Educating Reflective Learner Centered Designers

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Abstract. In this paper we discuss a multi-disciplinary course for educating reflective designers of technology-enhanced learning environments. The course supports the coordination of students in two disciplines, human-computer interaction and instructional systems design. Through the multidisciplinary teaming and an ontology of design processes, students in the course are encouraged to develop reflective practice as educational designers.

Learner-centered design of technology-enhanced educational environments (learning technology design, or LT design for short) requires both a focus on the learning goals for the design, and the ability to connect learning goals to their implementation in interfaces. While the ends, learning, may be relatively clear, it requires special expertise to develop the means for supporting learning through technologies. Early proponents of learner-centered design (Soloway et al.) were cross-trained individuals with a background in both computer science and education. The TRAILS project (http://www.trails-project.org) has as its aim producing more such individuals who can successfully integrate usability and interface design with educational theory and practice to produce effective learning environments (see DiGiano et. al., 2005.)

In this paper, we first discuss our goals for the Penn State TRAILS course, including a blend of both learning design and interaction design. We then discuss our pedagogical strategy for this goal, namely using reflective practice of design methods in an interdisciplinary context. We then describe the course in detail, including our teaming strategy, projects and assignments to promote student reflection and practice of various design methods, and an ontology of design methods used to help students compare and contrast various learning and interaction design methodologies.

Learning design versus interaction design

The design of successful technologies for learning must meet a wide variety of goals. Learning goals and interaction design goals may conflict. For instance, user-centered design emphasizes utility and efficiency for the user in accomplishing tasks. (UCD cites) However, designers of user-centered products might not even consider learning as a goal at all, much less intentionally include affordances for, or minimize impediments to, learning—for instance, an educationally sound interface might need to introduce “desirable difficulties” (cite) to allow a learner to improve their understanding, even though this might slow down their progress towards the immediate goal of completing an exercise.

In order to create designs that meet this variety of goals, a designer needs to have a deep understanding of techniques from many domains. Many user-interface designers may assume that since they have been learners and since they have been, for instance, children, that they are capable of learner-centered design for children, but this often proves to be untrue. Learning design requires empathy with the target population not only as users of software but as learners, and psychology literature documents that people are notoriously bad at remembering their prior understandings (or misunderstandings) of a domain (Carey, 1988). In education, curricular design requires knowledge of the general practices of teaching, an understanding of the target audience and their developmental readiness for certain concepts, knowledge of the target domain, and pedagogical content knowledge, or content-specific teaching techniques. For technology-enhanced learning design this is compounded by the need to understand both expert and novice users of interfaces and the attendant complexity of users who change over time. It is difficult enough to understand the unique usability needs of, for instance, children (Druin, 1996); it is more difficult to understand how those needs interact with the children's growing expertise with the technology and with the subject matter. In sum, the demands of designing for learning require an enormous wealth of strategies and empathies, ranging from understanding interaction design goals such as usability, engagement, or interactivity, to understanding particular audiences, to understanding a content domain plus its attendant pedagogical content knowledge, to understanding general principles of learning. How do these wide-ranging goals affect the ways in which designers design?

Learning design methods through reflective practice

Design education may focus on the goals of designs, the means to reach those goals, and/or the end results of the design process. For instance, an architecture seminar might address the end results of a design, such as the functional requirements of the treatment areas of a hospital. Or, it might focus on the means to reach those ends, such as different design processes like participatory design or iterative refinement. If the seminar were to emphasize a design's goals, there might be consideration of a large number of examples of hospital designs in a case library.

Design of learning technologies may be taught in similar ways. One may focus on the goals of designs, perhaps emphasizing learning theories and goals for educational environments or usability requirements. Or, one might focus on processes that lead to more successful designs, such as informant design or learner-centered design processes. Finally, one might focus on successful or unsuccessful designs as cases.

As noted above, design of learning technologies presents daunting complexity due to the many goals that are being addressed. Likewise, examples are useful as starting points, but it is difficult to assemble a truly representative library of cases that cover the range of issues in designing learning environments that are technology-enhanced. Schon and Argyris have argued that if professionals (especially professional designers) are truly reflective about their design processes and products, then they can improve themselves continuously over time, developing a greater basis of experience and a more mature practice. (educating the reflective practitioner) Thus, a focus on design processes (the means) can be crucial for beginning to address the complexity of LT design, because it may be more general than the goals or ends of LT design, and may allow the designer to improve in the future, even after their design training is over.

Penn State Learning Design Studio Course

Penn State's TRAILS course is an experimental combination of two courses. The first is a graduate seminar in the College of Education's Instructional Systems design program developed over eight years in a design studio format to teach principles of learning technology design (Hoadley & Kim, 2003). The second is a large, required undergraduate course on human-computer interaction and interaction design in the School of Information Sciences and Technology which has been taught for approximately the same length of time. These courses had always been taught separately, but the TRAILS project enabled an experimental coordination of these courses, bringing together both undergraduate information sciences majors and graduate students from education and other disciplines. In the section below, we describe how an emphasis on these multidisciplinary teams, reflective practice, and an ontology of design allowed us to teach both groups to work on problems of LT design. TRAILS is a multi-institutional research project which aims to improve the preparation of LT designers. The TRAILS project relies on a set of pedagogical principles for TRAILS courses which are manifested differently in the different partner sites (see other presentations in this session). In our discussion below, we focus on some of the unique aspects of the Penn State TRAILS course, especially as they relate to a teaching goal of educating reflective practitioners of learning technology design.

Audiences and coordinated course structure

The TRAILS project emphasizes that in order to produce software design products to promote learning, it is necessary first to bring together designers with the domain interests and expertise to contribute. Collaboration across disciplines links those who study learning with others who develop software, not only to scaffold one another in the creation of educational technology products, but also to synthesize design processes and redefine the discourse for so doing. While many of the TRAILS courses do this by integrating multiple domains of expertise into the teaching staff, and also try to achieve a diverse body of students in the TRAILS courses, our approach at Penn State was unique in capitalizing on Hoadley's joint appointment in two departments. We chose to pursue a coordinated, rather than cross-listed, course structure: students registered for either a course in the School of IST or in the College of Education, and while the students in these two courses met, by and large, simultaneously, their expertise, and requirements, were different. Thirty-five Information Science students (largely juniors) registered for the experimental section of their required course on HCI. Nine graduate students (six from Instructional Systems, and three from Information Sciences) registered for the education graduate seminar on design methods for emerging technologies. This seminar could be used for course requirements in both majors, although it is one of many possible choices.

The course was focused largely on two design projects, one on creating groupware for undergraduates to collaborate on IT projects, and one on a topic of the students' choosing related to learning and technology. In the first project, student teams were assigned with one student from the graduate education seminar and three to five students from the HCI course. Each team elected a project leader, and the graduate students were encouraged not to lead the teams, but rather to take on a role of "Chief Learning Officer." However, roles were left to the students to work out amongst themselves. Project deliverables were generally jointly constructed, with the education students' grades more heavily weighted towards the learning properties of the designs, and the HCI students' grades more heavily weighted towards the usability properties of the designs.

This project was selected to build on students' existing experiences. All of the students had extensive experience doing team projects using existing software tools, such as the University's course management system ANGEL, instant messaging tools such as AIM and Yahoo Messenger, and email or office productivity software. Thus, the goals of the design were very familiar to the students, as were existing end-stage designs such as the tools mentioned above. This was intended to give the students an opportunity to focus on design processes. Students in the HCI course used a textbook on interaction design (Preece, Rogers, & Sharp, 2002) that emphasized a number of typical HCI design processes. At the same time, the education students used a course reader that emphasized both HCI and educational design processes. Each student was required to produce two types of process reflections: first, an individual design reflection paper on their group's processes, and second, a detailed time and task accounting worksheet for 360 degree evaluation of their teammates.

In the second project, based on mid-semester feedback, the students were permitted to form their own teams, which might or might not contain a mix of students from both courses. Teams varied in size from three to eight students; most teams contained a mix of HCI and education students. Two teams consisted solely of HCI students and no teams consisted solely of education students. The project deliverables were divided for the two groups: education students were required to generate learning objectives,needs analyses, specifications, and justification for the educational aspects of the software; HCI students were required to generate prototypes, usability testing, and usability analyses of the designs. Both groups were still jointly responsible for participating in the project designs. Where teams lacked education student partners, the instructors played the role of the education consultants in the design process. Again, each student produced reflection papers and a 360 degree evaluation. Furthermore, students used the TRAILS-provided tool Gorp (Gallery, Organizer, and Repository of Projects) to turn in intermediate drafts of their designs. These designs were "frozen" and copied at various checkpoints so students could refer back to earlier drafts of their designs. They were also prompted by Gorp to describe their design process, war stories from the project, and so on. (See http://trails-project.org/webapps/gorp/Gorp.do for the Gorp library.) Other course activities included in-class charettes, a semester-long design journal for the education students, virtual visits from educational technologists with both education and computer science backgrounds, and an optional meeting with children engaged in participatory technology design (cite Kaplan). In addition, the graduate students engaged methods of design using their readings and the ontology described below. Course periods typically included discussions and presentations of readings, presentations and critique of interfaces (both for usability and for learning), and occasionally involved splitting the two groups of students for activities or discussions.

Overall, the course was designed to help integrate the two audiences and to highlight both similarities and differences in their concerns in learning technology design. Anecdotally, this is important because of the ease with which design traditions can develop independently and fail to inform each other (for example, see, Hoadley, 2004).

In prior iterations of the graduate course, there was sometimes a difficulty reinforcing the need to focus on learning outcomes and the unique needs of learning-oriented design processes—students would instead focus on usability issues. By separating these two roles, but forcing them to coexist in the same design projects, the hope was that each audience would develop an appreciation for the unique contributions of the two complementary perspectives.

Design ontology

Learner-centered design is a less well-developed domain than user-centered design; although a textbook was available for the undergraduates in the course on models of usability design methods, assembled research papers were necessary for the graduate education students. In addition, a design ontology was used to allow these students to compare and contrast different educational design methodologies.

The design ontology presented to the education students deals with design processes (means), as distinct from design intents (goals) or design products (ends). These students were familiar with one particular design method, the ADDIE model (Dick, Carey, & Carey, 2001) from earlier classes, but not necessarily with that method's components as representative of a more general family of design methods. This course encouraged a mutual analysis of methods characteristic from both human-computer interaction and education, and generalized beyond these disciplines via the an ontology. Exposure of otherwise independent design traditions (instructional systems and information sciences) to each other in the collaborative pursuit of a contribution to educational technology was intended to result in a synthesis of cross-disciplinary, and thus more comprehensive, discourse between them, addressing each and involving both.

While the HCI students encountered learning theories and their principles as applied to learner-centered aspects of user-centered design, the education students confronted the literature of technology design. And it is here that we survey the strategies facilitating those engagements. For instance, regarding approaches it is possible to consider design from the vantage of a designer's intent or goal, and Hoadley has created a framework called "design for distributed cognition" (Hoadley & Kilner, 2005) for design on that basis. This framework has been introduced in previous iterations of the instructional systems version of the course, and will not be discussed further in this paper. Likewise, another angle from which to view design, and another ontology altogether, is that of the design product. Gero (Gero & Kannengiesser, 2003) has collected and presented these knowledge representations thoroughly via the constructs of an object's (or, in some cases, concept's) structure, function, and behavior.

However, it was the design processes leading to emergent technology that were under scrutiny by the education students in this course. Within a domain, characteristic processes accommodate a range of intents and products, and perhaps brandish the hallmarks of a designer's tradition more consistently than either of the latter. They also provide a foundation on which to build via reflective practice, long after the course is over. Therefore, an investigation of design processes as part of the course's objectives included process in general as an ontology, specificity of processes with regard to each perspective (user-centered and learner-centered design), and a purposeful synthesis of a novel process with benefits for educational technology as learning enhancement.

What, then, comprise the representations of knowledge that designers use as means, either to convey their intent or conceptualize a product? Hoadley since 1998 has created an ontology from the following as a guide for assessment and evaluation of design processes and attendant literature: stages, values, roles, principles, patterns, models, techniques, and designer realities (internally and externally imposed constraints).

For instance, stages of a design reflect ways the design process may be broken into phases over time. A familiar application to the educational students involves the ADDIE model of instructional design with its progressive stages of analysis of needs, design as a formative and schematic response to needs, development of design, implementation of design, and evaluation of design response to needs.

In a similar manner of comparison to known processes, novel design processes encountered in the literature or laboratory may be interrogated to uncover their locations within a domain and similarities across domains by responses to ontologically based queries. Whose values shape the design process and how? How are roles differentiated among participants in the design process? What rules or principles must designers follow? What common design patterns (Alexander et al., 1977) are recognizable within the design process and how do those patterns drive the process, either immutably or as modified to suit changing contexts? What models of use and users (in this case, learning and learners), if any, guide the designer? What techniques do designers employ to impel or maintain design progress? Finally, what are the psychological realities, such as satisficing, that constrain the process? By applying this ontological lens to view processes of design documented in the literature of educational technology, education students broadened their concepts of instructional design through applications to, and comparisons with, educational technology design.

Results and future plans

The conclusions to be arrived at from this iteration of this TRAILS course must stem from the answers to three questions. Did education students develop a more sophisticated understanding of UCD, how it is assessed, and how it can be directed when performing LT design (and in general through the design ontology)? Did HCI students become familiar with learning theories and how those affect UCD processes when learning is a consideration? Finally, did both sets of students apprehend and experiment with each other's design traditions, thus broadening their own?

The design of this TRAILS course afforded multiple data sources for collection and analysis, among them in-class presentations by mixed groups of HCI and education students, design charettes for completion by one or two persons, and a post-course survey of direct questioning. Taking these in turn, the content of in-class presentations although produced by mixed groups tended to remain segregated. That is, in deference to education students, there was typically a list of learning theory terminology (typically one slide in a PowerPoint presentation) with which HCI students did not demonstrate familiarity or attempt to reconcile how the components of those theories were manifested in the design artifacts.

This disconnect was borne out in the design charettes wherein pairs of students (whether education, HCI, or a combination) were presented with a scenario for which to propose an LT intervention. Two recorded observations involved HCI students only, and in both cases the prompt to justify an adopted strategy on the basis of learning theory elicited a quzzical response. As HCI students scrambled to recall learning theories the term "constructivism" arose, and was quickly pasted onto their responses. As an aside, this suggests a correlation with the fact that of the nine education students (the source of learning theory information), four were concurrently taking a course in constructivist learning environments.

However, the Gorp displayed projects presented a different perspective on the cooperation among education and HCI students. Occurences of segregation were still evident, as when the Ca$hmoney Team 1 neglected to even attempt learning theory justification for their approach because there were no education students in their group. Furthermore, the Monkey Bar investigators split into two smaller teams of exclusively education and HCI members, resulting in competing products. But the remainder of the seven projects indicate that learning theories were, indeed, purposefully sought out as correspondence to, and justification for, the content.

This hopeful note also resounded in the post-course survey of all participants (education and HCI). For example, on a five point scale anchored by "Very" and "Not at all," about 25 of the 39 total students responded with "Very" or "Somewhat" to questions about the importance of understanding educational theory. Again, this was mitigated by the response to a question about working collaboratively, which was not supported at all.

In that student interest in cross disciplinary populations and a recognition of contributions from design tradition diversity to a mutual discourse has been uncovered in the classroom, the course has broken academic ground, justifying further iteration. What remain to be seen are the optimal modifications to accommodate this interaction.

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