Strategies for Research About Design:
a multidisciplinary graduate workshop

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ABSTRACT
We are developing a graduate curriculum and summer workshop on design research intended to prepare graduate students to do research about the nature of design or research about a class of designs, including concepts, models, and methods for that class. We expect our workshop to advance the science of design of software-intensive systems by creating a open community of design researchers, both in software design and in related disciplines, who are knowledgeable about design and design research methods and who are interested in advancing the field. The curriculum will create a common basis for discussion and identify core material to master, while the flexible format of the workshop will encourage the introduction of new ideas and new methods.

The goals of our course and workshop are to (1) develop an open community of graduate students, faculty, and industry researchers who are actively engaged in the advancement of software design research and (2) to associate this community with the larger community of researchers from related areas of design research who are planning design-related PhD theses. These students struggle with questions such as: What is a good research topic? How can I write a research plan when I don’t have any answers yet? How will I evaluate my results? Everyone on my committee has a different idea of what a thesis is – How can I write just one thesis that satisfies them all? Research methods classes are notoriously difficult to teach, but students who are struggling to write their thesis proposals are the most receptive audience, and this is the stage with the most leverage to influence the methods used in their research.

We draw on Shaw’s experience with a course on software engineering research paradigms. Although that course does not specifically address design research, we found most students are not aware of differences among research paradigms; they must be guided to look for the research argument of a paper instead of simply reading for the result.

Our design curriculum will include an overview of design and design research issues, a discussion of research paradigms, examples worthy of study, suggestions for projects and exercises, and an annotated bibliography of resources that cover the disciplines represented by the students. Summer workshop participants will:

- read classic design literature;
- study great designs and flawed designs whose flaws are revealing;
- study design research paradigms in software and other disciplines;
- engage in discussions with researchers and great designers from other fields such as engineering design, industrial design, architecture, and cognitive science;
- propose, discuss, argue and develop their ideas with fellow students and with faculty.

1. Introduction
In 2003 the US National Science Foundation held a workshop on the Science of Design. The Preliminary Report from the workshop says: “…workshop participants agreed … that we don’t teach software and software-intensive system design well. The most significant problem is that we still don’t understand the field well enough” (Sullivan 2003). The state of education for software design research methods is equally dismal. The report concludes (slightly rearranged): “The issue: Can there be a science of design for software and software-intensive systems, and, if so, what should it be?” was resolved by tacit agreement that science of design could be interpreted to mean an organized body of rigorous knowledge about how to make things (software and software-intensive systems).”
We plan thereby to create a curriculum and related materials that have been hardened and tested so they can be widely disseminated in differing formats depending on local needs. Our Wiki on the Science of Design (http://science-of-design.org) is a vehicle for our curriculum planning and may form the basis for a larger on-line community. Our workshop plan has grown out of discussions in an existing interdisciplinary group at Carnegie Mellon who meet to talk about design research and design education; here we found that cross-fertilization of ideas across design fields is essential to advancing design research. Our group discussions have been enjoyable and intellectually stimulating and we hope to make this enthusiasm for design research an essential part of the environment of the workshop.

2. Frameworks for studying design

Initial course planning generated a list of topics, including:

- Why should we understand design processes (the argument for “research in design”)?
- Design spaces: optimizing an objective function in a multi-dimensional constrained space.
- Coupling, clustering, and dependency: Identifying relationships between design decisions.
- Organizing for design: Control hierarchies: design as a social negotiated act over time.
- Design for change: How to design for evolutionary lifecycle change?
- Pattern Language: structuring observed relationships into representation for future design.
- Involving end-users and other stakeholders in a participatory design process.
- End-user designing: role of end-users in innovation, how and when to support user innovation.
- Problem-seeking; “system-analysis”; from needs into requirements and specifications.
- Documenting; design rationale; representations of alternatives; communicating designs for implementers.
- Representations: for exploring and comparing alternatives, consequences of representations.
- Innovative vs. routine (precedent vs. unprecedented) designs.

We are refining this topic list to a pair of frameworks for studying design; both are works in progress. One, presented here, considers the tangible domains associated with designs in the style of problem frame analysis (Jackson 2000). The other focuses on activities associated with creating designs.

The domains associated with design include bodies of information and communities of people. Their relations are suggested in Figure 1.

The design is central in our model. It has a structure (its position in a design space, its hierarchy, its coupling, and its rationale), a representation, and variability (evolution through time plus co-existing alternatives) It is directly related in some way to each of the other domains.

The problem represents the design problem to be solved. It has a context and a structure (which often differs from the structure of the design). It is shaped by end users but we treat it as a separate domain. The problem connects to (is solved by) the design, and this connection is mediated by design strategy.

Designers are the people who create designs. This domain includes their social interactions and ways they learn from one other. The connection of designers to the design is mediated by design strategies.

![Diagram of problem frames in design](image-url)
Design strategy is knowledge about how designers go about doing design. Designers consult it, and it thereby mediates activities of designers as they produce designs, and it shapes how problems map into designs.

Domain content includes domain knowledge as well as underlying reality that may be implicit but nevertheless constrains which designs can be realized (like physics, but more broadly). Content of multiple domains is usually brought to bear on a design. Domain content is connected to the design as it constrains the space of feasible designs.

End Users are the people who will ultimately use the realization of the design (not just the next customer down the line in the hierarchy or value chain). They may participate in the design and they may extend designs, but in general they do not function as professional designers. End users are connected to the design as the recipient of the realization, and also through end user participation. Further, they are connected to the problem as they are the ones who experience it directly.

Crossing our topics (above) with these frames yields some interesting observations. For example, the idea of design spaces probably belongs to design strategy, the specific design space for a given problem to the domain content, and the design is a point in a domain-specific design space -- or many points if we consider variability, or in many design spaces if we consider sets of goals from multiple domains. Similarly, the set of useful design representations are probably in design strategy, while the design itself is described in one or more of these representations.

3. Conclusion
The design research curriculum is designed to give students the intellectual underpinnings they need to do thesis work that will expand the body of rigorous knowledge about the design of things, and in particular, the design of software-intensive systems. In the summer workshop, students will develop a deeper understanding of how their research is informed by the state of the art in software design research and by design research in other disciplines. Including other design disciplines is important for several reasons. One is that other disciplines inevitably come into any real-world software system design. Another is that research approaches in other fields may be applicable to research questions in software design, much as the use of Pattern Language in software design borrows from prior research in architecture.

4. ACKNOWLEDGMENTS
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5. REFERENCES