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Beyond Implementation: Exploring Research through Design to Elevate Everyday Educational Innovation in Engineering Education

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(WIP) Beyond Implementation: Exploring Research through Design to Elevate Everyday Educational Design in Engineering Education

This work-in-progress methods paper contributes to seeing how Research through Design (RtD) can connect research and engineering educational practice. The following scenarios offer grounding:

- Scenario 1: Two educators, inspired by recent work on ungrading, decide to pursue ungrading for courses they teach. Through conversation, they realize their collective experiences could inform others who might be interested in themselves pursuing ungrading. As a result, the educators come together to analyze their approaches in four different courses (two each), identify insights about how to adapt ungrading to different contexts, and organize the insights into a framework that could guide other interested educators.
- Scenario 2: An educator becomes interested in the potential for students in project-based contexts to learn not only from engaging in their own projects, but also by having opportunities to see across projects done by their peers. This turns out to be more challenging than she had expected, and she creates multiple different approaches over time, leveraging the different educational contexts she happens to find herself in. Eventually, this work becomes a dissertation focused on naming the approaches she created over time and what the collection of approaches has to offer as guidance for others who might want to help students see across projects.

There are many ways to understand the work in the above scenarios. For example, the educators could be described as implementing (per the title of the paper), creating, adopting, engineering, innovating, sharing, etc. In this paper, the work in these engineering education scenarios is called out as research through design (RtD). This turn to RtD involves seeing the educators as designers (designing context-specific instances of a grading approach, designing ways to help students see across projects in the second scenario). In addition, this turn to RtD involves seeing the educators as researchers when they turn their attention to naming insights that stem from their design work and are relevant to future educators-as-designers. In the results section of this paper, the work of these scenarios will be further unpacked as RtD.

Engineering education practice can be seen as a site of extensive design work: for example, designing curriculum and courses, designing grading schemes and class sessions, and designing ways to make high-impact practices work in specific settings. Such design work can produce knowledge in the form of reusable solutions, insights about challenges and their resolutions, and even ways to leverage theory. Often, the knowledge resulting from design work stays with the designer as part of their repertoire and wisdom. However, in some cases, it is possible and worthwhile to harness the knowledge through intentional and systematic approaches. Pursuit of the knowledge that stems from designing is the core of research through design (RtD).

Research through design is an approach to knowledge creation that leverages the intellectual work inherent in designing - both the ideas embedded in solutions and the efforts to achieve them. Research through design work produces knowledge that can be used in future design work. RtD has a strong history in human computer interaction and is gaining interest in engineering education. Recent work by Nandram and Foster (2023) explores incorporating RtD into engineering education research (EER). While they grapple with important theoretical questions around terminology and

methodology, their focus on these larger issues leaves open a crucial question: What does RtD look like in practice within EER?

This work-in-progress paper is part of a larger project exploring the state of RtD in EER through examining concrete examples. Here, we focus on leveraging RtD literature to identify dimensions for analyzing specific examples, applying these dimensions to two examples, and considering what this analysis suggests for a broader review of RtD efforts. Drawing on RtD's strong history in human computer interaction, we turn to two widely cited works to identify dimensions for the analysis: a paper by US scholars Zimmerman, Stolterman, and Forlizzi (2010), and another by UK scholar Gaver (2014).

Background

In their paper, "An analysis and critique of Research through Design: Towards a formalization of a research approach," Zimmerman, Stolterman, and Forlizzi (2010) addressed their desire to understand current practices related to RtD in order to support advancing RtD. To do this, they interviewed twelve researchers they identified as "leading HCI researchers." One theme from these researchers was a need for more examples; this work-in-progress is partially motivated by that finding. Continuing the meta-engagement with RtD, in his paper, "What should we expect from research through design?," Gaver furthers the conversation about RtD by grappling with philosophical issues around the kind of knowledge produced by RtD efforts and how it is different from scientific knowledge. A full treatment of these two papers is beyond the scope of this work-in-progress; here we draw on three points from these two papers.

1. Designing for x. In his discussion of the kind of knowledge stemming from RtD efforts, Gaver offers an intriguing way of thinking about the focus of specific RtD efforts, through his use of the phrase Designing for x. Gaver notes, "Whether they build on borrowed theory or observation of the world or of specific design examples, such theories take the form *designing for X can lead to successful outcomes*, where X may be…" (Gaver, 2012, p. 940). In the rest of the sentence, Gaver proceeds to point the reader to HCI projects related including designing for the self and designing for suppleness. This linguistic framing seems immensely valuable for characterizing RtD efforts. What "Designing for x" RtD projects might engineering education have?
2. Documentation practices. In their discussion of what they heard from their participants, Zimmerman, Stolterman and Forlizzi call attention to the need to address documentation practices, as documentation of the design experience is a central part of how design efforts can also be RtD efforts. They note, "In their discussion of theory and formalizing this approach, a number of participants focused on documentation of the design process. They claimed that in order for RtD to intentionally create theory, the community needs to form standards for documenting an RtD process." (Zimmerman et al., 2010, p. 314).
3. Annotated portfolios. Finally, in synthesizing his thoughts on the knowledge that stems from RtD efforts, Gaver presents his conclusion that annotated portfolios are a promising way to represent the knowledge (he uses the term theories) that come from RtD efforts. He notes, "The notion of annotated portfolios is not a formal one. What is defining to the concept is not how materials are presented, but that a balance is achieved between descriptions of specific detailed examples of design practice, and articulates of the issues, values and themes which characterize the relations among the collection, and to which the examples suggest answers." (Gaver, 2012, p. 944).

Approach

In order to prepare for a more comprehensive analysis of RtD efforts, the scope of this effort was to select a contrasting pair of scholarly publications that self-identify as engaging in RtD and analyze them using the ideas from RtD scholars.

The papers were chosen to represent explicit framing of the work as RtD, different approaches to RtD (a dissertation and a conference paper) and the work of early career scholars (a doctoral student and an assistant teaching professor). The first chosen publication examines a sustained exploration into helping students engaged in project-based learning experiences learn from the range of projects being done (Shroyer, 2023). The second publication investigates the implementation of ungrading by two educators who teach in contexts that leverage project-based learning extensively (Coppola and Turns, 2024). These studies were foreshadowed in the scenarios at the beginning of this paper.

These scholarly publications were analyzed along dimensions related to scope, data, and knowledge:

1. Designing for x. What is the focus of the RtD effort? How is (or could) that focus be captured using a “designing for x” framing?
2. Documentation practices. What data is collected in the RtD effort and how?
3. Alignment with an annotated portfolio vision. What kind of knowledge is generated in the RtD effort? How close does the depiction of the knowledge come to Gaver’s idea of an annotated portfolio?

Results

The two studies demonstrate different but explicit approaches to Research through Design (RtD). Shroyer's work, a dissertation spanning four years, is organized around the question: "how might we design environments that support learning from seeing across individual design experiences." Her dissertation format provided ample space to explore ideas and include visual documentation, with **RtD explicitly framed** from page 7 as a series of research through design inquiries. Coppola and Turns present their work in a conference publication format, offering a retrospective account of implementing ungrading across four different classes within one discipline. Their work represents an effort to make sense of professional practice-based work that didn't originate as research. While grounded in scholarship around the broader concept of ungrading and building on Feldman's research, **they explicitly position their work within RtD** by stating, "We ask these questions as we do in order to situate our work as a research through design effort, specifically the approach advocated by Gaver (2012) in which a set of design solutions are interrogated to determine their invariances as well as their dimension of variation."

Scope/Designing for x. On a pragmatic level, the two publications have different (although potentially complementary) scopes -- addressing pedagogy and addressing grading. The two studies differ notably in their use of "designing for X" framing. Shroyer's work explicitly incorporates this approach in its title (i.e. “**Designing for** ‘Seeing Across Projects’ Based Learning”) and her framing of her methodology, which she described as, "The early Research Through Design (RtD) inquiries focused on co-research with students as a solution to the design research problem of **designing for** 'seeing across projects' based learning." In contrast, the publication by Coppola and Turns publication does not leverage this framing move. While their work could potentially have been framed as "**designing for** grading without power" or "**designing for** negotiated grading," such an explicit framing is absent. This absence raises interesting questions about its consequences - what is lost when a publication cannot easily be situated within a "designing for X" frame?

Data/Documentation practices. Shroyer's documentation approach over her four-year study was extensive and methodologically significant. She explicitly acknowledges that "The extent of documentation varied across the activities and sites of learning," noting that she selected activities that were "richly documented so that the analysis would be well-grounded." Her organization of documentation in Figma demonstrates a systematic approach, while the abundant visuals throughout the dissertation showcase the affordances of the dissertation format. The documentation process influenced her methodological choices, with clear allusions to selecting specific aspects of the work based on documentation availability, and she effectively leveraged student documentation. In contrast, Coppola's study took a different approach. To address a lack of initial documentation, the authors employed "semi-structured interviews" and "artifacts from their course implementations" to create a mechanism for the authors as designers to debrief each other. This creative solution to limited documentation represents a potential contribution to RtD methodology.

Knowledge/Annotated portfolio. Shroyer's analytical framework, explicitly addressed on page 22, is firmly grounded in the concept of annotated portfolios as units of analysis. Her approach is systematically organized, moving from depth-focused annotated portfolios to breadth-oriented ones, demonstrating a clear methodological progression. Coppola and Turns' work, while not explicitly framed as an annotated portfolio, embodies Gaver's ideals through its comparative analysis structure. Their publication develops a temporal framework that organizes eleven dimensions of variation across four phases: deciding to use ungrading, introducing ungrading to students, supporting ungrading, and determining grades. By presenting and comparing individual instances of ungrading implementation, their analysis effectively functions as an annotated portfolio, even if not explicitly labeled as such.

Discussion and Conclusion

This analysis of two engineering education RtD publications paves the way for a larger exploration of RtD's role in the field of engineering education research, by offering some initial insights. For example, the relationship between publication genre and RtD documentation emerges as a crucial consideration. Shroyer's dissertation format enabled extensive documentation and visual representation, while Coppola and Turns' conference publication required more concentrated presentation. This raises important questions about how publication venues might need to evolve to accommodate different types of RtD work.

The contrast between Shroyer's planned RtD approach and Coppola and Turns' retrospective application demonstrates RtD's versatility. While Shroyer explicitly embraced RtD during her design efforts, Coppola and Turns retrospectively applied RtD frameworks to understand existing practice. This suggests RtD's value not just for new design work but for making sense of established educational practices. Despite these different approaches, both studies culminated in frameworks - Shroyer's framework for configuring a seeing-across-projects experience and Coppola's temporal framework - showing a specific way that RtD can create knowledge of use in engineering education.

Finally, the presence or absence of explicit "designing for X" framing reveals its potential value for focusing RtD work. While Shroyer's explicit use clarified her focus, its absence in Coppola's work suggests opportunities for more intentional framing in future RtD efforts in engineering education.

Even this limited sample reveals how the approach can generate structured insights about educational design work while accommodating different scales of innovation. As we continue to examine additional examples of RtD in engineering education, these initial insights provide a foundation for understanding the approach's potential contributions.

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