Theories and Practice of Design for Information Systems: Eight Design Perspectives in Ten Short Weeks

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ABSTRACT

Students come to design education with different goals. Some seek to acquire expertise in design, others to learn specialized methods tailored to a research domain. Furthermore, students in the area of information system design confront a large literature of diverse perspectives on design, all of which are potentially useful. To disentangle this literature and to develop students' knowledge and know-how for design, a ten-week course, titled *Theories and Practice of Design for Information Systems*, was developed. Pedagogically, this introductory course is neither a studio course nor a methods course. Instead, it takes a "design perspectives" approach where students engage a number of substantial perspectives on design through conceptual and experiential study. This paper introduces this pedagogical approach and describes eight design perspectives including readings, key questions, and activities. It concludes with lessons learned for positioning students to engage the interplay between the theory and practice of information system design.

Categories and Subject Descriptors

K.3.2 [**Computers and Education**]: Computer and Information Systems Education; H.5.2 [**User Interfaces**]: User-centered design

General Terms

Design, Human Factors

Keywords

Learning to design, design education, curriculum, reflective practice, social processes in design, design rationale, hierarchical decomposition, design patterns, participatory design, personas, scenario-based design, Value Sensitive Design

1. INTRODUCTION

Students come to design education from a wide range of backgrounds and motivations. Some seek to become design experts and intend to devote a good deal of their study to the design process. Others – with primary interests that lie outside of design per se – seek specialized methods tailored to the problems of their domain. Still others do not yet know what knowledge, skills and sensibilities they seek from design. They only know that in some significant way design and design research will intersect with the work they intend to pursue.

Traditionally in design education, studio courses are well suited to students who intend to commit a significant portion of their coursework to design training. Targeted design methods courses are well suited to students who already know what design perspectives they will emphasize in their design research and practice with information systems. But how should we approach design education for students who come to information system design with a wide range of backgrounds and seek a broad exposure to design theory and practice – students who need the field as a whole untangled and linkages made to the work they will be pursuing? That is the design education challenge we take up in this paper.

To address this challenge, we developed a ten-week course *Theories and Practice of Design for Information Systems* based on the idea of design perspectives. Design perspectives, while never definite, refer to characteristic theories and know-how – theories for making judgments about the uses and merits of a perspective, know-how for making new artifacts and achieving results, fitting of the perspective. Certainly, to take a perspective and to work within it faithfully requires practice, along with reading, study, and critical discourse.

We make three contributions. First, we describe the design perspectives approach, which positions students to engage the interplay between theory and practice for eight major perspectives on design. Second, for each of the eight design perspectives, we present the readings, key questions, and design activities. Additionally, we give in-depth descriptions of three activities, showing how they integrate both conceptual and experiential study. Third, we discuss our experiences with this pedagogical approach, present lessons learned, and suggest how the approach might be applied to different settings and extended. All course materials are available in the Human-Centered Computing Education Digital Library [13].

2. LEARNING TO DESIGN

According to Schön: "The paradox of learning a really new competence is this: that a student cannot at first understand what he needs to learn, can learn it only by educating himself, and can educate himself only by beginning to do what he does not yet understand" [28, p. 93]. In design education two basic pedagogical approaches have been used to invite students to resolve this paradox: the studio project and the methods course.

The *design studio* is the quintessential environment for learning to design. It is distinguished from other learning formats in that: i) Students work on relatively open-ended problems where heterogeneous issues are addressed; and ii) Students iterate and produce multiple solutions with the guidance of faculty who help constrain the problem [20]. Studio courses tend to be time-

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intensive. They tend to take place within a dedicated physical space to afford the cultivation of a rich assortment of information resources that support the learning process. Finally, they tend to pose a single problem or a family of problems, enabling students to both collaborate and graciously compete with each other.

Coming out of the design methods movement of the 1960s [18], *methods courses*, in contrast, focus narrowly on techniques that facilitate particular modes of inquiry (e.g., analysis, synthesis, and evaluation). Method courses develop students' skills for selecting and executing particular methods, such as running a brainstorming session (analysis), producing an affinity diagram (synthesis), and performing a rigorous cost-benefit analysis of set of solution options (evaluation). In some courses, particular techniques are presented in an integrated fashion within an overarching methodology or point of view. Examples include Rosson and Carroll's textbook on scenario-based design [27] and Friedman's course on Value Sensitive Design [10].

With this paper we introduce a third approach, *design perspectives* courses that seek to promote "design thinking" and to develop students' skills and sensibilities for several substantial perspectives on the design of information systems. A perspective foregrounds a particular element of the design process, or constellation of elements, and is backed by a seminal writer and body of scholarship. *Design as Reflection* [28], for example, emphasizes that design unfolds through cycles of action and reflection, where a designer creates an artifact, then reflects upon its qualities which, in turn, leads to revisions. *Design as a Social Process* [4], in contrast, foregrounds different features, especially the centrality of design representations for externalizing knowledge and sharing it across boundaries. Design perspective courses do not privilege any one perspective; rather, they seek to equip students with a repertoire of perspectives that can be engaged in-depth in subsequent course work and research.

Pedagogically, a design perspective course seeks a blending between conceptual and experiential study. As described below, this is achieved by creating a close coupling between a set of readings about a perspective and a tightly focused design activity, which is structured to prompt students to "experience" a perspective. This blending develops students' knowledge and know-how for design.

3. COURSE OVERVIEW

3.1 Learning Environment

General curricular structure. The course, titled *Theories and Practice of Design for Information Systems*, needed to fit within a standard 10-week quarter. Offered as a 3-credit course, the class met once a week for three hours and included the expectation that students would work an additional nine hours per week outside of class. These constraints were imposed by general curricula considerations at the University of Washington.

Physical Facilities. We taught the course in a regular university classroom. No dedicated classroom or studio space was provided beyond the duration of the 3-hour weekly class meeting. While tables were fixed to the floor in an amphitheatre-type arrangement, chairs were movable so that students could form small groups to work on design activities.

Stuff. We provided students with materials as appropriate for the design activity. Typical materials included: thick colored markers, colored pencils, origami paper, multi-colored stickies of assorted sizes, colored dots, shiny gold stars, colorful modeling clay, glue sticks, string, scissors, and poster paper.

3.2 Student Background

Several assumptions about the background and motivation of students who would be interested in a perspectives approach to design explicitly guided our development of the course. We identify those assumptions here. First, rather than drawing students who had entered a design program (e.g., in industrial design), we assumed students would be pursuing graduate study in other disciplinary areas such as information science, computer science, and technical communication. We also assumed students would be at different stages in their graduate studies but that most students would be taking a full course load and would also be busy working on research projects. We further assumed that while some students might have a background in one kind of design (e.g., software engineering), all students would have a limited awareness of the broad sweep of approaches to design. Finally, we assumed students would have different motivations for learning about design, including to discover new knowledge through design-based inquiry or to inform the design of information systems through the application of social science research.

By and large, these assumptions were born out. Fourteen students representing information science, computer science, and technical communications enrolled in the course as well as a few students from geography and biomedical health informatics. Of the 14 students, about 10 were in the first or second year of their graduate programs. For all of the students, this was their first course on design as a subject in its own right. Most students anticipated carrying out some aspect of design or design research in their doctoral work.

3.3 The Design Perspectives

Given the pedagogical aim, the next step was to decide on what perspectives to include. We recognized it would not be possible to include all potentially valuable perspectives in a 10-week course and still engage each perspective in a reasonable amount of depth. Thus, we aimed for a balance among the design perspectives along three dimensions: rationale vs. intuitive processes; micro vs. macro levels of analysis; and bottom-up vs. top-down strategies. Students explored eight design perspectives in all as follows: design as reflection, as social process, as dialog, as hierarchical decomposition, as composition and pattern making, as invention, as participation, and for human values. The first class introduced the character of design and the last class was devoted to the Design Expo. Table 1 provides an overview of these perspectives including key questions and readings for each, pedagogical approach and a brief description of a design activity. As noted earlier, handouts for all the design activities are available [13].

Table 1. Summary of design perspectives and activities, weeks 1–10.

Design Perspective (weeks 1 –5)	**Key Questions and Readings**	**Pedagogical Approach**	**Design Activity**
1. The Character of Design	Can creative design be stimulated through prescribed activity? What is a wicked problem and are all design problems wicked? *Readings*: Mountford [23], Rittel & Webber [26].	Examine the qualities that differentiate design from other types of creative problem solving. Engage in a strongly constrained first design problem.	BLACK SQUARES I: Using 4 black squares cut from construction paper create four compositions that express each of the following concepts (12 sketches total): order, tension, calm. BLACK SQUARES II: After class, create solutions to the black squares problem for the words: increase and playful. Generate 6 preliminary sketches and select one "best" solution.
2. Design as Reflection	How do the materials of a design problem influence the design process? What guides the selection of an effective solution from a range of possible solutions? How do designers talk about the design process? *Reading*: Schön [28].	Reflect on the design process. Develop a vocabulary for describing design activity. Observe how an expert designer approaches a design problem. Compare the design process of expert and novice designers.	HOME ENERGY USE: Observe an expert designer as he invents an information system that promotes efficient energy use in the home. Reflect on how your design process compares with that of the expert designer.
3. Design as Social Process	How can designers account for users in a context-of use, specific usage scenarios, and, finally, that not all users are the same? *Readings*: Buucciarelli [5], Holtzblatt & Beyer [15], Carroll [7], Pruitt & Grudin [25].	Explore ways that design can account for social context, social process, and social actors. *Technique*: Expose students to contextual design, scenario-based design, and personas.	HOME ENERGY USE REVISITED: Use a combination of scenario and persona based design to solve the Home Energy Use problem from the previous week.
4. Design as Dialog	What is the role of rationale and rationality in design? How does the process of recording a design rationale influence the design process? *Readings*: Moran & Carroll [22], Isenmann & Reuter [17], Winograd & Flores[32].	Explore the value of capturing design discourse and decisions during the design process. *Technique*: Expose students to design rationale.	FIND MY MOMMA, PLEASE! Design an information system to help parents and their children get in contact with each other during an emergency. As you do so, construct a design rationale that captures your emergent decision-making process.
5. Design as Hierarchical Decomposition	In what ways can the design of information systems and people's interactions with those systems be understood as a hierarchy of components? How can the decomposition of elements be used to support design? *Readings*: Simon [29], Lane et al, [21], Greenberg [12].	Explore the value of task analyses and decomposition for improving design at the micro-level. *Technique*: Expose students to the GOMS (goals, operators, methods, and selection rules) model.	SWAPPING FAST, FASTER, FASTEST: Identify three different editing methods for swapping two phrases in Microsoft Word. Then, choose two of those methods to compare by (a) modeling performance with a keystroke-level model and (b) testing your models empirically with performance data from users.

Design Perspective (weeks 6 – 10)	Key Questions and Readings	Pedagogical Approach	Design Activity
6. Design as Composition and Pattern Making	If designs can be decomposed into basic elements, can they also be built up from smaller elements into larger ones? In what ways do patterns and pattern languages capture this proposition? *Readings*: Alexander [1], Erickson [8], Bang [3].	Explore the relationship among primitive elements and the construction of a pattern language built up from those elements. *Technique*: Expose students to patterns and pattern languages.	PARK CONSTRUCTION KIT: Develop a paper prototype of a visual programming language to support the design of a public park – including primitive elements (e.g., rose bush) and their composites (e.g., bed of roses) – as well as one or two "Alexander-like" patterns that link human activity with an aspect of the park design.
7. Design as Invention	How are new artifacts invented? Do they emerge out of nothing? Or are they best understood as incremental improvements? Where do really new ideas come from? *Reading*: Petroski [24].	Explore the incremental dimension to new designs.	THE NEXT GENERATION TIME PIECE: From sun dials to grandfather clocks to pocket watches, time pieces have evolved – greater mobility, smaller size, lesser weight, greater accuracy. Envision the next generation time piece.
8. Design as Participation	How can users participate in the design process? What do we mean by a robust sense of participation? *Readings*: Floyd, et. al, [9], Kensing & Madsen [19].	Explore substantive user participation in the design process. *Technique*: Expose students to the Participatory Design practice of Future Workshops.	INFORMATION SCHOOL PHD ADMISSIONS PROCESS: Conduct a future workshop with relevant stakeholders to generate new visions for the PhD Admissions process.
9. Design for Human Values	What is the place of human values in the design of information systems? How might the design of information systems transform not only everyday activities but society as well? *Readings*: Friedman et al, [11], Hendry et al. [14], Illich [16].	Explore the ways in which the design of information systems writ large can be used to address societal change.	INFORMATION TOOLS FOR SOCIAL CHANGE: Use Convivial Reconstruction or Value Sensitive Design to sketch a design program or approach to the societal problem of providing health information to groups that are often disenfranchised (e.g., homeless, drug users).
10. Design Expo	Given a specific design problem, how do designers know which design perspectives to invoke and when?	Designer's Choice! Explore when a design approach is appropriate and for what aspects of the design process. The integration of design approaches should be reasonable and reflective.	MANAGE MY MEDS (contributed by a student): Design an information artifact to help people managing complicated drug regimens (e.g., for HIV+) remember when their medications need to be taken. This device could also keep track of which medications have already been taken.

To engage the interplay between theory and practice within a design perspective, we selected readings and devised design activities to achieve a tight focus. The goal was to position students to experience the perspective directly through acting on a problem. Design activities typically lasted roughly 60 minutes, followed by 30 minutes of class reflection and conversation about the design experience. Given the short amount of time devoted to the actual design experience, our emphasis was on experiencing the design perspective and less so on the outcome of the design process. That is, we engaged in conversation around the rigor of the design process and how the design practice informed on students' understanding of the design perspective, its strengths and limitations.

The course culminated in a Design Expo (described in greater detail in Section 4.4) in which students brought any or all of the design perspectives to bear on a single student-defined problem. Here the challenge was for students to determine which specific design perspectives to bring to the design problem and to provide compelling reasons for their choices. As with the more focused design activities, our interest was more in understanding the value of a particular design perspective (or perspectives used in combination) than in developing a "best" design as a final product.

Finally, it is worth noting that as a group the design perspectives and associated activities covered a wide range of granularity with respect to human activity. The course began with students practicing design reflection on an information system to improve home energy use. Toward the middle of the course, finer-grained human behavior was explored through task analyses and key-stroke performance evaluations of word processing as part of investigating the hierarchical decomposition perspective. Toward the end of the course, larger organizational and societal concerns were brought to the fore when students engaged design as participation to examine a university's admissions process for PhD applicants and design for human values to envision a design program or overarching approach to the problem of providing health information for groups that are often disenfranchised, such as the homeless or recent immigrants.

3.4 The Weekly Intellectual Rhythm

To achieve the pedagogical aim to "think like a designer", we developed a weekly intellectual rhythm that began prior to class with individual reading and reflection on a new design perspective, class discussion about the central constructs of that perspective, a design activity targeted to that perspective, further class discussion about experiencing the design perspective, and concluded with individual written reflections on the design experience. During the 3-hour class meeting, breaks were interspersed as needed, typically during the design activity. Nine of the ten class sessions closely followed this rhythm. (The exception was week ten, where students presented solutions to the Design Expo).

Specifically, for each week, students and instructors progressed through the following five steps:

1. Preparing for class: Reading and reflective writing. To prepare for class, students read one to three short readings and wrote one-page position statements in response to a guiding question, such as "Write a question you would be interested in discussing based on any of the first three articles. Then, write a one-page reflection on your question. That is, discuss your own question." Students submitted their statements prior to class. In addition, students were occasionally asked to do some preparatory design work for Step #3, the design activities.

2. Focused discussion of readings. In the first 60 minutes of class, the goal was to establish a common, conceptual foundation for the week's design perspective. To do this, the instructors guided students in a structured discussion, which was based on careful review of the readings and students' written statements (from Step #1). The graded statements were returned at the start of class.

3. Engaging design activities. In the second 60 minutes of class, the goal was to engage in an "intense, interesting design problem". We sought to devise and structure problems so that the fundamental aspects of a design perspective would be experienced as the problem was engaged. We emphasized the importance of following a rigorous process. The quality and character of the final artifact was important only to the degree that it revealed key aspects of the perspective and process.

4. Reflections and critical discussion. In the last 30 minutes of class, the goal was to reflect on how the activity engaged particular aspects of the design perspective and to identify and discuss commonalities and differences. Typically, student groups described the outcome and the process that they followed, highlighting such things as impasses and how they were overcome, changes in perspective, and when new insights were discovered. Whenever appropriate, the instructors guided the discussion back to the readings.

5. Post-class: Reflective writing. After the class, students were typically asked to write a 1-2 page reflection about the design problem. Again, the emphasis of these write-ups was largely on the experience of following a disciplined process and on linking the felt experience with the readings.

3.5 Assessment

For assessment, students were graded as follows: 20% for the position statements (Step #1), 10% for the quality of in-class discussion, 55% for the reflective writings (Step #5), and 15% for the Design Expo.

4. DESIGN ACTIVITIES IN-DEPTH

In this section, three activities and the Design Expo are briefly described to illustrate the kind of work students engaged. The examples have been selected for diversity.

4.1 Design as Reflection: HOME ENERGY USE

Imagine a designer making a move, pausing to consider it, and then making another move. According to Schön [28], this two-step cycle, called reflection-in-action, is a fundamental organizing force that all designers work with.

To shape and elaborate this perspective of design as reflection, Schön develops a technical vocabulary for describing design processes. "Moves", for example, take place in a "virtual world" and are made with a "spatial-action language", which represents concepts from a "design domain" (e.g., website design) on a drawing surface. Once on the surface, a designer can pause, inspect the evolving design, draw out "appreciations" and affirm or discover new, sometimes surprising, "implications" of her moves. Then, she may decide to pursue an experiment ("exploratory", "move-testing" or "hypothesis testing"). With these experiments she will keep to a "discipline" until it can no longer be sustained, at which point she might "reframe" her approach and pursue a new discipline.

To engage students in this vocabulary, we invited a professional designer to class and observed him design ad hoc. He was given the following problem and asked to develop a solution with pencil on a poster-sized paper sheet while "talking aloud":

> *HOME ENERGY USE problem statement*. The problem is to invent an information system that promotes the efficient use of energy within the home. You should assume the following: 1) The cost of building and deploying the system need not be considered; and 2) Sensors of various types are available for monitoring energy use at various points in the home.

Students were asked to observe carefully and to identify activities that could be categorized under the above concepts (a worksheet, containing a list of some of these concepts, was handed out to prime students).

To prepare for this activity, students read Schön [28, Chap. 3]. In addition, in the previous week students developed solutions to a visual design problem, called Black Squares [31], which requires a designer to convey feelings for such concepts as "order" and "tension" by arranging exactly four black squares on a piece of white paper. As an example,

Figure 1 below shows sketches of three solutions for the concept "playfulness":

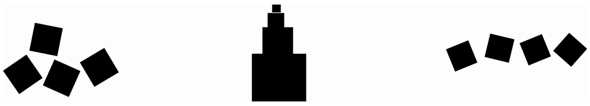

Figure 1: Three solutions for the concept of "playfulness"

This highly constrained, but surprisingly rich, problem was used to explore how the roles of "artist" and "judge" could be consciously embraced when seeking to ideate or select one of multiple options [23]. Students were asked to create six arrangements, choose the best one and give their rationale.

In written reflections on this activity, students were asked to consider both their own and the professional designer's work and to discuss salient aspects of both. One student, for example, noted the evident importance of making assumptions. Specifically, he described his assumption that "random arrangements" could be used to express "playfulness" and how the professional designer made several key assumptions about the home setting. In both cases, the student claimed, these assumptions drove the exploration of the problem. Other students described their tendency to self-censor ideas during the generation of black squares solutions. In contrast, the professional designer was willing to verbalize and jot down ideas while indicating that some of them would be considered more fully later. In identifying such similarities and differences and by working with Schön's vocabulary, students engaged both the conceptual and experiential aspects of this design perspective. Importantly, this activity also generated a rich set of shared experiences and common vocabulary that the class drew upon throughout the course. For this reason, this is a suitable activity for starting off the course.

4.2 Design as Hierarchical Decomposition: SWAPPING FAST, FASTER, FASTEST

Both "artificial systems" and people's interactions with them can be decomposed into their constitutive parts [29]. Hierarchical decomposition reduces the overall complexity of a system by isolating individual elements and by minimizing the interactions between elements. To demonstrate the merits of this influential perspective, we asked students to conduct a detailed analysis of human performance with a word processor. To set the background, students read chapters 1 and 3 of *The Sciences of the Artificial* [29] and to prepare for the activity, students read a relatively short paper [21] on the use of the keystroke-level model (KLM) to derive predictions of the time to complete menu selection tasks [6].

The activity asked students to examine a straightforward task: "swapping" words or phrases in a word processing application. An example of such a task is to swap the phrase "green Tortoise" with "brown Hare" in the following sentence: "One night the green Tortoise, happy as a clam, approached the brown Hare to talk." Swapping appears to be quite a common task in some word processing problems (e.g., assigning and reassigning people to groups).

This activity was structured in four steps, with the first two steps performed in-class and the second two outside.

1) Analysis. Working in groups of four, students were asked to analyze the problem and propose three different editing methods for swapping two phrases in a sentence. After discussion of all presented methods, the class selected two of them (referred to hereafter as Method A and B) and wrote detailed descriptions.

2) *Modeling*. Using a simplified approach, students derived KLM models, and estimated times, for the two methods selected in step #1. The class discussed the complexity of these models, especially the heuristics for where to insert "mentally prepare" operators (worth 1.35 seconds) in the stream of keystrokes.

3) *Invention*. Outside of class, students were asked to consider these analyses and to then propose a new command sequence (e.g., introducing a "swap" command in the edit menu), derive a KLM model, and compute a time estimate. Finally, students were asked to consider other criteria for judging the effectiveness of the model.

4) *Evaluation*. In this final step, students were instructed to conduct a simple experiment where they measured how long it took a single participant to complete methods A and B (five trials for each method, method order counterbalanced across the class). All students submitted their data, which was then aggregated into a single dataset and sent back to students. In the write up for this activity, students were asked to consider the aggregate data and how it compared to their models' predictions, to reflect on the process, and to discuss the types of information system design problems for which this kind of detailed analysis is appropriate.

Student collaboration, to formulate problems and to assess solutions, was the dominate feature of this activity. When proposing methods (Step #1), the class as a whole was able to generate more methods than could any one group of students alone, thereby illustrating the difficulty of exploring the full solution space of a problem. Furthermore, by discussing the detailed descriptions of the methods, students were forced to consider the small details of using a keyboard and mouse in word processing tasks.

When evaluating the models (Step #4), the benefit of asking each student to collect data and to contribute the data to the aggregate dataset was twofold. First, it forced students to observe a person's actual performance on methods A and B. This prompted students to reexamine their assumptions about how people would perform with the two methods and, equally important, produced observations that were brought back in class discussions. Second, the aggregate dataset allowed students to compare their data against their peers and to detect patterns that could only be found with a reasonable number of participants.

When discussing this activity in class, students first reported their predicted times for methods A and B with Post-Its on a whiteboard. The resulting plot showed a substantial variance of predicted times, which led to discussion about the subtle judgments that are required when making the models. Further, students' accounts of performing the experiment revealed a wide range of participant behaviors, thereby leading to discussions about experimental control and ecological validity.

4.3 Design as Composition and Pattern Making: PARK CONSTRUCTION KIT

Patterns provide a means for compactly representing a large number of design solutions to particular problems. According to Alexander, a pattern "describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" [2, p. x]. When patterns represent elements of different grain sizes, for example, a culture, a neighborhood, a library, and reading nook with an outside view, it becomes possible to envision the links between human activities with particular built structures and reason about future possibilities. This idea has influenced a variety of design methods and tools for information system design [8, 30].

To develop experience with this design perspective, students were asked to develop i) A paper prototype of a visual programming language to support the design of a public park; and ii) One or two "Alexander-like" patterns that link human activity with an aspect of the park design. They followed this three-step approach:

1. *Develop the "primitives"*. These are the basic elements for building all other elements in the language (e.g., rose bush, brick). Each primitive should specify how it i) Is affected by the elements next to it or in the nearby environment; ii) Changes over time – both the type of change and the duration (e.g., rose bush blooms every spring; bricks gather moss at 6 month intervals); and iii) Connects to or can be combined with other elements (e.g., rose bush connects to the side of other rose bushes; brick interlocks with other bricks).

2. *Develop "composites" from the primitives*. That is, combine instances of the primitives into larger meaningful units (e.g., an arrangement of seven rose bushes into a composite called a "rose bed"; an arrangement of bricks called a "path length").

3. *Develop a park or garden*. Aesthetically combine primitives and composites (e.g., a rose-lined path constructed from rose beds placed alongside of a series of brick path lengths) and develop Alexander-like patterns (e.g., a rose-lined brick path to invite park visitors to stroll through the park).

Finally, after class students were asked to write a 1-2 page reflection on the process of designing the park construction kit, where they explored such questions as: why did your team chose the primitives it did, in hindsight were these good decisions, and how did the composites you developed influence the Alexander-like patterns you developed and the park you eventually constructed?

Students found this to be a very engaging activity. Even within the 60 minute timeframe, they became committed to their parks and each of the proposed parks was remarkably different. Students employed a wide range of primitives, including water, trees, land, park benches, fire pits and so on. The initial choice of primitives seemed to lead to particular kinds of parks. One student noted that previous experience with software toolkits was a great influence on how the primitives were conceptualized (e.g., flowers would have attributes such as type, color, bloom time, etc. and therefore all primitives would likewise have attributes). When discussing their parks, students generally focused the rationale for particular kinds of primitives and how they could be combined to create a park that would facilitate desirable human activities.

A good question for discussing the use of patterns is: Could a single visual programming language be used to represent all the primitives and parks? By engaging this question, it becomes apparent that patterns provide an effective means for introducing and discussing abstractions. Indeed, one student noted that the park, and its primitives, was a special case for understanding the general problem of representing patterns in computational environments.

4.4 Design Expo: MANAGE MY MEDS

The class culminated in a Design Expo, a time-limited project where students were asked to select and apply some combination of perspectives to a design problem. Students, working in teams of 3 – 4 people, were to spend no more than 15 hours each working on the project and preparing for a presentation over a period of approximately 14 days. Project ideas were elicited from students. Students proposed projects that ranged from making user-interface improvements to a system for source code control for novice programmers to designing a system that would facilitate public dialog about the goals for local transportation systems.

We decided on a project, called Manage My Meds, an information system aimed to help people follow complex drug regimens. The student posed the following problem: "Create an information artifact to help people remember to take their medications when they need to be taken" and justified the importance of the problem on two grounds. First, for people with a serious illness (e.g., HIV), it is important to follow the proscribed drug regimens precisely. But, following regimens can be very difficult when the number of medications is large and the schedule complex. From this the student outlined four main constraints that had to be addressed. The solution had to: i) Remind people about when to take their drugs but not be annoying; ii) Operate in multiple locations, at home, at work, and while traveling; iii) Be capable of handling different drug regimens and be suitable for different patient lifestyles, and iv) Address issues of information privacy, security, and control.

Students were asked to select appropriate design perspectives and to integrate them in a reasonable and reflective fashion. In final class presentations and in a 4–5 page report, students were asked to address these and similar questions: What design perspectives were used and why? How were the perspectives integrated? What worked well? What do you wish you had done differently? In hindsight, how well suited were these design perspectives for the information design challenge you faced?

Students appreciated working on a longer-duration activity (about 15 hours instead of 60 minutes), to allow for a more thorough exploration of the problem. Still, like the other activities, the focus of the Design Expo was largely on the process. In this case, however, students had to select their own perspectives and to develop rationale for their choices. This was not easy and students found it challenging to select among perspectives, work within them effectively, and to reflect on how the process actually unfolded. In general, the projects focused largely on the context of use and the needs of the stakeholders. To work at this human-level analysis, all of the projects employed some combination of scenarios or personas to represent the actors, tasks, and situations. In addition, some projects drew on elements of design for human values, patterns, and participatory design. The most valuable aspect of the Design Expo was that it asked students to consider the merits of all the design perspectives and to discuss their decisions using design concepts and vocabulary.

5. DISCUSSION AND LESSONS LEARNED

5.1 Evidence that a Design Perspective Course Works

Was the pedagogical approach successful? In short, yes, we believe students broadened and deepened their conceptual understanding and know-how for eight substantial design perspectives in ten short weeks. In anonymous feedback at the end of the course, students gave positive comments on the combinations of readings and design activities. Several students reported that exposure to the broad range of literature on design was stimulating and would be beneficial in subsequent work. While we do not have firm evidence on specific learning outcomes, as the course progressed, we observed students mature in their use of design vocabulary and their approach to problems. Students, in class discussions, began to talk like designers, separating out goals from means, weighing strengths and weakness of solution options, explicitly pointing to the use of past experiences, asking for clarifications about assumptions and framings, and distinguishing between intended processes and the processes that actually occurred.

This kind of design discourse was especially apparent when students explained their choices of method and process for the Design Expo. Students, for example, described times where they paused to consider the current state of the project, decided on how to redirect it, and gave a rationale for why particular methods were chosen. Students often described impasses and how they were overcome. Students were often explicit about assumptions and points where additional exploration was required. These kinds of explanations conveyed exactly the kind of intentional action that we sought to promote.

5.2 Reflections on the Course

The weekly intellectual rhythm was the most important aspect of the course. We now draw some lessons, based on student feedback and our reflections.

Selecting readings. It is important to select readings that i) Introduce the key propositions of a design perspective; ii) Describe a methodological approach for applying a perspective; and iii) Connect closely with the design activity, by offering a set of concepts, or an example, which can be readily used while engaging an activity. To achieve these goals, we generally selected a conceptual reading from a seminal writer and a short, applied reading that exemplified the application of a perspective in concrete fashion. Requiring that students write position statements and grading them before class enabled us to structure the initial discussion around the students' questions.

Creating design activities. As seen in the SWAPPING FAST, FASTER FASTEST and the PARK CONSTRUCTION KIT activities, we generally posed challenging, real problems, but outlined specific steps for students to follow. The aim here was twofold. First, we required students to find and frame their own problems, at least within the scope we outlined. Second, we required students to decide how the process would be applied and be rigorous when engaging the problem. We found that it was important to remind students that the goal of the activities was to practice a process, a way of thinking, not to achieve a fully worked out solution. While at first some students were frustrated by the scale of the problems, as the course progressed students became comfortable working on complex problems and focusing primarily on process rather than outcome. Although perhaps surprising, 60 minutes proved to be sufficient time to meaningful engage a design perspective through a tightly focused activity.

Reflections and critical discussions. The reflective discussions that took place in-class immediately after the design activity were extremely important. Students liked talking about their work, and we believed a great deal of the learning occurred in these class discussions. In guiding discussions, we were especially careful to remind students to draw interpretations by referring back to the readings and to focus process on outcomes only. We learned that it was important to allocate sufficient time for these discussions, although the natural tendency was to give over more time to the design activities.

Working within constraints of a university structure. The design perspectives course we reported on here was developed as a 10-week quarter-long graduate course where such courses meet once a week for three hours. Others may teach in university settings where graduate courses meet for more than three hours per week or in a semester format. With differences in university structure in mind, we offer the following suggestions: To accommodate a course that meets for four hours per week, the design activities could easily be extended for an additional 50 – 60 minutes. To accommodate a semester-long (typically 13 – 15 week course) additional design perspectives could be introduced along the lines suggested below (see Section 5.3). The Design Expo could also be extended to cover a three-week rather than two-week period.

Structuring the student experience. To help students and visitors form expectations that are consistent with the design perspectives approach we offer four pragmatic suggestions:

1. Remind students repeatedly during the first part of the course that the focus of the design activities is on the process, not the product. Giving the rationale for this pedagogical move helps students adjust to the design perspectives approach.

2. Leave sufficient time for discussing design activities. On balance, a shorter activity session with adequate time to reflect and discuss the design activity works better than squeezing 10-15 more minutes into the activity and shortchanging the discussion.

3. During discussions, make connections between design activities and concepts from the readings and previously discussed design activities. For example, we frequently drew upon our observations and discussion of the professional designer in the second class when discussing subsequent design activities.

4. When outside reviewers are brought into the class to give feedback on student work (e.g., at the Design Expo), be sure to brief them about the aims of the course. If the visitors expect to see a persuasive presentation on the quality of the process followed and the merits of a final product, as they would for a final presentation in a studio course, the visitor's feedback is likely to be miscalibrated.

5.3 Extending the Design Perspectives Approach

As a group, the design perspectives represent a wide range of approaches to design. In choosing some subset of perspectives to include in a specific course, we found it useful to consider different ways of thinking (e.g., rationale vs. intuitive), different ways to approach building (e.g., building up from smaller elements, building down from overarching patterns, building incrementally from an existing artifact), and different levels of granularity of human experience (e.g., from micro-level analyses such as GOMS to societal analyses such as participatory design and Value Sensitive Design). Our intuition is that including a wide representation of perspectives along these (and perhaps other) dimensions provides students with an important exposure to the breadth of design approaches. In our discussions with students, we were careful to make these dimensions explicit as we introduced and contrasted the various perspectives. By doing so, we equipped students to construct a larger design landscape such that they would be positioned to integrate new design perspectives as they encountered them beyond the course.

In terms of specific perspectives, there are many combinations that can work well. Recall that in our 10-week course we explored eight: design as reflection, as social process, as dialog, as hierarchical decomposition, as composition and pattern making, as invention, as participation, and for human values. Others that might be of interest include: design for perceptual processing (e.g., eye-tracking), for persuasion, for aesthetics, for universal access, for sustainability, and for long-term human flourishing. When developing a new design perspective, two elements are critical: the readings to support the perspective and the design activity (see Section 5.2 above for detailed suggestions here).

As for the pedagogical approach, we believe that it can be readily adopted in educational settings that vary considerably in student preparation, curricula structure, and physical facilitates. In short, the perspectives, including key questions and readings, and the weekly intellectual rhythm should be widely transferable. However, we must also point out that our particular course was developed in the context of a large research university situated in an urban environment in the United States. The design activities, more than other elements of the course, assumed an information infrastructure appropriate to that context. Therefore, the question arises of how to make the perspectives and design activities meaningful for students who live and will work in different cultural contexts.

As an initial and we believe substantive response to this concern, the design activities can be fairly easily tweaked to reflect regional or cultural contexts. For example, as presented here the Home Energy Use activity assumes an ever present information infrastructure as well as a home with electricity, running water, centralized heating, and numerous appliances. With a small amount of reworking, the activity could be recast to a more rural context with less consistent (or no) Internet access in the home, wood heat, and intermittent electricity. The overarching design challenge remains the same: invent an information system that promotes the efficient use of energy within the home. Similarly, the design activity Find My Momma, Please! that assumes the Internet and Web as the information infrastructure could be modified for a regional context in which most communication happens over wireless and cell phones. Our key point here is that the design activity itself and the activity's usefulness in focusing students' experience on the design perspective largely stands; what changes are some details to make the activity more relevant to the environment the student lives and works in.

Another form of extension could place the design perspectives approach within an established course structure. For example, in a software engineering course two perspectives might be introduced in the first third and last third of the class to ask students to consider design-related, conceptual aspects of the material. As a second example, the design perspective approach and the studio format could be combined. Following one typical studio course format, a single design problem would be sustained throughout the course. Then week-by-week students would address that problem from a new design perspective. Design problems that involve the development of information systems to improve energy use, manage chronic health problems, or provide access to the justice system may lend themselves especially well to this type of course.

6. CONCLUSION

Increasingly design is recognized as a vital, unique form of inquiry by researchers and practitioners in technology, business, and the social sciences. This recognition will be most apparent when substantial intersections between design approaches and specific domains are created to discover new knowledge for intentional change. At these intersections, domains will both pull and push upon design, to borrow and to give over concepts and practices.

Consider, for example, graduate students with homes in geography, information science, or other field. Some will seek to *pull* design processes into their areas of research or scholarship that are not normally considered design fields (e.g., research on classification in library and information science). Here, the theory and practice of design will provide the means for discovering new knowledge or for making original interpretations. In other cases, graduate students will seek to *push* a particular analytic or empirical approach into design practice so that it becomes more widely available (e.g., network models for analyzing the flow of people in urban landscapes). Here, the problem lies in understanding how design is practiced so that a new kind of information can be utilized by designers, say landscape architects. In both cases, to succeed the student needs to begin with a firm understanding for design.

The design perspectives approach seeks to address the needs of these and similar cases. At the same time, in terms of a more comprehensive design education, we see the broad exposure to design theory and practice provided by the design perspectives course as positioning students well for more in-depth studio or methods courses.

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