THE ROLE OF ARTIFACTS IN COLLABORATIVE DESIGN

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Abstract. With the proliferation of digital technology, a new category of design artifacts, usually described with the term *virtual*, has emerged. Virtual artifacts have gained further prominence due to the advances made in collaboration software and networking technologies. These technologies have made it easier to communicate design intentions through the transfer and sharing of virtual rather than physical artifacts. This becomes particularly true in the case of long-distance or international collaborative efforts. This paper compares the two major categories of artifacts – the physical and the computer-based – and places them in relationship to an observed collaborative design process. In order to get at their specific roles in collaboration, two case studies were conducted in which designers in academic and professional settings were observed using a methodology which focused on participation in the everydayness of the designer as well as casual discussions, collection of artifacts, note-taking, and detailed descriptions of insightful events. The collected artifacts were then categorized according to the setting in which they were created and the setting in which they were intended to be used. These two attributes could have one of two values, private or public, which yield a matrix of four possible categories. It was observed that artifacts belonging in the same quadrant shared common qualities such as parsimony, completeness, and ambiguity. This paper finds that distinguishing between physical and virtual artifacts according to their material and imagined attributes is neither accurate nor useful. This research illustrates how virtual artifacts can obtain the qualities of their physical counterparts and vice versa. It also demonstrates how a new meta-artifact can emerge from the inclusion and unification of its material and imagined components. In conclusion, the paper calls for a seamless continuity in the representation and management of physical and virtual artifacts as a prerequisite to the success of: (1) computer-supported collaborative design processes, (2) academic instruction dealing with making and artifact building, and (3) executive policies in architectural practice addressing the management of architectural documents.

1. Artifacts, Representations and Design

If we accept Donald Schön's assertion (1983) that design is not primarily an information processing or problem solving activity, but a process of *making* then attention must be given to the things being made – the design artifacts – and their relationship to the design process in which they are created. The role of artifacts becomes particularly important when they are used to communicate design intentions. Thus, design artifacts become central to any investigation of collaborative processes in design.

What is of concern here is how designers create, share, and use artifacts to help them carry out their daily design activities. Designers are constantly manipulating, mapping, projecting, evaluating and reconciling representations of ideas in their mind, in the virtual realm, and in the physical world. The premise advocated here echoes the one presented in (Jabi, An Outline, 1996). Mainly, that any proposal for a computer-based system that supports the activities of designers needs to account for and integrate these varying forms of representation. That is, it needs to provide a seamless continuity in how designers and computers, among other activities, manage these artifacts. The term *representation*, as we will see below, is crucial to any understanding of the nature of artifacts.

1.1 ARTIFACTS

Before proceeding any further, it is important to define the term *artifact*. An artifact is defined as a physical or virtual representation or a set of representations that can be identified by humans or machines as a discernible unit. An artifact can either stand on its own or, more commonly, be interpreted through its relationship to other artifacts. For example, an architectural facade drawing can be interpreted in its relation to the architectural plan drawing of the same building. An artifact can also be a container for other artifacts thus creating a hierarchical set. A construction document set can contain many documents and references to other documents. Those documents, in turn, can contain drawings and other sub-artifacts. Artifacts are usually thought of as physical objects such as drawings, sketches, models, animations, and computer files. However, the definition of artifacts here inherits its definition from that of an abstract collaborative object as defined in (Jabi, Domain-Specific Tools, 1996) and illustrated in Figure 1. Collaborative objects are edited by one or more participants and include non-tangibles such as concepts, requests, tasks, proposals, and votes. For purposes of clarity, the term artifact in this paper substitutes for that of collaborative object. As such, the term artifact is used in a more expansive manner than it would be otherwise.

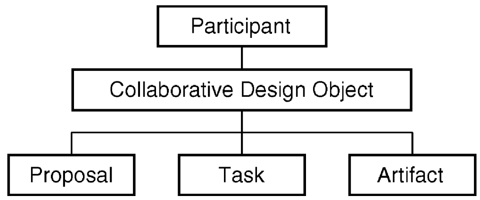

Figure 1. A representation of elements of a protocol of interaction for a computer-supported collaborative design system.

1.2 REPRESENTATIONS

If artifacts are representations, then it becomes important to clarify the nature of representation and its relation to design. Ömer Akin (1982) writes: "… design consists of a series of representations to one's mind, or to the minds of one's co-workers, clients, user groups." He continues by writing that "the mind has its own *internal* representations in order to communicate through *external* representations." That is, since we cannot as of yet communicate directly our internal representations and thoughts, we must rely on less-than-perfect external representations. However, Akin points out that internal representations of external ones are also incomplete, abstract, tentative, and aggregated. Distortion then is ubiquitous. Distortion happens when we form internal representations of reality, when we externalize those representations in order to communicate them to others and when others internalize our communication to them.

Yet, Akin is optimistic about the usefulness of representation: "… to the extent that a representation stands for a certain aspect of a reality it is potentially useful or purposeful." Thus, he derives a definition of an *appropriate* representation as "one that contains all the information at a level of abstraction suitable for its intended purpose." A pessimistic view of this issue would state that a representation can never contain all the needed information at a any level of abstraction suitable for its intended purpose. All representations rely on other representations (e.g. definitions in a dictionary) and the interpretive subject to complete the missing information or simply cope with incomplete, distorted, or polluted information.

It is misleading, however, to think that representations fulfill their role simply by corresponding to some aspect of reality. The danger of that kind of mapping is that it allows us to think that a representation can *stand-in* for the thing it represents. Invariably, this standing-in will diminish the artifact or idea being represented. For example, in the field of computer graphics and virtual reality, some researchers are trying to invent a set of representations that can trick their inhabitants to think they are in a real world. Yet, Richard Coyne (1995) points to the importance of the difference between the virtual and the real. He argues that virtual reality systems inform us about reality not by how well they emulate it, but through the limits of the technology and the difference between the fabricated and the real. It is only when breakdown occurs that we start reflecting on the conditions that brought it about which in turn reveals and opens up a world of attributes and practices.

It is not only through their limitations, differences, and breakdowns that representations allow us insights into a world of practices and traditions. Artifacts have the potential to tell us about how they were created, in what setting they were created, what traditions influenced their creation, and what purpose they served. It is still through difference that we can categorize artifacts into different groups, but, as we will see later, not all categories are equally useful. The most common categories when it comes to design artifacts – the real and the virtual – may prove confounding and less insightful than a categorization that informs us about the process of design. Furthermore, with increases in computer technology sophistication and its ubiquity, the lines between the real and the virtual may become blurred to the point where a simple *distinction* does not reveal a true *difference.*

1.3 DESIGN AS REFLECTION-IN-ACTION

It is curious that Donald Schön (1983) wrote about virtual worlds that exist not within the realm of the computer, but within the realm of the designer and his/her artifacts. In his book, *The Reflective Practitioner*, Schön analyzes the process of design by describing it as reflection-in-action. That is, the conversational process of recognizing an uncertain situation, comparing it to a repertoire of similar situations, carrying out a design move, and reflecting on that move in order to re-define the situation. Following his analysis, it becomes evident that artifacts play an important role in this constructed virtual world. Schön writes: “The [design] situations … are, in important ways, not the real thing … [The designer] is not moving dirt on the site … [He/she] is operating in a virtual world, a constructed representation of the real world of practice … Constraints which would prevent or inhibit experiment in the built world are greatly reduced in the virtual world of the drawing.” He goes on to articulate the importance of hypothesis-testing and constructing virtual worlds for the designer/practitioner’s ability “not only to perform artistically but to experiment rigorously.”

Schön views artifacts as the main enablers of this experimentation: “… Because the drawing reveals qualities and relations unimagined beforehand, moves can function as experiments.” In a similar way to Richard Coyne, Schön also analyzes the advantages of and cautions us against the pitfalls of abstracted representations: “Drawing functions as a context for experiment precisely because it enables the designer to eliminate features of the real-world situation which might confound or disrupt his experiments, but when he comes to interpret the results of his experiments, he must remember the factors that have been eliminated.” Thus, Schön’s analysis refutes the usefulness of the distinction between so-called real artifacts (drawings, sketches, models) and their virtual counterparts (computer drawings and models). Artifacts belonging to these categories can both be thought of as abstracted because they are abstracted from the real thing (e.g. the building and the site). If a designer is always engaging and manipulating abstracted artifacts and representations, then can one think of design as a form of abstracted craft?

1.4 DESIGN AS ABSTRACTED CRAFT

Surely, there exist differences between physical and computer-based artifacts. For example, while one can touch and hold in one’s hands a physical artifact, one cannot readily do the same with its virtual counterpart. Furthermore, the computer is usually thought of mainly as a tool for automation (e.g. computer-aided drafting in an architectural office). As such, until very recently, the skilled artisan was more likely to view computers with suspicion and less likely to view them as enabling mediums for the expression of his/her craft. According to Malcolm McCullough (1996) this reaction (which is becoming increasingly rare) is the unfortunate residue of industrial-era attitudes about technology. Instead, he calls for a post-industrial return to craft in creating computer artifacts and to an appreciation of human abilities: “We have reached a point in history of technology where it is important to take pride in human abilities. We must not only defend against further deskilling, but also direct inevitable technological change in a more human-centric direction.” McCullough emphasizes the potential for moving away from the deskilled computer operator towards the creation of a *digital artisan* through the proper design and use of computers: “Ultimately the computer is a means for combining the skillful hand with the reasoning mind … If designed and used properly, this already lets us apply something about what we know of symbolic processing to using tools, and this alone should become more enjoyable than industrial automation.” He then makes a strong case for the undeniable link between computers – more specifically computer-aided design and manufacturing – and artisanry: “ … no other equally prevalent application of computers is so closely related to that traditional locus of artisanry: the making of three-dimensional things. Never before has form giving had such an effective notational system or means of connecting three-dimensional sensibilities to the power of computers.” McCullough advocates thinking about computers and the creation of computer-based artifacts as a process of *abstracting craft*. That is, the computer should be thought of as a medium that allows us, in a personal context, to think and express artistically and experimentally our design intentions through the manipulation of symbolic structures and the application of abstracted tools. It is precisely in this respect that computer-aided design can claim its place in the tradition of craft as an expression of transformation not an opposition.

2. Case Studies

Two case studies were conducted that focused on observations of design teamwork and the collection and categorization of design artifacts as primary evidence and trace of thought processes. The importance of sketching as an indicator of modes of conceptualization is well-documented by Macmillan and Mezughi (1996). Additionally, the role of the physical setting (e.g. the design studio, the conference room) was studied and found to be a good indicator of the type of work protocol that take place in it. Lastly, the study was supported by note taking and tracking of design activities and discussions. The methodology used is based on a participant/observer model. Generalization of the findings in these studies can only be made through inter-subjective corroboration. The goal of these studies is to help generate a conceptual framework and a set of useful representations and protocols for the creation of a computer-aided collaborative design system.

2.1 CASE STUDY I: A PROFESSIONAL PRACTICE

The first case study and its resulting conceptual framework have already been published in (Jabi, An Outline, 1996) and (Jabi, Domain-Specific Tools, 1996). Therefore, only a summary of the findings is warranted here.

For a period of three months, a design project in a professional practice was tracked by documenting the role of various participants, their interactions, collection of the artifacts they generated, annotating the artifacts in relation to the observed process, and note-taking. The resulting conceptual model revealed an iterative, collaborative, and hierarchical design process with synchronous and asynchronous phases. Design teams were assembled with an identified leader, tasks were assigned, proposals were collaboratively generated, and design alternatives were reviewed, evaluated, and chosen for further development.

Based on this case study and its resulting conceptual model, an initial conceptual framework was built that represented the interactions of the following entities: Participant, Collaborative Design Object, Task, Proposal, and Artifact. Additionally, a software prototype that supports synchronous distributed collaborative sketching was developed and tested.

2.2 CASE STUDY II: AN ELECTRONIC DESIGN STUDIO

The second case study involved the observation and documentation of a design project in an academic setting. During the Fall 1997 semester at the department of architecture, State University of New York at Buffalo, the author conducted an Electronic Design Studio with the title: “A Proposed School of Architecture for the University at Buffalo.” The studio was composed of fourteen students who worked in teams of two throughout the semester.

The students immediately configured the physical studio space to enable easy intra-team communication. In a similar fashion, they also configured the studio’s computer server using team-specific folders as receptacles for sharing common artifacts (Figure 2).

The collected artifacts ranged from initial sketches to final drawings. After reviewing the artifacts, several attributes were considered: Completeness, parsimony, uniqueness, ownership, behavior, and state. While many other attributes may exist and prove useful, this set provided an adequate framework to compare and contrast physical and computer-based artifacts. Due to the constraints of space, only a summary of some of these attributes is included here.

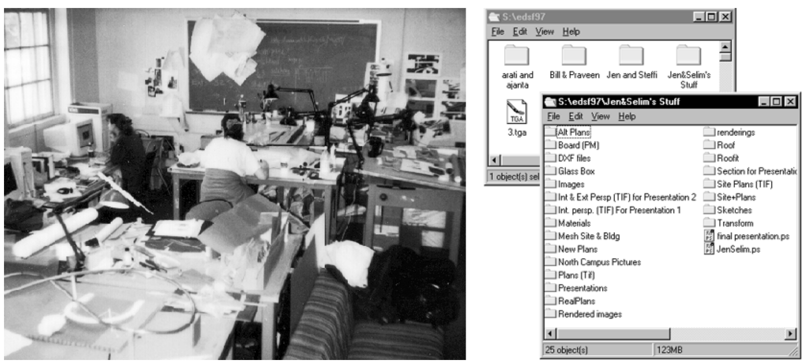

Figure 2. Physical and virtual studio configuration .

2.2.1 Completeness

Although computer models tend to look more complete and highly resolved, a closer examination reveals that they are as unresolved as their physical counterparts. The only difference is in the rendering technique used to delineate the concept. When asked, students in the early phases of the design process, were not able to provide area and volumetric estimates of what looked like highly defined computer-generated drawings. In fact, the students had approximated these shapes and placed them visually and intuitively in proportions to each other and to the site. Following instructions from the reviewer to “get a handle on the areas of the space program,” the students printed out the computer drawing and manually assigned and calculated areas. The end-result was a hybrid physical and computer-based artifact that defies easy categorization (Figure 3).

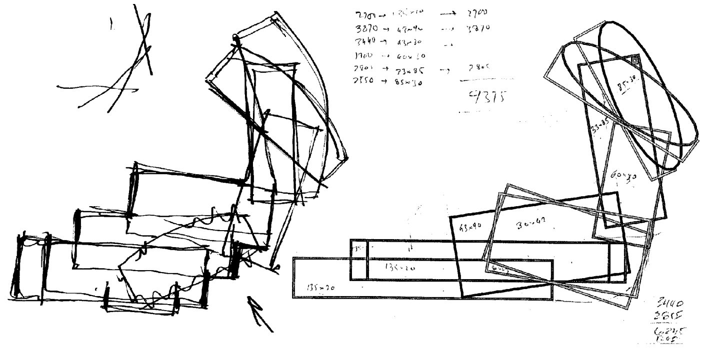

Figure 3. Physical, Computer-based and hybrid artifacts.

2.2.2 Parsimony

When conducting an initial study of alternatives, the designer usually generates as many solutions as possible given his/her finite resources (time and space). The result is usually manifested in artifacts where multiple alternatives are quickly generated and evaluated on one sheet of paper (Figure 4). When using the computer to conduct a similar study, the same mode was used. That is, multiple drawings were created within one CAD document, CAD documents were duplicated, brought up on the screen at the same time and compared. Given the relatively small computer monitor size, the students would usually use window minimization and expansion to quickly switch between artifacts.

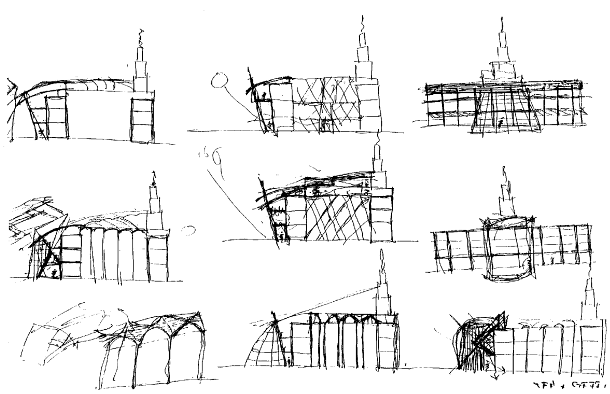

Figure 4. Parsimony in generating artifacts.

2.2.3 Uniqueness

Frequently, skeptics attack the lack of uniqueness associated with computer-based artifacts. They are usually suspicious of the computer's ability to duplicate those artifacts without any loss of information. The case study, however, indicated that students treat their computer files as truly unique and valuable objects. When they copy those documents into a shared folder or onto the local storage device for quicker access, those *copies* are clearly distinguished from the original and given a temporary status until such time where the copy acquires enough importance to supersede the original. At that point, the original becomes obsolete and is rapidly replaced with the newer now *official* version. In many cases, the students would refer to one version of their artifact as the official one thus describing it with the same uniqueness they would describe physical artifacts.

3. Modes of Creation and Use

The available literature indicates that representations are always fallible. The arrival of digital media did not fundamentally affect the relationship between the thing being represented and its material or digital representation. Thus, categorizing design-related artifacts as *real* and *virtual* gives little if any insight into the associated design processes or the artifacts themselves. Instead, a categorization of artifacts according to their mode of creation and intended mode of use yields more significant differences. Along these two dimensions, the artifacts can acquire one of two possible values: private and public. This matrix, then, yields four possible categorizations. Figure 5 illustrates this matrix and includes examples of the types of artifacts that belong in each quadrant. The case studies found initial significant differences in completeness, parsimony, and ownership when artifacts are categorized according to this matrix. A more detailed and systematic analysis of these differences will be conducted in the future.

		Mode of Creation	
		Private	Public
Intended Mode of Use	Private	Sketches Notes	Instructions Annotations
	Public	Presentation drawings	Quick sketches

Figure 5. Categorization matrix according to modes of creation and use.

4. Meta-Artifacts

In many cases, the designer refers to the *first floor* or the *east wing*. The *first floor* can be referred to and represented by many sub-artifacts: its floor plan, its database entry and the actual built structure. Thus, one is generally referring to the concept or the body of ideas and not to a specific *instance*. These abstract artifacts are the true virtual artifacts. Given their supremacy over any real or computer-based referrer artifact, we can call them *meta-artifacts.* Meta-artifacts can begin to emerge from the inclusion and unification of their material and imagined sub-artifacts; the incompleteness of which designers simply cope with on a daily basis. The ability to manage these components in a seamless way and relate them according to their parent meta-artifact will be a prerequisite to the success of: (1) computer-supported collaborative design processes, (2) academic instruction dealing with making and artifact building, and (3) executive policies in architectural practice addressing the management of architectural documents.

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