conclusions”, and its “superficial look at context”. Activity Theory can be effectively used to counter-weight these limitations of the “Expertise-Oriented” model, in particular because AT provides a framework for the study of activity and of the context in which it takes place.

Kaptelinin & Nardi (2006) argue that in the analysis of human interaction with technology, as is the case of the present evaluation, the analysis should be extended from ‘tasks’ to the social and meaningful context of a subject’s interaction with the world. Members of a community of practice conceptualize activity differently depending on what their perceptions of the tasks associated with their activity and the conditions associated with them. With this in mind and intending to improve the applicability of AT’s conceptual framework Kaptelinin, Nardi, and
Macaulay (1999) developed the “Activity Checklist”\textsuperscript{48}. They argue that the Checklist makes AT’s concepts more ‘concrete’ by helping the design and evaluation of the contextual factors of human-computer interaction (Kaptelinin, Nardi, & Macaulay, 1999).

In this case study, the Checklist was used to evaluate how each group defines the object of its activity when handling technology (the io2 ‘smart’ pen and computers in general) within the environment that supports their activity. The study was intended to evaluate the “relationship between artifacts, environments, and the world”, the kind of analysis that Kaptelinin and Nardi (2007) argue are “needed” to develop AT.

The Checklist\textsuperscript{49} is divided in four parts:

1. **Means/Ends**: related to the hierarchical structure of activity, this part addresses which goals can be associated with the particular needs of an individual.

2. **Environment**: related to the social-cultural environment, this part “identifies the objects involved in an activity” and how together they form the environment for an activity.

3. **Learning/Cognition/Articulation**: related to the internalization and externalization processes associated with cognition, and to learning as a context-dependent activity.

4. **Development**: looks at the “permanent developmental transformations” that impact any activity.

\textsuperscript{48} All references to the Activity Checklist are from Kaptelinin, Nardi, & Macaulay’s article *The Activity Checklist: a Tool for Representing the ‘Space’ of Context* (1999), unless otherwise explicitly noted.

\textsuperscript{49} Based on this four-part structure Kaptelinin, Nardi, & Macaulay created two slightly different versions of the Checklist, one to be used in evaluations and one to be used in design. Both versions emphasize “tool mediation” (Kaptelinin, Nardi, & Macaulay, 1999). The design version is further divided in two parts, one focused on ‘user’ and one on ‘design’. The evaluation and the user portion of the design version are very similar, while the design portion is more attuned to the design process. The evaluation version and the design portion of the design version are the primary references for the study discussed in this chapter.
The evaluation was triggered by the io2 DWS and moved from there to other aspects of their activity. The io2 DWS is treated here as a “boundary object”, defined by Warr and O’Neill (2007) as “conversational pieces that create and communicate knowledge, rather than a container of knowledge per se”. They propose using boundary objects to break down the barriers created by different perspectives and vocabularies of different communities of practice. It thus seems appropriate to use the io2 DWS to evaluate how different communities construct their activity and look at how they build common ground and share vocabularies.

The data was collected in one 1-hour sessions with each of the 25 participants. The objectives, instruments used in the data collection and other aspects of the evaluation are discussed in the next sections.

**Description of intended objectives of the evaluation**

Kaptelinin and Nardi (2006) write that in AT, the environment is not considered a mediator, like artifacts or tools are. However, they argue that by extending the notion of negotiation beyond tools and artifacts would make AT a more “powerful approach” to study among other things media spaces and electronic workplaces. Since it is being argued in this dissertation that we must take in consideration the history, theory and practice of art and architecture when doing such negotiations it is thus appropriate to use the Checklist in a field research that can offer subsidies as to how this can be done.

Kaptelinin and Nardi have argued that the Checklist is best used to provide a preliminary assessment of the main factors shaping a particular context, and to select tools and design

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50 The case study was designed with four groups in mind. Each group was to have 8 undergraduate students from one of the four already mentioned undergraduate programs: architecture, art and design, computer science / computer engineering, and creative writing. However, no students from creative writings responded to any of the invitations and/or requests to participate in the study. Therefore, the expected number of 32 participants was reduced to 25 (two groups of 8 and one of 9).
additional investigations. This is the case when looking for confluences of art, architecture, and activity to situate digital tools through this conceptual outlook we are calling ubiquitous virtuality. By choosing students from architecture, art and design, computer science and computer engineering, and creative writing, the evaluation looks for insights regarding a common vocabulary within interaction design between players from these different communities. It is assumed that each student would employ different tools — symbolic systems or conceptual frameworks — when defining their activity, because the training they are receiving from their respective academic programs in part shapes this choice.

Based on these considerations and using the Checklist as a reference the following evaluation objectives were set up:

1. Evaluate the participants’ need for a writing and drawing ‘smart’ gadget such as the io2 DWS.

2. Determine what are / would be the goals and sub-goals of target actions by each of the four groups in relation to the io2 DWS.

3. Find out which actions they associate with each of these goals.

4. Find out what are the tools used by each group to achieve their target goals when using the io2 DWS.

5. Discover which components of target actions need to be internalized by each participant, and learn how these actions become so routine and automatic that they would change the conditions of the participants’ use and/or development of the io2 DWS.
6. Learn how participants coordinate group activities and share resources that for their turn help define the social context of their activity.

7. Define what are the rules, norms, and/or procedures regulating the social interactions among peers in their groups.

8. Learn how each group anticipates changes in the social-cultural context and how they use this knowledge to promote and/or resist changes within their communities of practice.

9. Evaluate and compare how each group would use the four stages of Flusser’s *cycle of aesthetics* to determine needs and motives for activities in their respective communities of practice.

10. Compare how participants in each group evaluate the impact, if any, of the activities of other groups in their respective communities of practice.

**Instruments**

Besides the profile of the participants derived from the data collected through the Background Questionnaire (described in Tables 4 and 5, on pages 132-135), there were two additional evaluation instruments used in the case study. They are explained in the next pages.

**A- Instrument #1 / Interview Guide**

This 22-question guide was the main evaluation instrument. It was used to guide the interview, which was conducted in a conversational tone. Although all participants were asked the same 22 questions, additional questions were also used whenever additional clarification was needed and/or whenever their answers hinted at an unexpected topic that
could provide a better picture of their position. This way each participant had the opportunity to forward any extra information they felt like covering.

The Guide was made of the following questions:

1) Did you feel as comfortable holding the digital pen as you would be holding a regular pen? Please explain.
2) How do you compare the special paper with regular writing paper? Please explain.
3) What is your level of satisfaction with the way the software translates what you did on paper into a digital document?
4) When working on projects related to your major, do you feel the need for a writing or drawing tool like this? Please explain.
5) How would you define the main activity of people in your area of study?
6) What would you consider to be the main actions associated with this activity?
7) In case you had to work with a ‘smart’ system like the io2, what would be the goals of your actions?
8) Would there be also some sub-goals or secondary goals?
9) Can you list and explain a little bit what are the tools that people working in your area use?
10) When using these tools, what aspects of them do people in your community need to internalize?
11) Would you say that there is a consensus about this in your community?
12) Cancelled.
13) How do people in your community share resources related to the activities that you do?
14) Is there anything else that you and your community do to create a collaborative environment that can help all of you in your activities?
15) Can you talk a little bit about what, in your opinion, influences or even dictates the social interactions among your peers?
16) Can you talk a little about how you are handling the technological changes that seem to be popping up all the time? Do these changes affect your work?

17) How do you think that people working in area promote and/or resist changes in technology?

18) Lets think together for a moment about how changes in your work happen. Would you say that something beautiful is something that you are comfortable with, or familiar with?

19) What would need to happen to make something that is beautiful for you become less beautiful, or just pretty, but not so interesting?

20) Would you consider this less interesting thing maybe not beautiful but pretty?

21) And what, in relation to your work, would be really ugly for you?

22) Is this thing ugly because you are less familiar with it? Or is there another reason?

23) Do activities in other communities of practice impact the activities in your community? How?

Table 6 bellow shows how each question is related to one or more parts of the AT Checklist.

The exceptions are the first three questions, which were concerned with the usability of the io2 DWS, and a block of four questions at the end of the interview, which were related to Flusser’s cycle of aesthetics.

<table>
<thead>
<tr>
<th>Question</th>
<th>Activity Theory Checklist</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Usability</td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td>Usability</td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td>Usability</td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>Means / ends</td>
<td></td>
</tr>
<tr>
<td>Q5</td>
<td>Means / ends</td>
<td></td>
</tr>
<tr>
<td>Q6</td>
<td>Means / ends</td>
<td></td>
</tr>
<tr>
<td>Q7</td>
<td>Means / ends</td>
<td></td>
</tr>
<tr>
<td>Q8</td>
<td>Means / ends</td>
<td></td>
</tr>
<tr>
<td>Q9</td>
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<tr>
<td>Q10</td>
<td>Learning / Cognition / Articulation</td>
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<td>Q11</td>
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<td>Q14</td>
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Table 6. Intended relation between the questions from the Interview Guide, the AT Checklist, usability test, and Flusser’s cycle of aesthetics.

The following table shows the relationship between each evaluation objective and the questions from the Interview Guide.

Table 7: Relation between evaluation objectives and questions

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Question</th>
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<tbody>
<tr>
<td>1</td>
<td>Q1, Q2, Q3, Q4</td>
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<tr>
<td>2</td>
<td>Q5, Q7, Q8</td>
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<td>3</td>
<td>Q5, Q6</td>
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<td>4</td>
<td>Q9</td>
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<td>5</td>
<td>Q10, Q11</td>
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<td>Q13, Q14</td>
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<td>Q15</td>
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<td>8</td>
<td>Q16, Q17</td>
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<tr>
<td>9</td>
<td>Q18, Q19, Q20, Q21, Q22</td>
</tr>
<tr>
<td>10</td>
<td>Q23</td>
</tr>
</tbody>
</table>

Table 7. Table showing how each question from the interview guide was related to one or more of the evaluation objectives.

B- Instrument #2 / Video Recording

This Instrument was used as a back up to the written notes taken during the interviews. The recording was mostly used for later review of answers that, due to the conversational tone of the interviews, could not be adequately written down during the sessions. The video recordings were not transcribed, an expensive and time-consuming task that would have been necessary for a thorough analysis of the recordings, but not for the supporting role it was designed to have here.
Evaluation outline

Bellow is a summary of the step-by-step activities conducted during the evaluation.

1) Evaluation monitor/interviewer invites test participant to enter the testing room.

2) Monitor asks the participant to seat on the chair next to the io2pen and Anoto paper.

3) Monitor hands the “Informed Consent Form”, and waits for participant to read it and sign it.

4) Monitor reads the “Orientation Script” to the evaluation participant.

5) Monitor hands the “Background Questionnaire” to participant, and waits for it to be filled out.

6) Monitor points to the io2 pen and asks test participant if he/she knows what that is and if he/she has used one before.

7) Monitor asks the test participant to copy eight sentences previously selected from the “Sample Section 2: Example Sentences” of the MyScript Training material. Copying the sentences is meant to familiarize the test participant with the io2 pen.

8) Once the participant finishes copying sentences, he/she will be asked to copy two line drawings taken out of Paul Klee’s Pedagogical Sketchbook. Copying the drawings is meant to evaluate participant’s familiarity with visual languages.

9) Monitor asks if test participant wants to see what he/she did with the io2 pen on the computer monitor. Test participant will be able to use the io2 pen for additional tasks if he/she chooses to do so.
10) The computer (CPU, monitor, DWS cradle, keyboard, and mouse) with the Logitech io2 software already installed will be already on. Monitor will demonstrate how to put the pen into the cradle and open the files in MyScript.

11) Evaluation monitor ask test participant if he can ask a few questions while the participant explores whatever aspect of the DWS system he/she is more interested in.

12) Test participant can continue to experiment with any aspect of the io2 Digital Writing System during the interview. The participant’s choice will help guide the interview.

13) Start interview using the “Evaluation Instrument #1 - Interview”. Interviewer explains to participant that some terms used in the questions are related to the theoretical framework used in the design of the evaluation, and that he/she could ask if additional explanation was required.

14) At the end of the interview, monitor asks the participant if he/she has any questions.

15) Monitor thanks participant for participating in the evaluation, hand him/her a $10 dollar bill, and a description of the drawing for a Logitech io2 DWS among all 32 participants.

**Data summary**

This section organizes the data collected during the evaluation according to the twelve evaluation objectives listed in one of the previous sections of this chapter. Although some of the questions from the Interview Guide could be related to more than one objective, they were organized according to the table on Table 7 (page 144). The data is summarized in a table format for the readers’ convenience.
**DATA SUMMARY**

**Objective 1:** Evaluate the participants’ need for a writing and drawing ‘smart’ gadget such as the io2 DWS.

Data summary:

This first objective included three questions (Q1, Q2, and Q3) designed to test the usability of the io2 DWS. As explained in the “Evaluation Outline” section, participants were given two tasks and had extra time to experiment with the pen before answering these questions. Eighty percent (20/25) of the participants complained about the thickness and weight of the pen. They evaluated the pen as being “too fat”, “too bulky”, “too heavy”, “too big”, and “too uncomfortable”. Of the other 20%, one participant said the pen is heavier than a regular one but that nonetheless “ergonomically it works”. The other participants had no reservation about the io2.

Participants noticed little difference between Anoto’s ‘smart’ paper and any other regular writing paper. A few of the participants noticed a different “texture” due to Anoto’s dot pattern, but only one described it as a “pattern” while the others described it a “grayish” tone.

Interviewer explained to the participant how the io2 system works before asking Q3. Participants from the Architecture and Art &Design groups were generally very satisfied with the translation made by the io2 DWS. One student from Architecture, one from Graphic Design and one from Studio Arts would like to see improvements in how the system picks up “line weight” and “tone”. One student from Computer Engineering was not satisfied with the translation but said his/her handwriting was “naturally pretty bad”. One student from Computer Science said that it was “very disappointing” to have to ‘train’ the software to improve the
system’s performance.

Question (Q4) aimed at evaluating the participants’ “need” for such ‘smart’ artifact. All the participants from Architecture and Art & Design were excited with the possibility of using the io2 for sketching out their ideas in the early stages of any project. Participants from Architecture said they would prefer to use the io2 instead of having to use scanners for tracing sketches made by traditional drawing tools. They explained that tracing sketches is a common task among them. One participant from Art & Design would like to see improvements in the system to facilitate going back and forth between paper document and digital document. The great majority of participants form Computer Engineering and Computer Science did not see the need for a system like the io2 DWS. Only one student said he/she could use a system like the io2 for actions related to his/her work (in this case, writing down ideas to be distributed to a group in the early stages of a project); one said he/she could use it for “English assignments”; the others said they had no use for a system like the io2.

**Objective 2:** Determine what are / would be the goals and sub-goals of target actions by each of the four groups in relation to the io2 DWS.

Data summary:

All architecture students highlighted the need to sketch out ideas on paper before developing them into digital models. They all consider sketching to be a key aspect of their design process and an easy way of discussing their ideas with their peers and with clients. They consider digital models easier to edit; most of them argued that a few of their peers put too much emphases on 3D modeling instead of on the conceptual aspects of a particular project.
Art & Design students saw their main activity as putting together image and text to “communicate” some idea or making 3D models and animations on the computer. Sketching was mentioned by only half of them as an important action.

Seven out of nine participants from Computer Engineering and Computer Science mentioned “programming”, coding or software development as the main activity in their area. Of the other two, one mentioned “pattern recognition” and understanding the different parts of a problem, while the other mentioned “abstraction” as the main activity in their area. Among the main actions supporting such activities, they stressed the conceptualization of the problem as very important. Computer Engineers stressed “brain-storming”, “diagrams” (graphic representation of the problem), and UML diagrams (UML = unified modeling language, a standard graphic language used for the specification of the code) as important actions in their conceptualization process; one Computer Science student mentioned typing the code directly, compiling it, and re-writing, while the other stressed “thinking” and a “quest for elegance” as the main actions in the area.

Architecture and Art & Design students agreed that the io2 would be most useful to take notes in class or for working out ideas and presentations. They mentioned using the io2 to avoid having to scan an image and trying to create something new with a new tool as positive aspects of the system. Among Computer Engineering students, taking notes and documenting their ideas would be the main goals of using the io2; computer science students did not see much use for it.
**Objective 3**: Find out which actions they associate with each of these goals.

Data summary:

Architecture students consistently mentioned sketching as being important in their activity; two of them also mentioned talking with colleagues, and one said that he/she needed “a certain amount of movement, body movement”.

Graphic Design students mentioned sketching, “rough ideations”, manipulating reference images, and typography. Studio Arts students were evenly split, with two of them mentioning sketching and two mentioning manipulating 3D models on the computer.

For Computer Engineering students, conceptualizing a problem and drawing diagrams were the main actions, while the two Computer Science students were split between the main action being typing the code and testing it, and thinking about the problem and finding an “elegant” algorithm to solve it.

**Objective 4**: Find out what are the tools used by each group to achieve their target goals when using the io2 DWS.

Data summary:

When answering the question directly linked to this objective (Q9), all the students listed a number of tools used in their areas, but did not necessarily relate these tools to the io2 DWS, as asked in the question.

Among the tools used in their area, Architecture and Art & Design students consistently mentioned an number traditional ones such pencils, pens, papers, erasers, rulers, clay, wood, and
sketchbooks, and digital ones such as scanners, computers, and digital cameras, and software such as Photoshop, SketchUp, Cinema 4D, and AutoCad. Computer Engineering and Computer science students mentioned computers, software used for coding (text editors, compilers, IDE - Integrated Development Environments, FPGA – Field-Programmable Gate Array for developing circuits, and debugging tools). One Computer Science student stressed that he/she used “biological and normal computers” and algorithms.

**Objective 5:** Discover which components of target actions need to be internalized by each participant, and learn how these actions become so routine and automatic that they would change the conditions of the participants’ use and/or development of the io2 DWS.

Data summary:

Architecture students expressed the need to become comfortable with the materials used in the design process. These materials include pen and pencil (be able to use line weight to indicate volume), rulers for straight lines, material used in physical models (paper, foamcore, wood, glue, etc.), and computer interface so that they can use software efficiently.

Studio Arts students and two of the four Graphic Design ones stressed the need to internalize the computer and software interfaces; one of the GD students mentioned being able to use the “standardized rules about typography (adequate letter spacing, size, etc.)” and being able to deal with image’s more “subjective” character, while another one mentioned “being able to put down one’s ideas so that [they] can be shared with others” as the most important action to be internalized.

Among Computer Engineers, what needs to be internalized is the ‘logic’ of programming and
being able to find samples on the Internet. One of the Computer Science students stressed the need to internalize typing skills and be comfortable with the keyboard while writing code; the other one stressed the need to internalize the “stable rules” of programming and the abstract thinking processes needed to transform a problem into an algorithm.

The great majority of the students from all three groups responded affirmatively when asked if their peers agreed with what they were saying that needed to be internalized.

**Objective 6:** Learn how participants coordinate group activities and share resources that help define the social context of their activity.

**Data summary:**

Architecture students view the studio as a common space where they can borrow material and supply from one another, and where they can share ideas by critiquing each other’s work and sharing resources such as references, books, digital files, and for short periods even computers. They talked about informal exchanges of ideas being common due to the physical organization of the studio, where a number of individual stations share a room, and the fact that they often work on similar projects. One student mentioned that the io2 would be more helpful if it could facilitate the exchange of sketches and blue prints. One student said that the competitive nature of the program sometimes prevents collaboration, while another one had the opposite impression saying that they “want to help each other be better designers”.

Art & Design students did not mention having a common space like the architecture studios and did not report the same kind of collaboration. Three of the four Graphic Design students mentioned ‘critiques’ as being a particularly important situation for exchanges. Students from
Studio Arts reported exchange happening more one-to-one and through word-of-mouth, but only one mentioned ‘critique’ as being important. One of the students said that they “typically work in group”, one said they “don’t collaborate that much”, while another one said that they collaborate on projects but with each one working on a different part (different objects in a 3D animation or video-game, for example).

Computer Engineering and Computer Science students reported using the Internet either through emails, instant messaging, Wiki’s or web forums for help. They use these channels to find samples of code or to seek help from someone that has already worked on similar problems. When working on group projects they can use meetings and study sessions to make sure that “everybody is on the same page”. One participant said that engineers don’t try to create a collaborative environment, that “they assume that you know how to do things”, and that one needs to “ask” for help.

**Objective 7:** Define what are the rules, norms, and/or procedures regulating the social interactions among peers in their groups.

**Data summary:**

When asked about what in their opinion influences or even dictates the social interactions among their peers, architecture students mentioned the studio space and shared assignments. Graphic design students also mentioned having to work on the same assignment influences their social interactions. One of the students in studio arts said he/she is not very social, another said that trying to be better than peers drives their interactions; the other two had a more collaborative approach relying on peers that know about a particular software for information.
Class assignments, projects, tests, etc., and doing other things together were also pointed out by five of the computer engineering students; one mentioned that each person’s “political bias” regarding software (if the student favors open source or proprietary software, for example) can also dictate the social interactions between them.

**Objective 8:** Learn how each group anticipates changes in the social-cultural context and how they use this knowledge to promote and/or resist changes within their communities of practice.

**Data summary:**

When asked about how they are handling technological changes and if people in their area promote or resist changes in technology, the group from architecture seemed concerned about how new technology and the constant upgrading of software affects the design process. One student said that his/her community is handling this situation “badly”, one said he/she “is bothered by the shift away from craft”, while another one said that he/she is “pretty on top of everything that is coming out”. The group is evenly split between those who think their community promotes technological change and is handling well the new technology, and those who think that their community resists change and resists finding a balance between “efficiency and inspiration”, as one of them put it.

Three of the graphic design students said that they don’t think technology is affecting them too much; the fourth one said that he/she “hated computers” until two years ago but that everyone “has to learn how to figure it out”. All four students in this group think that their community promotes technological change; one participant pointed out that there might be a generation gap regarding this, with older professionals resisting it and new ones promoting it. The four students
from Studio Arts expressed that technology is affecting their area but that they feel comfortable with it. Studio arts students seemed to perceive their group as promoting new technology, although some may resist upgrading software or hardware because either they feel comfortable with the older version they already have or because of the financial cost to upgrade. One student said that being comfort with existing technology (either a particular hardware or a version of a software) can make people resist changing to newer technology.

Computer engineering students were emphatic when answering this question about how they are handling technological changes and if people in their area promote or resist changes in technology. They said that they “produce that change” and that they are “responsible for producing this new technology”. However, one of these students pointed out that they tend to resist when a technology they use works fine and learning a new one would be a hassle. This student gave as an example text editing tools that may not be the most up-to-date or efficient but that keep being used because the students are familiar with them. Another one said that companies sometimes resist change because they might have something to loose. He/she gave the example of Microsoft as sometimes promoting new technology when it is in their interest and sometimes resisting it when it goes against their existing business models. This student gave open source software such as the Linux operating system as an example. One of the computer science students said that his/her peers “accept change positively”, while the other one said that one has to choose between useful and not useful technology.
Objective 9: Evaluate and compare how each group would use the four stages of Flusser’s cycle of aesthetics to determine needs and motives for activities in their respective communities of practice.

Data summary:

As shown in Figure 35, a block of five questions were included in the Interview Guide to try to get a sense of how the four groups use the concepts of “ugly”, “beautiful”, “pretty”, and “kitsch”, i.e., the four stages of Flusser’s cycle of aesthetics.

Most of the students in architecture and art & design did not relate what they consider to be beautiful with something that they are comfortable with; on the contrary, something ‘new’ or technically or conceptually intriguing were usually considered to be more beautiful than something that they were familiar with. Some students mentioned familiarity and lack of craftsmanship as making something less beautiful. The majority of these students agreed that pretty would be a better term to describe something that lost its “edge” and is no longer ‘new’.

For most computer engineer students, beauty was more a matter of ‘readability’ and the ‘cleverness’ of the code’s logic than a matter of comfort. Figuring out how to achieve this was also mentioned as being something beautiful; modifications that disturbs the readability of a code was usually mentioned as making it be less beautiful. One computer science student said that not being familiar with something makes it more beautiful even though “not everyone gets it right away”. The other one said that the “notion of beauty is inconsistent and incoherent” and one “cannot frame an incoherent concept in terms of being comfortable or not”. He/she later said that “something beautiful never becomes less beautiful”.

Most of the students in all groups would consider something that is less interesting to them
“pretty” instead of “beautiful” when asked specifically about this.

Regarding their concept of “ugly”, architecture students mentioned buildings that are mass-produced, or that does not take in consideration the architectural context in which they are built. One student also mentioned bad craftsmanship. Graphic design students mentioned things that “make no sense”, that are not “refined”, of poor quality, or that have been “overused”. One studio arts student also mentioned poor craftsmanship, but not familiarity, as something that leads to ugliness; one mentioned things that have “no structure” or a composition without “harmony, unit, balance” but also said that something can become less ugly “if we see it overtime”; another one said that being someone that praises “representational” art, showing “skills” is important. One of the studio arts student said that ugliness is hard to define because something can be ugly in one context and beautiful in another; this student also said that familiarity is definitely not what makes something ugly.

Computer engineer students consistently mentioned ‘inefficient logic’ that would lead to programs with too many lines of code as being particularly ugly. Bad documentation or poor naming of variable was also mentioned. One computer science student described ugliness in similar terms. One computer engineering student said that “legacy stuff” like Microsoft’s “Windows registry” as being particularly ugly (the registry is where a computer operating system records its settings). One computer science student said that “nothing” is ugly (according to this student things can be “tedious” but not ugly).
**Objective 10:** Compare how participants in each group evaluate the impact, if any, of the activities of other groups in their respective communities of practice.

Data summary:

When asked if other communities’ activities influence activities in his/her community, almost all architecture students said that they do. They pointed to social, economic and cultural issues in general, as well as materials and software developed by other communities. One of them said that as students, activities in other communities usually don’t affect them but that in professional circles they do.

For graphic design students, the professionals in their area need to meet someone else’s needs (i.e., ‘clients’); others said that art and other design disciplines also influence what they do. For studio art students, architecture and other design disciplines as well as culture in general influence what they do. One said that they are more influenced by what other students do, and one said that the “market” demands some things that the industry tries to provide.

Most computer-engineering students said that what they do is either a service provided to other communities or something they do to improve other people’s lives. One computer science student said that besides having to attend to the clients’ needs, his community also depends on the activities of mathematicians and physicists, for example, to write new formulas or invent some new material; the other one said that “almost any other field influences and is influenced by his/her field.”
Discussion of the case

The discussion of this case study brings insights from the field research into the larger goal of situating digital tools through ubiquitous virtuality. The evaluation discussed here shows how hard it is to help students balance an in-depth understanding of a particular area with an equally far-reaching awareness of other professional fields. Although understanding how different fields are interconnected is always difficult, it is not surprising that this seems to be particularly the case for people at this age and at this stage of their professional life. On the other hand, the difficulty they have in articulating a concept of their own activity can also reveal interesting aspects of how a concept of activity is actually constructed.

Not surprisingly, there was a clear difference in how sophomore, juniors, and seniors articulated their answers during the interview. Students would spend more time answering the questions and tended to be more comfortable marking a particular position that diverged from that of their peers the closer they were to graduating. This was verified even though a detailed discourse analysis that included measuring the time spent on each answer was beyond the scope of this study.

When designing this field research, it was assumed that the number of students from each of the four target groups would be relatively the same (see Table 4 on page 132). Thus, the lack of participants from creative writing was totally unexpected. One possible explanation is that there is no undergraduate program in creative writing at Iowa State University, only a graduate one. The other three areas — art & design, architecture, and computer engineering and software engineering — are actual majors offered by the university. At the undergraduate level there is

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51 Douglas Hofstadter's *Gödel, Escher, Bach: an eternal golden braid* is an excellent exploration of this territory in which different fields interconnect with one another.
only a concentration that is part of the English department’s “literary option”. At the graduate level there is a specialization in creative writing within the Master of Arts in English program and a Master of Fine Arts program in “Creative Writing and the Environment”. It seemed reasonable to assume that these two graduate options in creative writing would indicate a significant commitment by the English department to expose its students to creative writing even at the undergraduate level. Since the io2 DWS is primarily a writing system and “mobile professionals” are among its target audience, it also seemed reasonable to expect that some of the undergraduate students would be interested in participating in the study. Nevertheless, the reasons for their lack of interest could not be determined at this point. Similarly, the reasons for the lack of students majoring in painting and drawing and intending to professionally pursue participating in a study like this also could not be determined.

Furthermore, during the design phase of the study, it was anticipated that there would be a small number of female students from computer engineering and software engineering because engineering in general have had problems attracting women. However, the extraordinary low number of female participants from all majors was unexpected. The reasons for such low participation could not be assessed based on the information collected in this study.

A usability test of the io2 DWS conducted a few months prior to the current study had already indicated problems with the design of the pen. Like the participants in the current study, in that case too participants’ stated that the pen is too big and too heavy to be handled as a regular writing artifact. The majority of the participants in both studies complained that the hand they used to hold the pen hurt after writing just a few lines of text. It is clear that from these students’

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52 The usability test was part of the course CI 504 – Managing and Evaluating Instructional Technology Programs, which is offered at Iowa State University by the Department of Curriculum and Instruction.
perspective the io2 pen must be made into a more comfortable artifact in order for it to have a real chance of becoming a commonly used writing, or drawing, tool.

Despite of these usability issues, in general participants responded positively to the potential use of a digital writing system like the io2. A different and more extensive study would be needed to investigate how effectively the current system can be integrated into their activities. Such investigation would most likely require giving the students the opportunity to use the io2 pen for many days so that it could be tested in the context of their activity. This investigation was among the options considered when designing the field research being discussed in this chapter, but the cost involved in a study like this were beyond the financial resources available to this study. Its realization would also require a different institutional support than the one in place at the time of the study.

The next few paragraphs are used to discuss the evaluation objectives related to the Activity Checklist, as listed in Tables 6 and 7 on pages 142-143. As noted before, Kaptelinin and Nardi have argued that the Checklist is particularly useful in preliminary evaluations of the main factors shaping particular contexts. By using the io2 DWS as a ‘boundary object’, this field research offers substantial material that can be used to design additional investigations aimed at understanding the barriers created by the different perspectives and the vocabularies of different communities of practice. Furthermore, the topics discussed in this dissertation will help situate digital tools in an even larger context.

Regarding the Means/Ends part of the Checklist — related to the hierarchical structure of activity — covered in particular by questions 4 to 8 (see Table 6) and objectives 2 and 3 (see Table 7), the majority of the students in all three groups agreed that at the beginning of any project most of their actions should be geared towards developing its conceptual aspects. Operations like
sketching and making diagrams support the actions in this phase. Since operations need to be somewhat automatic to actually support more goal-oriented actions, the less intrusive a tool is, the better the conditions afforded by it. Digital tools like the io2 seem to be particularly useful at this initial phase. According to the students, its usefulness drops in the editing phase of a project; at this point computer becomes a more helpful tool because they facilitate the manipulation of 3D models and the writing and testing of codes. However, since corrections and improvements in an architectural design or a code, for example, need to be made throughout the entire development and implementation processes, the io2 DWS could continue being used beyond the initial phase if the system were designed to support such processes at the operational level. Among the conditions needed for this to happen, there must be a better way to go back and forth between sketches and editions made on Anoto’s ‘smart’ paper and the ones made on the computer. It is possible to achieve such integration by, for example, making printing part of the system. Printing corrections made with the computer onto the DNS ‘smart’ paper brings paper back into the design and editing process much like what often happens when people write texts using digital word processors such as MS Word but often print it for easier editing. This integration of printing into the DNS would support the kind of operations — sketching, planning, drafting, reviewing, and collaborating, for example — that creates the conditions for negotiations between subject, object, and the community that in Activity Theory are associated with actions.

The Environment part of the Checklist — concerned with identifying the tools, materials, spatial layout, and social organization that form the social-cultural environment of an activity — was covered in particular by questions 9, 13, 14, and 15 (see Table 6) related to objectives 4, 6, and 7 (see Table 7). When asked about which tools they used, students in architecture and art and
design listed a number of traditional ones such as pencils, paper, erasers, rulers, etc., that by being relatively cheap can be easily shared with peers. There is, however, a significant difference in how this exchange takes place because architecture students have their own fixed working space within large studios, while the art and design ones move from classroom to classroom. Architecture students specifically mentioned the spatial layout of the studios as facilitating interactions between them with traditional tools being also useful in breaking down the boundaries between individual spaces. Students said that informal critiques are common and that they also share digital files and even computers. Without this individual fixed space, art and design students mentioned group critiques as being particularly important to create a social context for their activity. Art and design students were less likely to mention ‘collaboration’ as being important to them. Computer engineer and computer science students, on the other hand, rely much more on the Internet to create some kind of social context. For them, the Internet is a repository of sample codes as well as a vehicle for interacting with their peers through emails, Wikis, forums, and instant messaging. Some of them mentioned leaving instant messaging turned on all the time and using it for conversations and for exchanging files. This group’s social-cultural environment seemed to depend much more on the Internet than on the other groups, even though the Internet is also an important tool for the other two. This is a very interesting situation because the last group referred to itself as being a group of ‘promoters’ of new technology. This group related this need to promote new technology with using the computer to achieve that. The computer is really necessary to translate a text file into machine language, a basic step in software development. But it seems that this operational condition of one activity ends up impacting how this group develops technology that is going to be used by other groups. Boundary objects, such as the io2 DWS, are particularly useful in showing to one
community, even one that sees itself as promoting innovation, the different perspective and
different vocabulary of other communities. It is being argued throughout this dissertation that
this kind of understanding is not just desirable, but necessary.

The Learning/Cognition/Articulation part of the Checklist — related to the internalization and
externalization processes associated with cognition, and to learning as a context-dependent
activity — was explored in questions 10 and 11 and objective 5. Regarding this section, most of
the students in architecture and art and design mentioned being comfortable using the tools
utilized by their communities. These students seemed to understand that there were notional
operations associated with these tools, and these operations were important in their activity. The
students from computer engineering and computer science were even more direct, with most of
them saying that what they need to internalize is the “logic of programming”, or in other words
the notional operations that support their activity.

Regarding the Development part of the Checklist — which looks at the “permanent developmental
transformations” that impact any activity — and addressed in questions 16 and 17 and objective
8, students from architecture in particular but also the ones from art and design seemed
concerned about finding a balance technological change and other aspects of their activity.
Computer engineering and computer software students were clearly convinced that the changes
brought by the new technology they promote are good, even though they too may resist
changing the tools they are comfortable using. In their seek for balance, architecture students
could be expressing an awareness that a building condenses culture in one place, as Casey (1993)
argued, and responding to the fact that changes in this ‘cultural capital’ need to be negotiated.
Since students from all groups mentioned that working on the same or a similar assignment
stimulates collaboration and cooperation among them, they would benefit from working together on joint projects that would foster this need for negotiation.

The evaluation of how each group understands the terms used by Flusser to define the four stages of his cycle of aesthetics showed that the majority of the students have a much softer understanding of the transitions between those stages. Flusser’s position is that something one considers to be ugly is much more visceral and disturbing than what the students seemed to be considering. For Flusser, turning something ugly into something beautiful involves a significant break that requires so much energy to be realized that it is never taken lightly. Part of the energy required to experience this shift has to be spent in breaking away from rules and norms consciously and unconsciously determined by the community. The students’ lighter approach to this experience may be due to their acceptance of these rules and norms that are passed along from member to member and that establish a community’s expected standard knowledge. It is difficult for someone to break away from these rules while negotiating one’s acceptance into the community that set them in the first place. One can insist and persist negotiating with a particular community, or he/she can experience the ‘terror’ of leaving a community for another.
PART III – IMPLICATIONS AND APPLICATIONS
CHAPTER 8: UBIQUITOUS VIRTUALITY: THE SPACE AND PLACE OF ACTIVITY IN THE CONTEXT OF ‘SMART’ TECHNOLOGY

Implications

Situating digital tools through ubiquitous virtuality means that technology must be understood as a participatory process that involves continuous collaborations between producers and users, and must include not only engineering aspects related to its development but also the knowledge and sensibility that comes from recognizing complex social dynamics and the interdependency of people, tools and the built environment. Such social dynamics are played out in real spaces but also rely on virtual spaces for experimental exercises aimed at extending their reach and intensifying the interactions between subjects, objects, and communities.

The issues discussed in this dissertation illustrate the need to directly address cultural intersections such as the ones explored here between art, architecture, and activity theory, in order to better situate digital tools in the contexts in which they are used. It has been argued that such intersections are further complicated when this context includes an increasing number of mobile devices and comprehensive ‘smart’ environments. In such a context, situating digital tools must take in consideration the social and the built infrastructures in ways that desktop computers can get by without doing. Some of these issues were explored in the studies discussed in Chapter 4, regarding digital tools for painting and drawing, and in Chapter 6, regarding ‘smart’ environments.

The embedding of sensors, actuators and computing in objects and environments brings a new level of complexity to the design process of digital tools. Such complexity can only be properly addressed through multidisciplinary research and robust collaborations between different
communities of practice. For these collaborations to work, there needs to be a concerted effort to integrate the empirical processes typical of design disciplines such as architecture, and graphic and product design, with the usually more formal and controlled processes commonly found in engineering. The evaluation discussed in Chapter 7 looked at the challenges involved in building up such collaborations that require balancing an in-depth understanding of particular domains of knowledge with a broad, but potentially insightful engagement with other disciplines. This is particularly important when what is at stake is the development of technology that can significantly and profoundly impact people’s lives, as is the case with ‘smart’ technology. As discussed throughout the dissertation, ‘smart’ artifacts and ‘smart’ environments can empower end users by giving them tools that enhance their ability to multisensorially process information distributed through digital networks. However, when poorly designed they can also intrude and interfere in people’s lives in ways not seen before. Such intrusion can also be intentionally included in the design of digital tools or be a side effect of technical features; in either case, consumers’ privacy concerns must be addressed and they should be given the means to turn off these features.

The impact on individuals and groups of the widespread dissemination of the conditions needed to create virtual space based on digital technology cannot be underestimated and requires constant attention. These ubiquitous virtual spaces create the conditions for new interactions between individuals, and between them and the social infrastructure and the built environment that supports them. What is emerging is a new base for human activity, i.e., a reconfiguration of social structures and built infrastructures resulting from ever changing blends of local and global conditions. It is not a complete break away from prevailing conditions but the superimposition of new ones over these existing ones. Even though global transactions can
now be updated in real-time, they still depend on boundaries and conditions set up by the built environment. After all, even wireless communication through mobile devices needs a physical infrastructure to support it, and where and how this infrastructure is built tells a lot about the state of the surrounding social environment.

Design processes typically exercised within the architecture and product design communities are beginning to be accepted and included in the development cycle of this digital layer that is being meshed into the existing infrastructure. An example of trend is the Solar Decathlon, a biennial competition sponsored by the Department of Energy, in which design and engineering criteria have similar weight. It is likely that this integration of different processes will continue to grow and will increasingly impact the theory and practice of HCI. Art and art-related processes and goals, on the other, are still seen as too wild and unreliable to be of any use in the design of technology. Art is a testing ground, an activity aimed at producing “improbable situations”, situations that produce maximum information, as Flusser puts it. Art’s focus on the ‘virtualization of virtuality’, as put by Lévy, makes its theories and practices a crucial experimental ground for human-to-human interactions. As uncomfortable as the results of art activities may be, it is necessary to have a continuous effort towards finding common ground between art, science, and technology development.

The work of Lygia Clark, discussed in Chapter 5, illustrates the challenges and rewards of looking for such common ground. Her work compellingly moved towards propositions involving dispositives for individual and collective processes of subjectivation. Her work triggered cross-pollinations between environments’ infrastructures and humans acting within them, challenged the ‘visual bias’ that has characterized western societies, and explored multisensorial interactions in human-to-human interactions mediated by relational objects.
Clark’s work offers a roadmap for HCI’s pressing challenges as its community discusses theoretical models and works out practices aimed at moving away from fixed, centralizing computational hubs such as the desktop computer towards computational capabilities embedded in mobile devices and ubiquitously distributed in the environment. The emerging concept of cloud computing — computing capabilities distributed through the Internet — suggests the maturation of the necessary computing capacity to make this a reality. However, its expansion requires more than just the development of some hardware and software; it must also reflect social-cultural changes that are being enabled by the current technology and must include some of the concerns with its impact on society.

A better starting point for the development of digital tools is to set them to be dispositives for individual and collective processes of subjectivation, and not just the application of some breakthrough in hardware and software. The biggest challenge is to integrate these dispositives in a new articulation of real and virtual spaces that encompasses these emerging, ubiquitously distributed digital technologies. As discussed throughout this dissertation, virtual space has been explored and integrated to real space through weaving, painting, writing, city planning, and tabulation, for example, an indication of their interdependence throughout most of human history. The difference now is that the plane — the concept that establishes the condition for carrying out virtual space — is being fundamentally transformed by digital technology.

Electronics is embedding information patterns to the materials, objects, and environments that support the real spaces and places in which we live, thus creating a condition of virtuality that is pervasive, ubiquitously distributed, and networked in a global scale. This condition is not just techno-logical, in the sense of relying on a technical apparatus, but also cultural. Nevertheless, like any other cultural dimension of social life this one too is subject to competing political
forces with conflicting interests. It can be employed to create a technological substrate to support surveillance and other intrusive uses by powerful groups in governments, corporations, etc.; on the other hand, it can foster a new social infrastructure. Both uses are now common; governments have been using this condition to monitor the flow of people, goods and information across their borders, and social networks formed on the Internet, such as MySpace, Orkut, and Facebook, are now major forces in shaping the contemporary cultural landscape. As discussed in this dissertation, the history, theory and practice of art and architecture can have a significant role in supporting new global networks that enhance the flow of information and create conditions for richer, more-inclusive social relations. They can also help understand some of the problems that are emerging from this condition of ubiquitous virtuality, supported by the swarm of devices that rely on the miniaturization of planes with highly complex patterns as the ones that can be found in computer chips, circuit boards, sensors, and actuators.

Applications

This highly complex network is finding its way to small, mobile devices as well as the fixed infrastructure that surrounds us, as it should be expected to do considering the plane’s history of creating the possibility of “relations apart from specific instances” that defines the concept of notionality proposed by Summers (2003). In any case, artifacts and architectural infrastructure make “human purposes present to us” (idem). In talking about architectural plans, for example, architecture theorist Robin Evans writes that what they describe is “the nature of human relationships” because what is traced there are the architectural elements employed to regulate the inhabited space (Evans, 1997a). The wall, he argues, is an “armory” set up to protect an individual or group’s “integrity” in face of other people and of the elements of nature (idem). This protection is not just physical but also includes preserving against information coming
from the outside and cultural habits brought by outside groups that may impact the social fabric of a certain place. This is brought front stage when walls become ‘skins’ as is the case with the “photosensitive membranes” described by Alicia Imperiale and on mixed systems such as the ‘smart’ fence that is being built at the American-Mexican border.

This so-called “virtual fence”, made possible through the Secure Fence Act of 2006 (H.R. 6061; public law number 109-367), is part of a broader effort by the U. S. government to control its borders. The government proposed and the House of Representatives approved this act as an amendment to the Illegal Immigration Reform and Immigrant Responsibility Act of 1996 after al-Qaeda’s attack to the Twin Towers of the World Trade Center in New York. It specifically instructs the Department of Homeland Security, itself an entity created in response to the attacks, to “provide at least two layers of reinforced fencing, installation of additional physical barriers, roads, lighting, cameras, and sensors” along the American-Mexican border extending from the states of California to Texas. Part of the Secure Fence Act’s legal framework remains unavailable to the general public, as the government argues that making it available would compromise its efficacy. This secrecy regarding the “Virtual Fence” is part of a much broader legal framework created after the attack as indicated by much harsher and much more secretive U. S. Patriot Act of signed into law less than two months after al-Qaeda’s attack.

The construction of such fence in the US-Mexico border has been at the center of a number of controversies regarding the social structure of American society, such as how to handle the ever-increasing number of illegal immigrants trying to enter the US, the need to stop drug smuggling and human trafficking, and the need to control the borders to prevent terrorist threats. The fence provides to the majority of the American and Mexican populations a much clearer evidence of the legal framework created after the 2001 attack. The fence provides an
architectural evidence of the changing nature of human relationships, and although all these issues have been significantly impacting the American society, the American political scene, the American-Mexican relationship as well as the relationship between the United States and the rest of Latin America, there has been little or no scholarly written article about its social and cultural implications. The enormous technical challenges involved in such a project, and the political pressures for quick solutions to stop illegal immigration, have turned the reconfiguration of the border into an engineering and “security” problem without much consideration for important cultural considerations regarding the relations between countries and peoples. Although the virtual smart fence has had from the start a major symbolical impact in the relationship between the US, Mexico, and all the other countries and cultures from the other side of the Rio Grande, these cultural aspects and international implications are for the most part absent from the design process. It has been argued throughout this dissertation that it is absolutely necessary to include other ‘non-engineering’ aspects if we want to address all the complex issues that emerge when implementing ‘smart’ technology. Failing to do so will create cultural tensions, as the fence, once completed, becomes not just a physical barrier but also a symbol for the changing nature of the human relations across the border.

The growing political pressure to install barriers such as the ‘virtual fence’ is associated with changes of a global scale demonstrated by relentless and widespread migratory trends resulting from large numbers of people from one region seeking better living conditions elsewhere. For Flusser, this recent flux of migrations is in many ways “in-habitual”, because the ‘threat’ is experienced by the richer communities and comes not from foreign armies but from hordes of ordinary people, many of them very young (Flusser, 1983a). He argues that there is not a single winning side or group under these conditions; everybody has to go through painful processes
because all of us will need to change to handle the new social conditions. This constant pressure to change will never go away anymore, and for Flusser aesthetics offers the best models to deal with such situations. Such models are the most appropriate because we will have to cycle through terrifying transformations at a much faster pace than ever before, find ways to accept and integrate these transformations into the social fabric, foresee that they may turn commonplace for a while, but also anticipate that the resulting situation will be eventually challenged by some new conditions or re-arrangements of older ones. These challenges will re-start the aesthetic cycle; inflict ‘terror’ again, become acceptable, be challenged once more, and so on.

The role of art under these new conditions, then, is to explore new cognitive territories made possible by artifacts and environments border resources. Artifacts and environments carry needs old and new, as reproducing the known is one way of being contextual in the sense of being continuous with one’s daily patterns while introducing the new. Border resources sometimes lie latent until social, cultural, or technological conditions provide someone what George Kubler calls “a good entrance”, i.e., a combination of someone’s temperament and training with that person’s position within a tradition (Kubler, 1962). The inventor of anything “rejoices in the familiarity with certain kinds of difficulties”, argues Kubler, but exercises his or her freedom to interrupt operations being automatically repeated by all and vary actions a little. The majority does this with great trepidation as familiarity and habit provide a convenient cushion to everyday actions. The inventor of major innovations is the beneficiary of his/her training and temperament and of changes in the cultural-technological conditions. Without these changes, though, one risks being caught in a situation in which he/she will be just passing along the conditions that he/she received, independently of personal talent and/or training. Aesthetic
inventions enlarge “human awareness directly with new ways of experiencing the universe, rather than with new objective interpretations” (Kubler, 1962), and therefore enable the experience of everyday life in ways that can be absorbed into new modes of individual and collective subjectivization. Aesthetics provides a channel through which these modes form a new cartography of human existence, and thus should also be incorporated into HCI theory and practice.

**Final remarks**

The ubiquitous use of sensors, actuators, and computing in objects and environments, supported by global digital networks, is radically changing the cultural-technological conditions of everyday life. It is forcing a rearrangement of social structure and bringing a new level of complexity to the world. Under these changing conditions, individuals and groups have to continuously balance local conditions and needs with multiple external global forces. The environments that emerge from this situation overlap contexts that require multiple perspectives to be conceptualized. The scale and potential impact of the technological changes currently under way make this an un-habitual environment par excellence. As such, it provides the conditions for terrifying experiences, and it is no surprise that terrorism has become such a common, albeit ill-defined threat. What remains to be determined are the choices that individuals and groups will be able and/or willing to make in their daily life, which in turn will start to shape future times.

There are no simple solutions to these challenges. This dissertation explored a number of issues from the history, theory and practice of art and architecture, and from a context-motivated framework of human activity and technological innovations, that under a cultural perspective called ubiquitous virtuality help situate digital tools in this emerging social and technological
infrastructure. The issues discussed here demonstrate the need for a continuous reconsideration of the underlying conditions and interdependency between virtual and real spaces and places, and some of the means to achieve that.
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