

**AC 2009-2347: DESIGN RESEARCH AND DESIGN PRACTICE: A FRAMEWORK
FOR FUTURE INVESTIGATIONS**

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Design Research and Design Practice: A Framework for Future Investigations

Abstract

Recent research has found that design could be thought of as a separate discipline with common elements identified regardless of the disciplinary context. However, the practice of design always occurs within a disciplinary context. While studies have been conducted that show the ways designers have experienced design across disciplines are common, it is often hard to see how these overarching results can be applied to the specific contexts that they came from. This paper presents a framework for moving between design practice in a disciplinary context on the one hand, and design research often across disciplines that treating design as an entity unto itself. This framework provides not only a way of understanding the framing of future research around design and design practice, but also suggests ways to move from one space to another.

Introduction

Design has long been considered a core part of engineering practice and recently a growing field of engineering research. Further, design is often cited as a defining feature of engineering, distinguishing it not only from applied science but also other professions. Recent studies however have indicated a level of commonality across disciplines when it comes to design practice¹.

Design is usually practiced in practice in a disciplinary context and cannot be meaningfully separated from this context. This context brings with it an embedded knowledge of past experiences, including what has & hasn't worked, what norms exist (i.e. rules of thumb), what usual procedures for designing exist and what the usual outcomes and products are. The disciplinary context also influences what sorts of problems are identified and solved as well as the nature of the solutions. For instance do civil engineers always build bridges when another solution is better; echoing the old saying when you're holding a hammer everything looks like a nail.

However when doing design research that has underlying it the quest for generalizability (a well recognized tension between academic rigor versus professional applicability), we often want to either go across contexts or generalize findings from one context to another. If beneficial results are been found that improve design practice in one context, how can these be meaningfully applied to other contexts and disciplines. How do design researchers go about applying general findings to a context that itself is rich and usually fixed in the way it operates.

How then can research be conducted across design contexts without losing the sense of context underpinning the research results? Conversely how can generalized design research results be integrated back into an existing context? Without addressing these questions, engineering design research and practice will miss out on understandings that can come from looking across disciplines¹.

This paper offers a framework for this movement between doing research on contextualized practice to then applying generalized results back into practice and vice versa. In order to understand this framework, two previously published research studies of design are first discussed^{1,2,3}. Both studies used a phenomenographic approach^{4,5} looking at the differing ways design and sustainable design had been experienced by design practitioners. The framework is then presented and applied to these studies to explore how this movement between design research and design practice can be accomplished.

Previous Research: Design Across Disciplines

This phenomenographic study was designed to explore how design practitioners experienced design¹. The researcher believed that the ways designers experienced design impacted the way they approached future design tasks. An intended implication of the results was to impact design education and professional practice. While the researcher was an engineer in an engineering education department, it did not seem that confining this particular study to engineering designers would bring about full awareness of all of the ways design had been experienced; thus, the anticipated outcome of providing designers with new ways to think about design, and therefore, approach design, would be restricted to only how engineers experienced design. Therefore, the study was designed to provide a broad scope of the ways design has been experienced by designers in multiple disciplines, both within engineering and outside of engineering. Twenty design practitioners were interviewed from a range of disciplines. Table 1 displays the fields represented by the participants in the study. Some participants identified more than one disciplinary association and there were multiple participants from some disciplines.

Table 1: Contexts for Design Research

Architecture (1)
Biomedical Engineering (1)
Chemical Engineering (3)
Chemistry (2)
Civil Engineering (1)
Computer Science (1)
Culinary Arts (1)
Dance Composition (1)
Education (1)
Educational Research (1)
Fashion Design (1)
Learning Sciences (1)
Mechanical Engineering (2)
Painting (1)
Physics (1)
Writing (1)

Resulting from this study were six qualitatively different ways that practitioners in these contexts have experienced design. These different ways design has been experienced provides six different lenses designers could bring to design tasks based on their previous experiences. These reflect what it means to design, which could result in six different general approaches to

accomplishing the task. The following summarizes the ways design has been experienced, which imply an approach those that have experienced design in that way could bring to a new design task.

- Design is finding and creating alternatives, then choosing among them to make evidence-based decisions that lead to determining the best solution for a specific problem.
- Design is organized translation from an idea to a plan, product, or process that works in a given situation.
- Design is personal synthesis of aspects of previous experiences, similar tasks, technical knowledge, and/ or others' contributions to achieve a goal.
- Design is dynamic intentional progression toward something that can be developed and built upon in the future within a context larger than the immediate task.
- Design is directed creative exploration to develop an outcome with value for others, guided and adapted by discoveries made during exploration.
- Design is freedom to create any of an endless number of possible outcomes that have never existed with meaning for others and/or oneself within flexible and fluid boundaries.

The nature of this study as one that included design practitioners across a diverse range of contexts allowed for a broad understanding of design experiences, which are believed to impact lens on design and design approach. The study results contribute to the understanding of design as a domain unto itself as well as provide implications for designers in a broad range of disciplines.

Previous Research: Sustainable Design

The second study of design was an empirical study investigating the qualitatively different ways that sustainable design has been experienced by practicing engineers and non-engineers within an engineering context^{2,3}. It revealed the critical variations in the ways twenty-two sustainable design practitioners described their experiences of sustainable design in one-on-one interviews. It was important that these individuals had as many diverse, rich experiences of sustainable design as possible. Further, they came from a variety of disciplinary contexts, including product engineering, process engineering, architecture, urban planning, environmental science and industrial design. This larger group was selected to help understand the larger practice of sustainable design and to thus better inform the future education of engineers about what sustainable design could be rather than just what it is currently. The five categories developed are presented in Figure 1.

Category Name	Description
Solution Focused	
Category 1 Solution Finding	Sustainable design is finding a solution, either a product or process(es), to satisfy a client's declared requirements while decreasing the associated environmental, social and economic impacts.
Problem Focused	
Category 2 Reductionist Problem Solving	Sustainable design is the process of identifying and solving a client's problem by taking a reductionist approach to making decisions that each decrease the associated environmental, social and economic impact.
Category 3 Holistic Problem Solving	Sustainable design is the process of identifying and solving a client's problem holistically on a systems level, to increase the environmental, social and economic value of the solution.
Social Network Focused	
Category 4 Social Network Problem Solving	Sustainable design is the process of identifying and solving a client's problem as part of a network of wider problems facing society to increase the environmental, social and economic value of the solution to both the client and society.
Category 5 A Way of Life	Sustainable design is a way of life where all design problems, professional and personal, are solved to increase the environmental, social and economic value of the outcome to both the individual and society.

Figure 1: Ways of Experiencing Sustainable Design

These five categories are in a way five ways that designers could approach sustainable design tasks. Taking a different approach will more than likely result in a different and more comprehensive outcome. The categories are in a hierarchical structure from less comprehensive to more comprehensive in both the aspects the categories include and the linkages between these aspects. Figure 2 presents the categories in this hierarchy, including the variations between the categories. As the categories become more comprehensive the possible scope of the solutions increases. As Mann et al² indicates

The solution focused category is just looking for the solution within the client's declared requirements. A solution is found solely to fit with the requirements, as that is all that matters to the designer. The problem focused categories widen the available scope of solutions by reconsidering the client's problem in collaboration with the client, and jointly determining the final requirements of the solution. This enables other possible solutions to be proposed that solve the client's problem, but that may not have been allowable within the initial client's requirements. The social network focused categories take the focus on the problem a step further, but looking not just at the client's problem, but at the network of problems facing society that surround and influence the client's problem. The solutions that are found are done so within the broader framework of the social network.

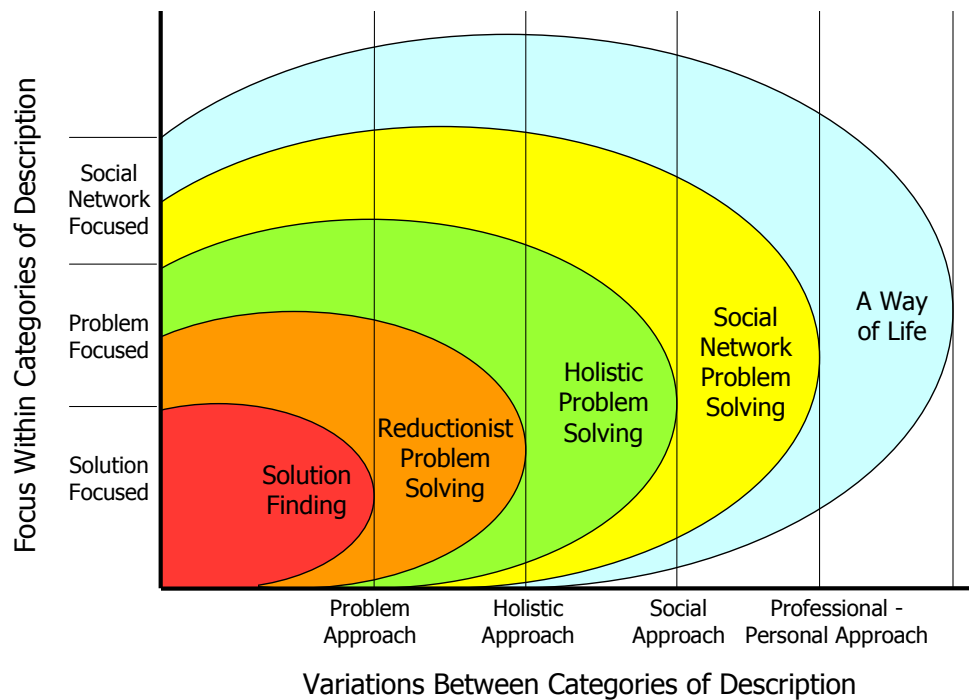


Figure 2: Outcome Space of Sustainable Design

A Framework for moving from Practice to Research

This framework moves from design practice to doing research on such practice. From the authors' perspectives, we could see that there were aspects of design practice that we wanted to investigate, namely the nature of design across disciplines and sustainable design. In particular we were aware that, from our experiences across disciplinary contexts, not only did practitioners from different disciplinary contexts do similar things, but the differences could be used improve current practices in other disciplines. For example one of the authors is both a chemical engineer and a choreographer of modern dance. Once when she was choreographing a dance, she brought along her dance design on excel spreadsheets. While needless to say the dancers were a bit put off to start, they soon understood that it was a very useful way of designing and articulating a quite complex dance sequence. Ideas from engineering were used to improve the design of dance.

This framework involves four steps:

1. See something within your own context in practice that you want to know more about. Find out what's known already and from that, develop a question.
2. Identify the assumptions behind the way that it is currently done or understood in practice. This is particularly important to enable cross-contextual studies.
3. Work out what data you will need to answer your question, what methods you will need to gather that data without losing the context in which it is situated. For example, if you

are researching design practice, don't lose the real life practice context. Also identify if any extra training or learning is required to use the research method selected effectively.

4. Conduct the research & analyze the results – try to generalize across disciplinary contexts but be sure to also describe the contexts that the research was undertaken.

While this appears somewhat basic, the main focus of this framework is to enable rigorous research to be conducted on design practice. It is important that while context is maintained, the results are generalizable to other contexts.

In the research on sustainable design described above, this framework was followed.

1. Sustainable design was identified as the area of interest as it was identified as an imperative for the future and something that current design practitioners were struggling to define and implement. Research was conducted into what was already known about sustainable design, particularly within an engineering context. This resulted in the realization that different people have experienced sustainable design in different ways. The research question was then developed, namely “what are the ways that sustainable design has been experienced among the participants involved”.
2. Current practice was further investigated to understand what assumptions existed about sustainable design and how it was understood in practice. It was found that different disciplines had differing understandings and ways of operating even though they were working on the same projects. This led to the realization that a more diverse range of views was needed to better inform what sustainable design practice is and should become in the future.
3. A research method known as phenomenography was selected as it was best able to answer the research question posed. The best way of gathering data with this research method in mind was through interviewing sustainable design practitioners about their experiences. This method would not only allow rich data to be collected from a number of different perspectives but this method would also not lose the context in which it is situated. This was because the participants were interviewed about their experiences, in context, with sustainable design rather than what they thought it was in an abstract way.
4. The research was then conducted and analyzed. Twenty-two sustainable design practitioners were identified from a range of disciplines but all working on engineering projects. These participants were interviewed one-on-one with the interview later transcribed and de-identified. The de-identified transcripts were then analyzed using a phenomenographic approach (for a much more detailed explanation of this process see²). The results were then developed into the categories and outcome space presented above. These results are generalizable across disciplines as they show a way of thinking and acting independent of context (even though they were derived from contextual experiences).

A Framework for moving from Research to Practice

This framework uses design research outcomes to influence and change design practice. This framework is based around developing an awareness of other perspectives and ways of being and understanding and specifically changing the practitioners themselves rather than the 'design practice' removed from the practitioners.

This framework involves six steps:

1. Make practitioners aware of their own practice through reflection
2. Make practitioners aware of other ways of practicing by bringing in the results from studies
3. Help practitioners to reflect on the similarities and differences between their practice and other ways of practicing
4. Help practitioners with the adoption of some changes to their practice to 'trial' a new way of practicing
5. Help practitioners further reflect on the effectiveness of the changes made
6. If positive, help introduce a wider adoption of different ways of practice

The main focus of this framework is to enable the results of rigorous design research to be adopted into practice. Here it is important to move generalized results into specific disciplinary contexts.

This framework was trialed on a group of students who had experience designing from industrial co-op experiences.

1. The students were first required to reflect on their design experiences on their co-op placement in industry. They were particularly focused toward reflection on the processes they went through as well as how they considered the environmental, social and economic impacts of their design decisions (as a precursor to talking about sustainable design)
2. The results of the sustainable design research were then presented to the students as models for understanding practice and discussed with them.
3. The students were then asked to reflect on these models in relation to their own experiences. Many students reported that their experiences were more closely aligned with the first category (solution finding) given their perceived lack experiences and the scope they were allowed to work within. Most however recognized that taking a more comprehensive approach would have resulted in better design outcomes. The students were encouraged to also reflect upon what they would do in future practice.
4. Students were then enrolled in a design course that emphasized sustainable design conducted in cross-disciplinary teams (electrical, mechanical and civil). They were encouraged to use their new understandings of sustainable design within the course.

5. The students reflected on how effective their implementation of their new understanding was and what improvements they would make.
6. Finally the students were encouraged to take their new understandings on their next co-op and vacation work placements and disseminate it to other designers.

Discussion & Future Directions

The framework for moving from Practice to Research and back was developed based upon our own work and experiences. Although research interactions with professional populations are at times more difficult to attain than student populations at university, research and collaboration with professionals is an essential contribution to the improvement of engineering education. The ability to connect to these groups provides different and relevant perspectives and broadens the understanding of phenomena that often exists in the literature.

The examples of research studies presented in this paper that involved practicing professionals were approached from a phenomenographic perspective. This particular approach was well-suited for interactions with professionals and to answer the research questions posed. This approach provided us with a broad understanding of aspects of the world that had not been investigated from the professional perspective, those of design across disciplines and sustainable design. While phenomenography facilitated the movement of practice to research for our studies, the framework presented in this paper is independent of research approach.

The framework for moving from Practice to Research seems more straightforward, most likely because most of us as engineering education researchers are accustomed to seeing issues in practice and education and designing studies to explore aspects related to these issues. The framework was presented in part as a reminder of the connection of engineering education to professional practice and our potential to bridge these two areas through research and collaboration. It was also presented to suggest that there is an equally important parallel framework for taking what we learn in our investigations back to inform both education and practice that is often missed.

It seems that implications are often suggested from research studies without a strategy for carrying out those implications. The framework for moving from Research to Practice provides a foundation for how we can create change, and it is grounded in the idea of awareness. We believe that essential components to have the potential to change practice is to 1- facilitate practitioners in having an awareness of their own ideas, actions, meanings, and experiences and how those impact their approach to tasks, and 2- facilitate an awareness of others' ideas, actions, meanings, and experiences, so that practitioner may be able to develop the ability to work with a new approach.

The frameworks presented in this paper were aimed to serve as supports to guide interactions with professional practitioners. They come from our own experiences and our own goals to carry out the implications suggested by our work. In the future a wider exploration and development of the framework is needed, particularly due to the apparent disconnect between the results of design research and changes in practice.

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