Early Experiences with Interdisciplinary Design Studios

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1. Introduction

Architectural and fine arts education has long employed the studio paradigm to foster creativity. This project aims to apply the studio paradigm to achieve similar benefits in computing science. Rather than attempt this in isolation, without prior experience or a studio "culture" in computing science to draw from, we have created an interdisciplinary studio that partners students in the College of Computing Sciences with peers in the School of Architecture. There are two main issues in conducting this joint studio: (1) a design project that stimulates mutual interest; (2) an infrastructure that supports interdisciplinary work, through either physical proximity of the studios or broadband communication between them.

Our studio project focuses on ubiquitous computing, which is a topic of interest to both communities. Rather than force all of the students to meet in the same place at the same time (which is difficult to achieve due to spatial constraints, scheduling conflicts, and divergent interests in the two academic units), it seems natural to rely on ubiquitous computing itself to provide the necessary synchronous and asynchronous communication between the studios. In particular, we are using a plasma poster network and other "smart campus" infrastructure to foster interaction between the studios.

2. Ubiquitous Social Computing Design Studios

We are conducting an interdisciplinary and interconnected design studio to foster problem seeking and problem solving for computing sciences students (i.e., students majoring in computing science, information systems, and information technologies). Students enrolled in this studio design ubiquitous social computing applications that facilitate interactions between colleagues, friends, and even the entire campus community. We chose ubiquitous social computing (USC) as the topic of our studio because ubiquitous technologies blend the digital, physical, and social spaces into a single socio-computing learning space, which can fundamentally improve students' creativity.

2.1 Interdisciplinary Studio

Since the studio culture in computing science is minimal, we decided to form an interdisciplinary studio in order to take advantage of the experience with design studios accumulated in the field of architecture (Schön, 1987, Cuff 2003). In this way, both the computing science students and faculty can learn the studio culture in a very direct way through interactions with architecture students and faculty. In collaboration with architecture students, computing science students design and implement novel digital/physical systems and applications that take into consideration broader issues such as the relationship of technology to physical context, ergonomics, and human behavior. Furthermore, their creativity is stimulated through semester-long interdisciplinary design projects and real-world problem solving in a more interactive environment where they can freely exchange ideas (Figure 1).

Figure 1: Interdisciplinary Student Project for an Accessible Interactive Plasma Poster

2.2 Physical settings

Studio settings are expected to improve the productivity and creativity of computing science students. Researchers have reported that the physical settings had a direct impact on students' satisfaction and productivity (Carbone and Sheard 2002, McCoy and Evans 2002). With the help of architects, researchers at Monash University have specifically re-designed an old classroom to provide a "precinct" of inter-related design areas including: (1) a design studio, (2) an Internet café, a meeting room, and an area for technical support. Their research results indicate that the physical setting of a studio resulted in greater satisfaction among their students. Similarly, innovative designs of physical spaces can improve business operations and employee productivity (Horgen et al. 1999). Despite the temptation to have just one common studio for all students, we chose to have two physically separated studios, one for computing science and one for architecture. The reason stems from the significant differences in the topics of interests for students. While USC provides a good common ground, we believe that students should work not only on common interdisciplinary projects, but also on separate projects that accommodate their specific disciplinary interests.

2.3 Inter-Studio Communication

The two studios are tightly interconnected to ensure a continuous exchange of ideas between the two groups of students. We set up several formal design reviews throughout the semester, in which the two groups meet in one studio and provide feedback to each other. Besides these face-to-face meetings, students use both synchronous and asynchronous communication tools to maintain a continuous interaction, review each other's ideas, and provide quick feedback. Skype and video cameras are used for synchronous communication (Figure 2). A wiki is used for asynchronous communication. To provide a novel communication mechanism for better casual interaction during the design process, we connect the two studios with large interactive plasma displays. Existing literature clearly illustrates what can be achieved with connected and interactive public displays. For instance, the value of casual interaction in workplaces is widely recognized and was convincingly demonstrated by studies of workplace collaboration at Bellcore in the 1980s (Kraut et al. 1990). More recent studies also proved that computer mediated communication can encourage such informal interactions (Fish et al. 1990, Churchill et al. 2003).

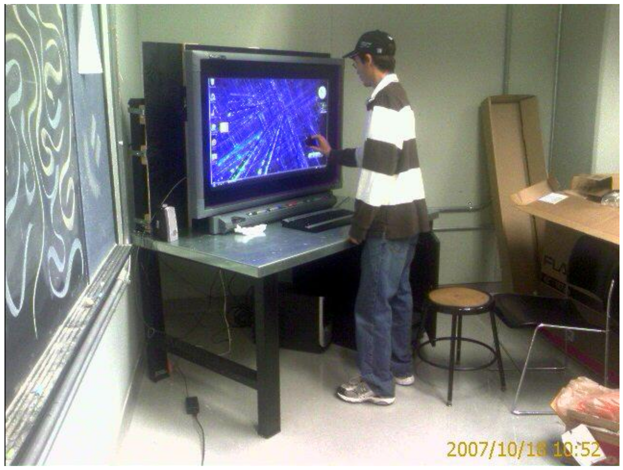

Figure 2: Interactive SmartBoard and Webcam in Design Studio.

2.4 Community-Studio Interaction

A key characteristic of our studio is the use of interactive plasma displays installed across the campus to continuously exchange information between students enrolled in the studios and the rest of the university community. As demonstrated by previous research, large-screen systems can be used to increase the informal community interactions through any of five basic approaches: community notice boards, media-spaces, community awareness systems, walk-up-and-use personal interactive public surfaces, and proactive displays (Churchill et al. 2003, Dourish et al. 1996, MacIntyre et al. 2001, McCarthy et al. 2002). Since most USC projects are of interest to a larger user population, our plasma displays can enable interested community members to leave comments or questions regarding the designs proposed by the studio students. This early feedback from real-life users helps students to refine their design and come up with novel solutions to non-envisioned problems. The deployment of interactive displays is done in such a way as to achieve greater feedback and interaction among students. The design literature provides several guidelines for their effective placement. The literature recommends high traffic areas, but locations where users can linger and have enough time to interact with the information are also important (Izadi et al. 2003, McCarthy et al. 2002, Churchill et al. 2003). Currently, we plan to deploy three such public displays in the student center, the library, and a student dorm.

2.5 Casual Interactions using Mobile Devices

Casual interactions and social networks can improve creativity. For instance, in the discipline of design, casual interactions have been observed to help designers solve problems collaboratively (Lawson 1980, Jabi 1996). Our SmartCampus infrastructure (http://smartcampus.njit.edu) aims to use mobile devices, such as smart phones, to give students serendipitous community interactions with our USC infrastructure, and specifically with the public plasma posters. This test-bed serves as a dispersed laboratory for the study of USC applications, in particular systems that link People-to-People-to-Places. Students can keep in touch with each other anytime, anywhere using their mobile locatable devices and SmartCampus applications such as CampusMesh, a location-aware social networking application. Furthermore, plasma posters can use SmartCampus technologies to identify the users in front of them and display personalized or customized content, thus enhancing the chances of receiving feedback from community members. Finally, users can use their mobile devices to interact with the public display and generate new content.

3. Challenges

Like any research project, this one has encountered many challenges. Some had little to do with the premise of the project, but with the administrative and educational environment at the host institution.

However, the project's particular concern with inter-disciplinary collaboration led to several unique issues worth discussing here. First, the notion of solving problems using a design studio setting was not readily accepted or understood by those outside the realm of the field of architecture. Students and faculty in computing science and university administrators are accustomed to lecture classes that meet for only a few hours per week. Studios on the other hand demand that students inhabit the physical space, take ownership of their work area, and approach the environment as a semester-long work environment with no segregation of class contact hours from homework hours. Studios require different furniture that is arranged differently from a lecture room. The computing science department did not have such a space. Setting up the actual physical space and obtaining the approval and support of the administration was difficult and time consuming.

The notion of a design approach to solving problems also differed between architecture and computing science. Computing science faculty members and students are accustomed to scenario-based methodologies that envision a particular fictitious scenario that gets acted out. A software/hardware solution is then designed to address this particular scenario. In architecture, on the other hand, scenarios such as described above are not usually implemented. Instead, the context of the problem is analyzed, several basic conceptual issues are delineated, and then the design progresses by deploying these conceptual ideas. Once the first iteration of the design is created, it proposes its own problems and questions to be addressed. One of the challenges we faced in this project was the skepticism we had regarding each other's design methodology. The architects insisted that they knew best how to creatively design while the computing science side insisted that their scenario-based methodology was superior. They derisively critiqued the architects that what they designed were scaled-down models of the "real thing" while computing science students needed to design the "real thing" itself (as in a piece of software). These differences in the educational culture need to be overcome for inter-disciplinary work to succeed. As the project progresses, we are hopeful that these differences can be overcome.

Another challenge involved the scale and nature of the project. Given that accreditation requirements dictate that architects be concerned with "buildings," and given their training, they had an expectation of working on large-scale physical projects. Architects are neither product designers nor software engineers. Consequently, the two studios could not work on the same project semester-long. Rather, they proceeded with their own separate projects and only when the issue of deploying technology in the building came up did they find the opportunity to collaborate. The initial notion that the two studios would work on a common project semester-long has proved to be impracticable. Instead, a strategy for success may be that inter-disciplinary work should proceed more episodically. When there is a specific issue to be solved, consultants and collaborators are brought in to work together. The teams would work together when needed and diverge to work on their own projects otherwise.

4. Plasma Poster Network Implementation

A dialog of ideas, both with peers and with a wider audience, is a critical part of the creative process. Accordingly, we are developing a network of interactive plasma posters to support this dialog. The salient features of these posters are:

- freedom of expression: authors should have the greatest possible latitude in presenting their ideas, without being constrained to predefined formats or templates;
- interaction: viewers should be able to communicate feedback to the authors, either graffiti-style or as type-written annotations;
- automation: the poster displays should operate as kiosks, inviting interaction without demanding it.

PDF documents are well suited for encoding and disseminating static content, and are easy to create with standard desktop applications. The PDF format also supports dynamic content plug-ins, but the tools and skills for creating such documents are less common. In contrast, HTML web pages seem better suited for sharing freeform, dynamic, frequently updated content. Social networking websites and common desktop tools have brought HTML authoring to the masses. Thus, we have selected HTML as the medium for encoding the poster contents.

We have looked at several precedents for annotating HTML documents, but found them to be less than ideal for this poster application. In particular:

- *u*-Annotate (Chatti et al., 2006) provides for freeform "digital ink" annotation of e-learning content. Though the annotations are freeform, it's not clear that the original content can be so. If the content is revised or even merely re-flowed with a different font size or window dimensions, it may go out of sync with previous graphic annotations. The content is created by a privileged group (instructors) and may be constrained to conform to a specific format to avoid these issues in an e-learning context.

- Diigo (http://www.diigo.com/) provides for textual highlighting and annotation of free-form web content. The highlighting is somewhat robust in the face of re-flowed or revised web pages. (If previously highlighted text subsequently moves within the document object model structure, the highlighting follows it.) However, the annotations are not freeform and are less robust; they may become visually disconnected from the highlighted text they're intended to refer to. Moreover, the highlighting and annotations are strictly text-based, not freeform, and are not well suited for non-textual graphic content.

In our poster application, we aim to support freeform annotation of freeform content. The strategy we have adopted is to allow authors to submit poster content as HTML web pages with minimal restrictions on their structure or layout. When a viewer chooses to annotate a poster with feedback, the system captures a PDF "snapshot" of its current state, and then uses existing technology for annotating PDF documents. For this, we are relying on the Adobe Acrobat software development kit (Figure 3).

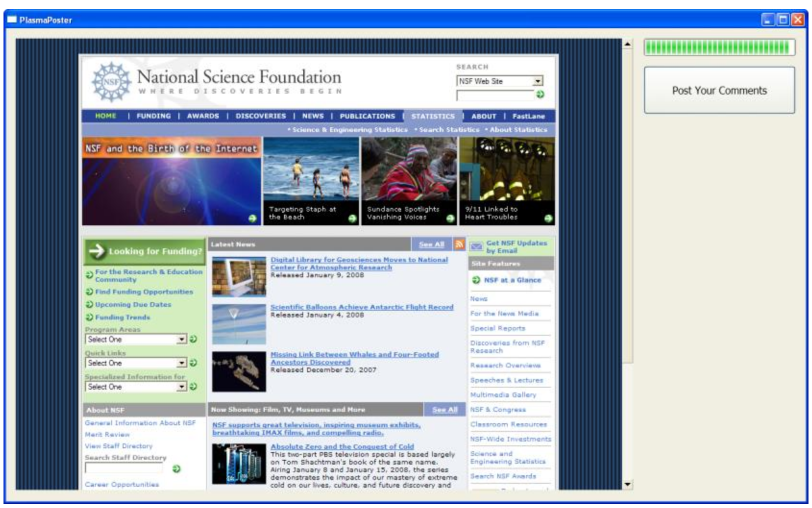

Figure 3: Plasma Poster Development Prototype.

Poster authors create their content, upload it to a web server, and submit the URL to the poster system. A moderator reviews the submission, and if the content is not inappropriate, adds the URL to a queue on the poster server. The plasma poster kiosks retrieve the URL queue from the server and display the posters in sequence. When unattended, the kiosk displays a poster for a preset time, then advances to the next poster in the queue. While displaying a poster, the kiosk software watches for user interaction, which appears as mouse events generated by the touch-sensitive plasma screens. Whenever it detects such an event, the kiosk resets the time-out clock for the current poster. There is no limit to the time that a user may spend interacting with a poster, but in the absence of such interaction the display does not stall; it proceeds to the next poster in the queue.

Most of the area of the plasma display is devoted to the HTML view frame. A progress bar indicates the time remaining for the current poster before the system advances to the next poster in the queue. A scrolling menu of poster thumbnails allows users to circumvent the normal queue order. An on-screen button initiates user feedback, at which point the system prompts users to identify themselves. (The SmartCampus infrastructure will eventually aid automatic user identification via Bluetooth communication with mobile computing devices, but prompting may still be necessary to distinguish between several nearby users.) The system creates a PDF snapshot, swaps the HTML view with an Acrobat PDF annotation view, and allows the user to mark up the poster graffiti-style. A virtual on-screen keyboard may also allow for textual annotations. The software e-mails the feedback as a PDF document to the poster author, who may choose to make the feedback public (with moderator approval, as for the original poster content). Another on-screen button allows poster users to see the feedback for the current poster. Thus, the poster system aims to foster creativity by promoting a dialog between creators and consumers of ideas.

The system described here is currently under development. For compatibility with existing university infrastructure, we are developing with Microsoft Windows XP Pro, Visual Studio, C#, and the Adobe Acrobat software development kit.

5. Evaluation

In order to assess the learning and behavioral impact of the pedagogical approach, we collected baseline data on the formal, informal and emergent interactions observed in the studios. We employed both *qualitative* methodologies, by documenting observations and conducting semi-structured interviews with students, and *quantitative* data (through surveys). In Spring 2008, we will assess creativity and innovation in students' projects and artifacts, comparing them to artifacts submitted in Spring 2007 (our first studio pilot). Multiple rater evaluation will be used to assess the quality of the deliverables.

More specifically, in Spring 2007 we collected data through observations, interactions and interviews. The semi-structured interviews were aimed at understanding how students in architecture and computing science view creativity; developing stories on creative "episodes;" identifying and providing feedback on the interactions with students in other disciplines. The interviews are used to define "learning episodes" described by the students. These episodes are then generalized using the context-content-process (CCP) model (Pettigrew, 1985, 1987, 1990), identifying physical and digital *contexts* (key environmental factors that facilitate learning), *contents* (multidisciplinary work and development of new creative artifacts), and *processes* (development of meaning, commitment and methods of studio design). In addition to defining "learning episodes" based on context, content and process characteristics, the interview data is abstracted and analyzed to identify patterns following the criteria-based model from Candy and Edmonds (1997). This model moves beyond the context-content-process equation to include behavioral, compositional, symbolic, preferential, pragmatic and performance aspects of a generalized creativity framework. The results of the content analysis will be available in Spring 2008.

With regard to the quantitative analyses, during our second studio pilot (Fall 2007) we collected baseline data on the perceptions of creativity by students both in the architecture and computing science studios. This data is based on validated questionnaires used by creativity researchers (Holt 2002). The survey includes both visual exercises and Likert-scale questions aimed at capturing creative behaviors, motivation, and personality differences that may facilitate innovative thinking and deliverables. Finally, in Spring 2008 we expect to move a step further by linking creative behaviors with actual outcomes and deliverable by evaluating the level of innovation in the students' artifacts delivered in the projects assigned in our third and last studio. We will complete this evaluation task by asking students to provide structured peer evaluations of earlier artifacts designed in prior studios. The students will be asked to rank order the artifacts in terms of innovation, effectiveness, aesthetics and novelty of the submissions, and will compare these evaluations with those of other subject matter experts (SMEs) such as the instructors and external reviewers. In addition, we will challenge the students with the same assignments and projects assigned in our first studio, with the expectation of improvement from earlier artifacts. The quality of such artifacts will again be rank ordered by the peers and SMEs, and recurring "creative qualities" of the artifacts will be generalized from the rankings.

6. Conclusions and Future Work

Our work thus far has exposed both challenges and opportunities in transferring the design studio paradigm from architecture to computing science. We have established procedures for assessing and comparing students' creative output and are continuing to develop supporting technology for ubiquitous social computing. Success depends not only on technology and instructor commitment, but also on developing shared understanding and acceptance at the institutional administrative level as well as among students.

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