Well How Would You Do It?
Facilitating the Transfer of Knowledge in Collaborative Design Environments
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Introduction

Competitive, global design companies cultivate fast-paced, innovative work environments where diverse teams use a wide variety of tactics and strategies to respond to emerging trends and opportunities. The increasing complexity of problems tackled in the design industry have introduced a need for designers from all disciplines to operate and make contributions within multiple areas of inquiry. For design educators, there is an urgent responsibility to ensure that graduating students will thrive and succeed in such workplaces. To do so, design schools must create meaningful, challenging and collaborative learning environments, where diverse groups of students develop and share interdisciplinary and transdisciplinary knowledge

Our recent field study of graduate design students in a large state university revealed product design opportunities for improving interdisciplinary knowledge sharing. Students from architecture, industrial design and visual communication design concentrations each displayed unique, discipline-specific methods for developing data as well as incomplete and/or inaccurate awareness of methodologies and approaches taught and used within other design disciplines. Additionally, members of each discipline showed a willingness to engage in collaborative and reflective activities.

The insights garnered from the study led to the development of a mediated design space called the LifeSampler Design Studio (LSDS). LSDS allows users to capture, annotate and archive authentic activity in a design studio environment built for small group collaboration. The hypothesis is that LSDS will facilitate critical reflection on best practices between the three concentrations, resulting in increased awareness that will, over time, lead to transdisciplinary innovation. This paper presents preliminary findings from our recent studies using the LSDS and proposes several new and exciting research directions for further developing this work. We begin by describing the pedagogical theories motivating our research and discuss relevant prior work in the areas of Reflective Design Practice, Transdisciplinary Education and Everyday Documentation. We then introduce our research method, followed by a description of the design, execution and results from our ethnographic study of university students in three design concentrations. We then introduce the LifeSampler Design Studio and present findings and insights from our ongoing studies, before concluding with some summary discussion and suggestions for possible new research directions.

Related Work

Reflective Design Practice

The pragmatist and educational theorist John Dewey succinctly described reflection as the examination of the basis for a belief. It is a fundamental component of the thinking process and is essential for successful learning. While the field of informal education occupied Dewey's examination of the reflective process, Donald Schön studied reflection within the realm of professional practice. Schön defined reflection as an iterative act that occurs both during (reflection-in-action) and after (reflection-on-action) problem solving activity (Schön, 1983). In the heat of the moment, a lawyer notices an anomaly in a witness' testimony and seizes the opportunity to redirect her line of questioning. A few weeks later, she describes this event to her colleagues, justifying her decision-making process and explaining the implications of her actions. Engaging in this iterative practice of in-the-moment and after-the-fact reflective thinking helps practitioners develop a repertoire of concepts, approaches, ideas and methods that together form a collective frame of reference for tackling new problems.

Within the field of design, the tenets of reflective practice are manifest through the acts of planning, making and evaluating. Beginning with Issue-Based Information Systems (IBIS) in 1984, design rationale has blossomed into numerous approaches based on reflection (Rittel, 1984). These approaches include Representation and Maintenance of Process Knowledge (REMAP) (Ramesh & Dhar, 1992), Procedural

Hierarchy of Issues (PHI) (McCall, 1991), Questions, Options, and Criteria (QOC) (MacLean, 1991), Decision Representation Language (DRL) (Lee & Lai, 1991), and Problem-Centered Design (PCD) (Lewis, 1991). These system design approaches share numerous similarities leading to the emergence of a generic model for reflective design. Developed by Panagiotis Louridas and Pericles Loucopolous, this model involves focusing on identifying assumptions through collection, deliberation and argumentation, supporting synchronous interpersonal communication and employing a semiformal structure in favor of a presupposed, controlled environment (Louridas &Loucopolous).

The LSDS system supports this model by building an informal design environment that provides a forum for increasing awareness of best practices across design disciplines. The system supports participants in easily video recording their design activities and provides them with a variety of tools for emphasizing key moments through thoughtful editing and annotation. These videos are then accessible to the wider design community in an online repository where they can be viewed, evaluated and used to provoke discussion as a creative intervention in the design process. Figure 1 illustrates a conceptual framework of the LSDS within the reflective design model.

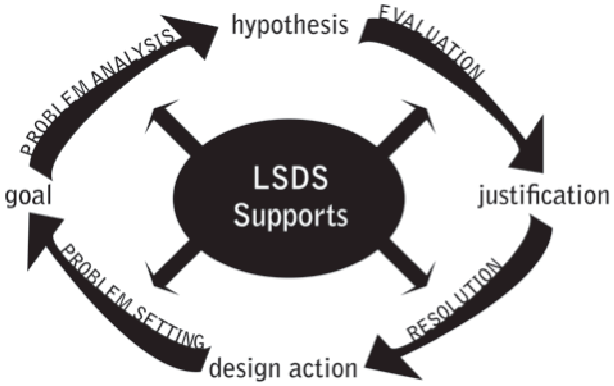

Figure 1. The LSDS reflective design model.

Transdisciplinary Education

The need for transdisciplinary collaboration as a foundation for the emergence of creativity, transformational research and the solving of complex problems is well understood and documented (Mitchell et al). Transdisciplinary research exists within a flexible and permeable framework, where multiple disciplines communicate openly, share and evolve working models and methods and resist becoming entrenched in closed departmental silos (Somerville & Rapport, 2000). However, transdisciplinary collaborative efforts face considerable challenges and can be constrained by cultural biases that prevent them from realizing their potential. In particular, there is a need for approaches that extend the human experience past traditional models of self-actualization. Technological and computational advances that allow unprecedented levels of sharing of creative outcomes can support this advancement. Indeed, the collective articulation, interpretation and understanding of successful research and work-based processes is vital for fostering creativity and driving innovation in culturally diverse, highly collaborative, discourse-based networks of knowledge workers. Ben Shneiderman's model of creative practice calls for systems that foster individuals' ability to "*collect, relate, create and donate*" (Shneiderman, 2000). Here, information and communication technologies act as the *glue* connecting diverse domains of creativity and enterprise. This facilitates the emergence of new types of transdisciplinary creative processes, products and innovations that transcend discipline and domains, and "propose entirely new possibilities" for, and "rethinking" of, design research.

Our ethnographic research confirmed the need to develop tools and technologies to better support the capturing, sharing and interpreting of knowledge across multiple design domains. Such a system could facilitate the emergence of greater understanding about the contributions and approaches of different disciplines, while also helping to foster respectful dialog and communication between participants. It could also function as a useful repository of community "know-how" or practical wisdom that exists outside of conventional reports or presentations and is traditionally difficult to capture, archive, access or reconstruct. To this extent, the LSDS system has been designed and deployed with these goals in mind.

Everyday Video Documentation

Outside the design community, educational researchers have incorporated video playback into learning systems since digital video playback was first possible (Burke, 1995). This work, however, involved the presentation of professionally crafted educational video sequences. More recent work has addressed the capture of knowledge in less controlled environments using automated systems in place of trained video production professionals (Abowd, 1999; Ranjan, 2008). Researchers have addressed the presentation

and search of information in online teaching, training and educational systems (Clulow, 2003; Hampel, 2001). Additional work has addressed the issue of empowering individuals to create more meaningful documentation of their everyday lives in low-barrier-to-entry ways (Barry, 2005).

At the same time, increasing bandwidth and processing power have made everyday video recording and sharing a reality for end-users in a casual usage context. Web applications like YouTube [http://www.youtube.com] and Vimeo [http://www.vimeo.tv] provide users with simple tools to capture relatively brief video from existing sources or from web cameras. The popularity of these tools in terms of both publication and reception suggest that users are becoming comfortable with the tools of video creation and sharing. Applications like Sclipo [http://www.sclipo.com] apply this video creation and publication to knowledge transfer in a general sense, providing a forum for users to share their expertise. Other communities less focused on video, such as Instructables [http://www.instructables.com], provide step-by-step, text-based, how-to instructions, while the increasing popularity of screen-capture software supports the emergence of "screencasts" with instructional narration. Together, the focus on video as an instructional tool along with the sharing of how-to information within formal and informal communities of practice points the way for a system like LSDS to provide opportunities for knowledge-sharing and reflection among and between design disciplines.

Research Method

In this section we will introduce our research method, followed by a description of our case study of design students in different disciplines. We utilized a case study methodology focused on capturing, analyzing and presenting "thick descriptions" (Geertz, 1973). Methods used throughout the course of the pilot and primary study were activity assignments, discourse analysis, interviewing, narrative inquiry, semiotic analysis, surveying and video observation. Our field study examined research methods, cross-disciplinary awareness of collaboration, research purposes, how members of each discipline view each other, as well as social networks and the physical design studio environment. Key behaviors observed in the results were identified in the form of a user activity model. From these key behaviors we developed a list of design insights that contributed to the development of both the LSDS environment and our hypothesis.

Case Study Methodology

The field study utilized a flexible research approach to construct a case study (Robson, 2006). We implemented ethnographic observation and surveying to investigate knowledge sharing, awareness and practice across graduate level architecture, industrial design and visual communication design students. We recorded 21 hours of video footage of a collaborative architecture course, industrial design qualitative research methods course and a visual communications course. In addition, a total of 31 surveys were deployed among all three courses. We were primarily interested in exploring and understanding the following aspects:

- What types of research methods individuals used
- If and what previous research experience individuals possessed
- If and what experience individuals had working in an interdisciplinary environment
- Diversity of the professional social network within and across disciplines
- Knowledge about practitioner activity within and across disciplines

The survey used direct questions such as "What research methods have you learned in the College of Design?" as well as questions requiring higher levels of abstraction such as "If architecture was a mode of transportation, what would it be and how would you use it?" Thirty-one surveys were deployed and fifteen were returned, four of which were incomplete.

Case Study Results

The observation footage taken of the three courses uncovered behaviors that informed the development of LSDS. From these behaviors we developed a high-level activity model that succinctly explains classroom interactions. During steps one through three of the activity model, reflection-in-action occurs. During steps four and five of the activity model, reflection-on-action occurs.

1. **Set up:** Students and instructors prepare equipment and course materials.
2. **Align:** Instructors discuss the seminar's agenda and how it fits in with the course objectives.
3. **Present:** Student groups present work.
4. **Critique:** Instructors, student colleagues, and, at times, guests discuss student work and set goals for future work.
5. **Mirror session:** Students and instructors move to the "mirror session" room, where they discuss their performance, develop strategies for improving communication, identify process challenges/objectives and brainstorm solutions.

Architecture students demonstrated a research methods approach focused on historical research by conducting literature reviews of past architecture projects. Literature review results were presented in the form of written papers and collages. In contrast, the industrial design students identified research methods as opportunities for developing new data. Methods demonstrated included observation, surveying and interviewing. Text driven research methods such as semiotics and discourse analysis were also discussed. Finally, visual communications students demonstrated multiple research methods approaches, acknowledging tools for collecting historical data and developing new data.

The members of each discipline reported different purposes for their research. Architects gathered and recombined previous knowledge to develop a product. Both industrial designers and visual communications designers recognized gathering and recombining, but also mentioned research in terms of exploring and increasing resolution of information to produce new data. While visual communications designers recognized the outcome of their work as a product, industrial designers recognized that intangible outcomes, such as a process, could also be an outcome.

Views on collaboration differed with no overall consensus. All three disciplines viewed collaboration as the process of partnering with individuals to leverage unique skills that generate otherwise unattainable outcomes. However, 40% of architects viewed collaboration with other disciplines as a process of employment. For example, one architect stated that he "used visual communication designers to make posters," which connotes an uneven power structure. Additionally, the survey showed that despite a university-wide emphasis on interdisciplinary collaboration, both architecture and industrial design student social networks tended to stick to their own disciplines. Visual communication design students reported a more diverse social network, encompassing members of all three disciplines with a reported distribution across disciplines only slightly favoring their own.

Comprehensive understanding of the area of inquiry of each discipline varied greatly. Similarities across and between disciplines included ideas of making and dealing with form. Additionally, all three disciplines agreed that visual communications design dealt with developing representations of information.

Architects viewed themselves as human-centered problem solvers who designed buildings. They also viewed industrial design as a human-centered concentration, but their opinions were more scattered as to what industrial designers did. Answers varied from "defining market segments" and "designing objects" to "daydreaming for a job." Industrial designers saw themselves as human-centered makers, while they viewed architects as builders, instead of designers, that focused on building aesthetics. Industrial designers viewed visual communications designers as communicators of information. Visual communications designers' self-representation concurred with architects and industrial designers, seeing themselves as designers of information. They viewed architects as creative, out-of-the-box thinkers that designed buildings. Visual communications designers viewed industrial designers as precise and human-centered with a focus on technology-driven solutions.

Case Study Insights

This field study reveals that despite working under the umbrella of the same college in concentrations that focus on researching, making and reflecting, members of all three disciplines maintain distinct identities as researchers. The study also revealed that despite the home university's stated initiative to develop

transdisciplinary professionals, success remains marginalized at the student level for the following reasons:

- Differing views on what constitutes research
- Differing views on the value of collaboration
- Differing views on what constitutes collaboration
- Lack of diverse social networks
- Fuzzy and sometimes inaccurate views of what each discipline does
- Lack of overall buy-in

These deficiencies are viewed as symptoms of an overall lack of awareness between the disciplines. Our hypothesis is that developing tools that pool knowledge and allow sharing and interpretation of knowledge in a public forum will increase awareness leading towards transdisciplinary action. We developed the LSDS tool to test this hypothesis. In addition to identifying these deficiencies, the field study allowed us to develop a list of insights for developing LSDS. These insights fell into three categories: knowledge sharing, cross-disciplinary awareness and the design studio space.

LifeSampler Design Studio

The LSDS builds on two prior hardware/software systems, the *LifeSampler* and the *Eventory*, more fully described elsewhere (Wang et al, 2007). In the LSDS iteration, the system allows practitioners to record video of their work using a web camera, microphone and lighting equipment pre-set by video professionals to capture their workspace. The barrier to entry is extremely low – to start and stop the recording system, the designer need only make a few mouse-clicks. In the prototype system, researchers manually segment and annotate the recorded video using an off-the-shelf nonlinear video editing package with input from study participants; however, future work includes the creation of integrated segmentation and annotation tools to allow users to perform these tasks unaided. Once segmented and tagged, the video is uploaded into the online Eventory media repository, where it may be further annotated by both the contributing participant and other viewers. The repository makes these videos available to participants for browsing and search based on these annotations.

Data Collection

We situated the LSDS within a temporary design studio space, the construction of which was also based on insights developed from the case study. We solicited volunteers from the architecture, industrial design and visual communications concentrations to participate in design activity user studies.

Six discipline-specific pairs worked in the space. The first three teams to use the space served as our control groups, completing scenario-based design activities that were recorded using the modified LifeSampler system. After the participants completed their tasks, we conducted a post session to review and annotate video footage of their design activities. During this post session, each team selected various video clips that they deemed representative of important events, annotated these events with text-based input and then uploaded them to the Eventory – the LSDS online component.

Teams four, five and six were given a different scenario and design task to complete in the LSDS. However, they were also given access to the annotated videos uploaded by teams one, two and three to support their work. After completing their task, the members of teams four, five and six were given a post session survey to evaluate the effectiveness and usefulness of the LSDS.

While the first set of teams and the second set of teams worked from different scenarios, they were asked to follow a similar process consisting of research, ideation and evaluation. We decided that giving teams this loose process framework would create boundaries for task completion and provide common ground.

Data Analysis

Analyzing the data gained from the LSDS study consisted of tabulating Likert scale responses and studying participants' written responses to statements made about their LSDS experience. The survey consisted of five statements that investigated if and how incorporating the LSDS tools into the design

process affected their research strategy, development of ideas and deliberation about their final outcome. Additionally, we coded the video footage across four dimensions; atmosphere, actors, activities and artifacts that afforded us the ability to look at interactions in a modular manner. Our final method was discourse analysis of team conversations to examine if and how the LSDS affected topics of discussion.

Discussion

Preliminary analysis of the LSDS study yielded mixed results as well as highlighting opportunities for improving the system functionality. These results suggest that the system supports reflection-in-action. This process of reflection-in-action occurred most regularly during the ideation phase of the design activity. Teams four and five reported that watching footage of other teams ideation phases changed the final outcome of their project. The most dramatic change occurred with team four's design approach, as having viewed footage of other group activities, they shifted their focus from designing a flex office space to incorporating issues of lifestyle, such as diet and exercise. Participants suggested several improvements for increasing the LSDS system's capability to facilitate reflection-in-action. These suggestions included a more informative content browsing interface that displays the event narrative and a search-by-keyword option to identify events of greater relevance to their activity.

During reflection-on-action, groups one, two and three annotated their selected video content for seeding the LSDS with individual keywords, rather than descriptive narratives. Group three, which comprised industrial design graduate students became highly invested in the event parsing and annotating activities, opting to participate for an additional half hour after the scheduled session end time. While they spent a good deal of that time deliberating about parsing and annotating important events in the footage, their event descriptions were also predominantly keyword rather than narrative in nature. In order to make the descriptions coherent for groups four, five and six, we made some minor grammar corrections. Undertaking this activity introduced the need for an interface that either guides users through a more detailed process of annotation or, alternatively, a more computationally heavy model of developing a feature that takes keywords and provides users with a list of complete sentences to choose from.

Participants described the concept of capturing and annotating authentic activity to develop everyday documentation as beneficial to their work, but that current LSDS control structures need more definition to provide proper support for task completion. Again, participants mentioned the implementation of more robust annotation tools for narrative development. Participants also suggested the inclusion of more cameras to allow for angle changes and microphones for more consistent audio capture. Finally, participants requested the option of enhancing the capture of authentic activity with post-activity video interviews. Building these additional control structures into the LSDS system could reduce the cognitive load associated with creating coherent narrative statements in the moment.

More research, development and testing of the LSDS system needs to occur to determine the value of the system for supporting transdisciplinary education. The previously discussed instance of group four (comprised of industrial design students) changing their design idea to include issues of lifestyle occurred when they watched an event uploaded by architecture students. While this occurrence is promising, we will continue to conduct additional experiments to validate the repeatability of such events.

Conclusion

In this paper we presented our ongoing research into the development of computational media tools for capturing, sharing and interpreting design practice activities. The purpose of this work is to facilitate greater communication and sharing of research practices and strategies among students from different departments within a large design school. In our paper, we described the design and development of the LifeSampler Design Studio based on the results of our ethnographic case study and modifications to our own prior work. Findings from a preliminary user study with the system were presented, along with descriptions of potential future research directions. We are currently working on extending the LSDS to include more comprehensive content search and retrieval functionality, user-interface refinements and additional annotation and discussion features.

References

Abowd, G.D. (1999). Classroom 2000: An experiment with the instrumentation of a living educational environment. *IBM Systems Journal*, *38*(4), 508–530.

Barry, B.A. (2005). *Mindful documentary*. MIT.

Bodker, S., Ehn, P., Kammersgaard, J., Kyng, M., & Sundblad, Y. (1987). A utopian experience. *Computers and democracy: A scandinavian challenge* (pp. 251). UK: Aldershot.

Burke, R. and Kass, A. (1995). Supporting learning through active retrieval of video stories. *Expert Systems with Applications. 9*(3), 361–378.

Clulow, V., & Brace-Govan, J. (2003). Web-based learning: Experience-based research. In *Web-based education: learning from experience*, 49–70.

Farooq, U., Carroll, J.M., & Ganoe, C.H. (2007). Supporting creativity with awareness in distributed collaboration. *ACM Group,* 31.

Geertz, C. (1973). Thick description: Toward an interpretative theory of culture. *The interpretation of cultures,* 3–30.

Hampel, T., & Keil-Slawik, R. (2001). Steam: Designing an integrative infrastructure for Web-based computer-supported cooperative learning. In *WWW '01: Proceedings of the 10th international conference on world wide web*, 76–85.

Lee, J., & Lai, K.Y. (1991). What's in the design rationale? *Human Computer Interactions, 6*(3-4), 251.

Lewis, C., Rieman, J., & Bell, B. (1991). Problem-centered design for expressiveness and facility in a graphical programming system. *Human Computer Interactions, 6*(3-4) 319.

Louridas, P. & Loucopoulos, P. (2000). A generic model for reflective design. *ACM Transactions on Software Engineering and Methodology*, *9*(2), 199.

MacLean, A., Young, R.M., Bellotti, V.M.E., & Moran, T.P. (1991). *Human Computer Interactions,* 6(3-4), 201.

McCall, R.J. (1991). PHI: A conceptual foundation for design hypermedia. *Design Studies, 12*(1), 30.

Mitchell, W.J., Inouye, A.S., & Blumenthal, M.S. (2003). *Beyond productivity: Information technology, innovation, and creativity*. Washington, DC: National Academies Press.

Nickerson, R.S. (1999). Enhancing creativity. *Handbook of creativity*. New York, NY: Cambridge University Press.

Potts, C., & Bruns, G. (1988). Recording the reason for design decisions. *10th ICSE,* 418.

Ranjan, A., Birnholtz, J., & Balakrishnan, R. (2008). Improving meeting capture by applying television production principles with audio and motion detection. In *CHI '08: Proceeding of the twenty-sixth annual SIGCHI conference on Human factors in computing systems.* 227–236.

Ramesh, B., & Dhar, V. (1992). Supporting systems development by capturing deliberations during requirements engineering. *IEEE Transactions on Software Engineering, 18*(6), 498.

Rittel, H., & Webber, M.M. (1984). Design problems are wicked problems. *Development in design methodologies*. New York, NY: John Wiley and Sons.

Robson, C. (2000). *Real world research.* Malden, MA: Blackwell Publishers.

Schön, D. (1983). *The reflective practitioner: How professionals think in action*. New York, NY: Basic Books, Inc.

Shneiderman, B. (2000). *Creating creativity: user interfaces for supporting innovation. ACM Transactions on Computer-Human Interaction* (TOCHI), 2000. *7*(1), 114-138.

Somerville, M., & Rapport, D. (2000). *Transdisciplinarity: Recreating Integrated Knowledge*. EOLSS, 248-249.

Wang, X., Mamadgi, S., Thekdi, A., Kelliher, A., & Sundaram, H. (2007). *Eventory--An event based media repository.* International Conference on Semantic Computing, 2007. ICSC 2007. 95–104.