

“Spend another day in our class talking about this research please”: Student insights from a research-based design thinking exercise

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Abstract: This paper explores how guided discovery can be used to connect insights from the ever-growing body of research on design processes with design teaching. This paper focuses on a specific instance of a guided discovery activity in which engineering students were invited to engage with selected timelines from a study of designer processes; guidance included prompts at two points in time. The goal was to see if the students could discover meaningful insights about the design process and what features of design processes contribute to quality solutions. The students in this study succeeded in discovering six meaningful insights about the design process. The distribution of students’ insights was not the same at the two time-points, suggesting that the guidance is important in what students discovered. Our findings speak to the value of the specific guided discovery activity that we studied, and the overall idea of developing activities using guided discovery.

Keywords: design pedagogy; guided discovery; design representations; design expertise

1. Introduction

An ever-growing body of research documents insights into features of design processes that contribute to successful design outcomes. In their synthesis paper “Engineering Design Thinking, Teaching, and Learning,” Dym and his colleagues (2005) have called attention to divergent-convergent questioning, thinking in systems terms, and decision making as important aspects of successful design processes. In another example, two of the authors and their colleagues have investigated how the amount of time spent gathering information and the frequency of transitions across design activities contribute to successful design processes (Atman et al., 1999; Atman et al, 2007). Still further, an examination of any issue



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in Design Studies inevitably uncovers additional research-based considerations about how features of the design process contribute to successful design outcomes.

This paper is concerned with how such findings can be leveraged to inform design teaching. One general pathway could be embedding the findings in the environment. For example, one approach would be to prescribe a design process that directs student designers' attention towards the very activities that have been shown to be important in the body of research on design thinking. An illustration of this could be a student designer being given a system that helps with effective questioning. A related approach would be to create resources, such as virtual agents, that could remind a designer when they are deviating from such desirable approaches in order to help the designer *get back on track*. With the current focus on problem-based learning and project work for teaching design, the *embed the findings in the environment* approach may seem familiar. For instance, much of the conversation around getting project based learning *right* involves navigating questions of how to structure an environment so students succeed.

In contrast, another pathway (explored in this paper) involves embedding the findings into the designer's mental model of the design process. In other words, in this pathway, the idea is to help the student designer understand research-based findings about design thinking so that the findings are later available when they engage in metacognitive-level efforts such as planning of design, reflection in action, and executive control. Such metacognitive-level effort relates to designers' abilities to "use design strategies effectively"—key performance dimensions identified in the extensive literature review by Crismond and Adams (2012, p.745). With this pathway, a general question is how to help the student designer come to understand and appreciate these findings. A straightforward strategy to achieve this objective would be to present research findings to students or ask them to read research articles. However, this strategy is not often reported to be successful.

In this paper, we explore an alternative method of embedding the findings into the designer through a form of guided discovery learning. Discovery learning is an inductive learning approach in which students receive a problem to solve with little or no guidance from the teacher. Guided discovery is a type of discovery learning in which the student receives a problem to solve but the instructor also provides focus, coaching, feedback, and other such guidance to direct the students (Mayer, 2004). Guided discovery attempts to remediate the challenges that have arisen through completely open discovery learning (see Alfieri et al., 2011; Bruner, 1961; Dean and Kuhn, 2007 Kirschner et al., 2006; and Mayer, 2004)

In this guided discovery activity, students interact with research-based visual representations of first-year (freshmen) and graduating (senior) student design processes to see if they can develop personal insights about design that are similar to findings discovered by the researchers. We provide a worked example for one of the conference themes, specifically using design research as an active force that allows design students to rethink their ideas about design.

Pragmatically, our approach does not require a changing of project structures as an *embed the finding in the environment approach* might. Since projects are hard to structure, it can be challenging to restructure the environment. Our approach provides student designers with the opportunity to directly explore research findings so that they can learn about important aspects of design processes; aspects that may come to positively influence their own future design activities. Given the potential benefit of such an educational activity, we set out to answer several questions:

- Will students discover any insights about design? What insights about design will they discover?
- How can we characterize the type of guidance provided to the students? What will be the effect of the guidance?
- What will be student’s reactions to their discoveries and to the experience of being asked to discover?

In this paper we explore these questions through the instantiation of, and experimentation with, a guided discovery activity. The paper represents an empirical proof-of-concept, showcasing what such an activity might look like and gathering evidence that demonstrates that such an activity successfully helps students learn about design.

The rest of the paper proceeds as follows. First we describe our specific instance of guided discovery of design processes. The contribution of the paper is a study of the guided discovery activity in action—the methods and findings occupy the bulk of the paper. In the conclusion we discuss the significance of the work.

2. The Research-Based Guided Discovery Activity

Research has demonstrated that engineers with different levels of experience (first-year students, graduating students, expert practitioners) exhibit different patterns of design activities when they solve a design problem (Atman et al., 2007). These differences are made visually apparent when they are displayed as timelines that indicate the time spent in different design activities and the number of transitions among design activities. Timelines from six engineering students, three first-year students and three graduating students form the basis of the guided discovery activity (see Figure 1).

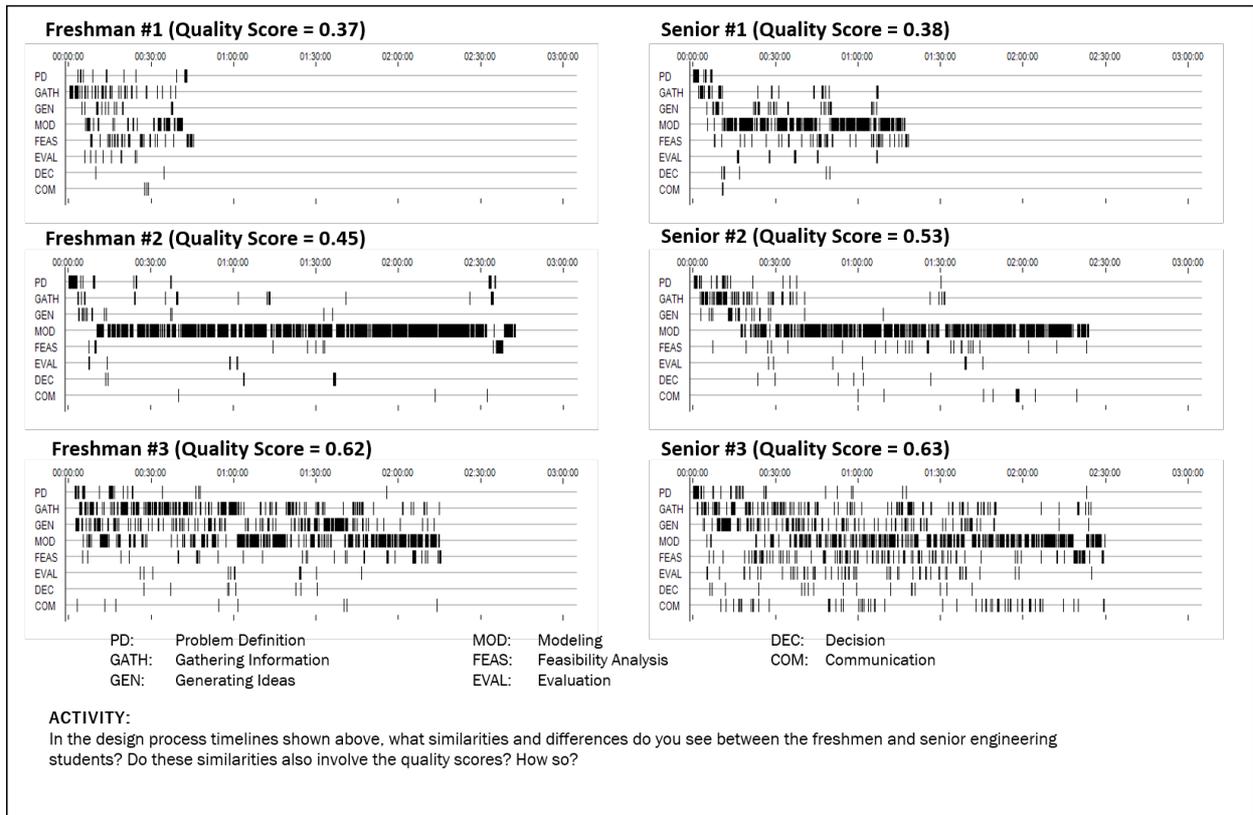


Figure 1 – Timeline activity handout. Timelines represent typical low-performing, average-performing, and high-performing freshman and senior engineering students.

The steps to the activity are as follows (total time is 50 to 60 minutes):

1. An educator gives a brief presentation about the development of the design process timelines used in the task (10 minutes).
2. Students are each given a worksheet (the timeline activity handout) with questions on both sides (Figure 2). Students are given five minutes to individually analyse the timelines and respond to Prompt 1 on the front of the sheet (Figure 1).
3. Students then discuss their responses with their project teams (10 minutes).
4. The educator then leads a discussion with the full class about student insights. Additional research findings are presented, including results from a sample of expert engineering practitioners, and the statistically significant results from the comparison across the three groups (20 to 25 minutes).
5. Students then turn the page over and take 5 to 10 minutes to respond to Prompts 2 and 3 (see Figure 2 for an example scan and transcribed answer from a student participant from the class discussed in this paper).

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Activity Worksheet Components

Front

Data
6 timelines

Prompt 1
freshman vs. senior and quality insights

Back

Prompt 2
Most important thing learned

Prompt 3
feedback

Student 22's Response

Prompt 1

ACTIVITY:
In the design process timelines shown above, what similarities and differences do you see between the freshmen and senior engineering students? Do these similarities also involve the quality scores? How so?

Senior 3 uses time modeling frequently checking in about feasibility, eval, and even making decisions + communicating earlier than others. Just more integrated in general. Lots of info gathering for both #3's, even towards end. Lots of idea generation toward beginning for #3's. #3's have feasibility towards end. Lots more eval in general for 3's. Senior 3 communicates well - important.

Prompt 2

REFLECTION ACTIVITY:
What was the most important thing that you learned today? Why?

Super valuable! Much more compelling to see real data, detail, makes me believe, instead of tuning out "prescribed" info, can't trust how they derived it b/c don't know. Spend another day in our class talking about this research, please!

Most important thing - don't get stuck in modeling (seems dull but striking) → stay big picture
- feasibility important
- continue gathering information, even towards end (would like more detail on what this info should be, when)
- evaluation → rethink

Prompt 3

How can we improve this talk for future audiences?

Hand out print of all the graphs, + publication based on research, or a link, so we can inspect more

Figure 2 – Activity worksheet and Student 22's Response

The Prompts are as follows:

Prompt 1: ACTIVITY: In the design process timelines shown above, what similarities and differences do you see between the freshmen and senior engineering students? Do these similarities also involve the quality scores? How so?

Prompt 2: REFLECTION ACTIVITY: What was the most important thing you learned today? Why?

Prompt 3: REFLECTION ACTIVITY: How can we improve this talk for future audiences?

In the case of this activity, guided discovery learning was implemented instead of pure discovery learning to increase the likelihood that students with limited design experience would be able to uncover insights in a short period of time. The amount of data, representation of data, and guiding questions were specifically scoped to direct students through the activity while still allowing for autonomy to discover trends. For example, instead of presenting students with a large amount of raw data, six specific design processes were visually represented in the form of timelines.

Rather than simply listening to a lecture or being provided with a generalized design process diagram, students were purposefully guided to inductively uncover trends from design process data. By exploring the timelines independently prior to responding to Prompt 1 and subsequently with their teammates, students develop relevant insights into design processes. Following this, the educator then facilitates a discussion with the full class and compares the student insights to research findings. Students' final perspectives on important lessons are then solicited with Prompts 2 and 3. In other instances where the authors have presented this exercise, audiences (students, educators and practitioners) have identified the statistically significant differences across the two student groups in the timelines just from this guided discovery task. Audience member observations are reinforced when they learn about the experimental results, increasing both confidence and excitement with their discovery.

Student 22's response, which is presented in Figure 2, demonstrates both the breadth and depth of insights that students can gain with this exercise.

3. Methods

3.1 Participants

Twenty-four mechanical engineering students in a third-year Introduction to Design course at a large research university participated in this classroom activity in the spring of 2015.

3.2 Code Book

The responses from the twenty-four students were analysed based on their written responses to Prompts 1 and 2. The responses to Prompt 3 were not included in this analysis (the purpose of Prompt 3 is to solicit input about teaching activity rather than student

learning about the design process). The responses to the first two prompts were coded for presence or absence of ten design insights in each response. These insights were based on nine codes used in a previous analysis of this activity (Borgford-Parnell, 2010). An additional code (Time) was added and several codes were clarified resulting in a final set of ten codes.

In our findings from this data set, only six of the ten codes were prevalent (Breadth, Problem Definition, Gathering Information, Modelling, Iteration, and Time). In this paper, we therefore focus on those six codes.

Code Book			
Name	Definition	Examples – Prompt 1	Examples – Prompt 2
Breadth	Breadth (accomplishing more of the design process) correlates with higher quality design	<i>“High quality scores were varied in the design process, with all steps prevalent throughout the timeline”</i> - 17	<i>“To produce a good design you must split your time more evenly between the different stages.”</i> - 11
Problem Definition	More time spent on problem definition activity correlates with higher quality design	<i>“Better scores returned to the problem definition throughout the process ...”</i> - 2	<i>“Always go back to the problem and ask yourself if you are really solving it.”</i> - 11
Gathering Information	More time spent on gathering information activity equates to higher quality design	<i>“Something that seemed to promote high quality work was to continue to keep gathering information and generating ideas throughout the whole process.”</i> - 12	<i>“Lastly it is important to continue to ask questions & gather information throughout the process.”</i> - 23
Modeling	Everyone spends the most time in modeling activity	<i>“Modeling took up the majority of the time for most people.”</i> - 3	<i>“... though even experts spend the most time / effort into modeling.”</i> - 16
Iteration	Iteration and/or transitions correlate with higher quality design	<i>“The high quality designs bounced around a lot ...”</i> - 19	<i>“The design process is most effective when undertaken as a nonlinear, cyclical process. The different activities or ‘phases’ of the design process should be integrated and revisited throughout designing.”</i> - 6
Time	Total time spent on the design process correlates to higher quality design	<i>“Students that spent less time have lower quality score.”</i> - 10	<i>“I [learned] that putting in enough time is valuable up to a certain point ...”</i> - 15

Figure 3 - Descriptions and examples of the six codes

3.3 Coding Process

The coding process was carried out by two trained researchers that independently assigned design insight codes at the sentence or sentence group levels for each of the 24 sets of student responses. Since we coded responses to two question prompts for each student, the actual number of responses that were analysed was 48. This coding process initially began using the a priori categories that were developed using a bottom-up approach in a previous study that is extended by this research (Borgford-Parnell, 2010). The researchers trained on a separate set of student responses. Once finished, the two researchers compared results, arbitrated any discrepancies on this training set to agreement. Minor refinements were made to two of the code definitions and a 10th code (Time) was added.

After training was complete, the researchers replicated this process on the forty-eight student responses used in this study. After this first iteration, the researchers leveraged their emerging insights to make minor refinements to four of these codes for the sake of specificity and inclusiveness. Additionally, the researchers noticed patterns of differences in the level of students' engagement and insights being demonstrated within the texts. Opportunistically, the researchers began looking for those patterns and annotating for statements that seemed to go beyond the acquisition of design insights. Statements in this category had to indicate that the student was now more curious about design or was somehow related to their self-identity as a designer. The researchers reported 22 agreements out of 24 judgements for this BDI code (Beyond Design Insights) and consequently, we have chosen to include it as part of our discussion due to some of the insights it surfaced.

Upon completing their analysis, the researchers compared results and arbitrated discrepancies to agreement. Two judgements (out of 480) required external adjudication through a majority vote by a third researcher. For the 6 most prominent insights discussed in this paper (a total of 288 judgements) 26 were briefly discussed, 10 warranted further discussion or clarification, and 1 required adjudication by a third researcher. Prior to this arbitration, the initial inter-rater reliability for these six codes was also computed using Cohen's Kappa (1968) and found to be 0.78, 0.59, 0.88, 0.85, 0.83 and 0.86 respectively.

4. Findings

Despite the relatively short nature of the design timeline exercise, it provoked a variety of student reactions—many of which were characterized by building a stronger appreciation for considering a fuller range of design activities. In what follows, we first describe the high level results of our analysis, including attention to how student reactions shifted between the two prompts. We then describe the insights that students take away from the exercise.

Figure 4 shows the distribution of the 89 design insights that researchers observed across the 48 student responses throughout the activity by category.

Figure 5 provides additional detail on these results by showing the number of students reporting each insight for Prompt 1 (the light bars) and Prompt 2 (the dark bars). Recall that Prompt 1 captures the students' initial insights while Prompt 2 is designed to capture final takeaways after a presentation of research findings and a group discussion. All but five of the students added at least one new idea to the insights they included in their response to Prompt 2. As the figure shows, some insights such as Breadth and Gathering Information were mentioned with similar frequency in response to Prompt 1 and Prompt 2. Other insights, such as Iteration, Problem Definition, Modelling, and Time were differentially prominent.

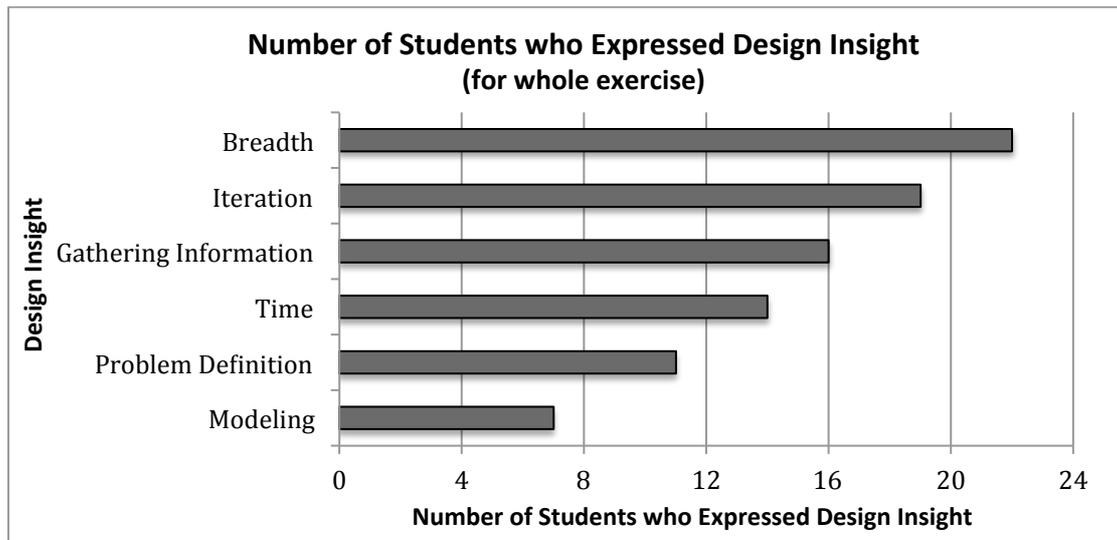


Figure 4 - The total number of student insights by category

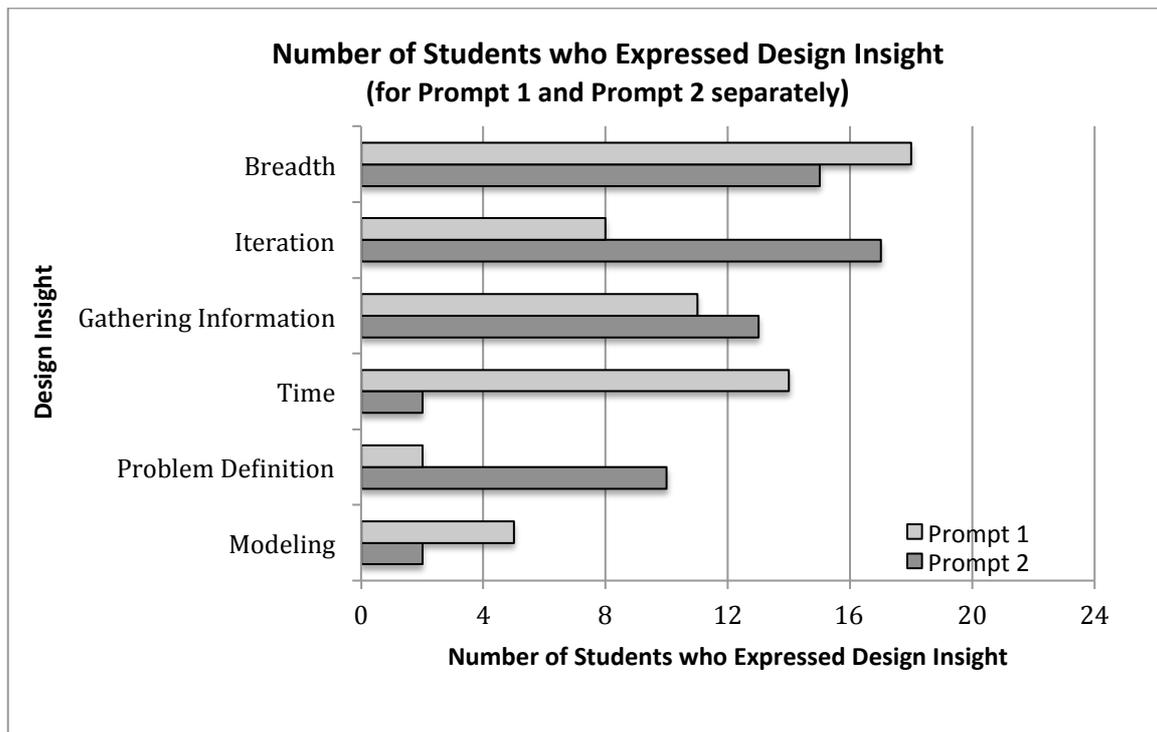


Figure 5 - The number of student insights by category and prompt

Below, we provide a description of the student responses that comprise the six coded categories. We also present our findings for the BDI (Beyond Design Insights) code in this section. The student quotes that we highlight in this section have been selected for being representative, interesting and for their illustrative power.

4.1 Student Insight: Time matters (Time)

One of the initial insights reported by fourteen of the students after examining the design timelines revolved around equating overall time spent with good quality design. This was generally expressed in a fairly succinct manner by students with statements such as *“the more time you spend, the more likely you can get a good score”* and *“students that spent less time have a lower quality score”* (students 4 & 20). Interestingly, whilst fourteen students considered this a notable observation to share initially, only two of them chose to discuss it as a point of learning later on in response to Prompt 2. This would seem to indicate that many of these students didn’t consider what they could make of this observation to be a takeaway important enough for them to include as their response to Prompt 2.

Three of the students also further qualified their observations by noting how time spent stops being a factor past a certain point. For instance, student 15 wrote how he *“learned that putting in enough time is valuable up to a certain point but then a more iterative design process becomes helpful”*. These nuances effectively foreshadow the other themes which the students wrote about regarding *how* time should be spent in design while still paying homage to the idea that a certain amount of time expenditure is inevitable if quality is desired.

4.2 Student Insight: Time spent gathering information raises quality (Gathering Information)

Within the theme of how time should be spent, two thirds of the students wrote about how designers with *“good scores gathered info throughout the process”*. The relatively even split of responses (eleven in Prompt 1 and only an additional two in Prompt 2) suggests that students came to this point by themselves and were attentive to its significance.

One minor distinction that we could see in the student responses came from how the majority of them saw high scorers and experts gathering information continuously throughout the design process while others perceived that the information gathered in an earlier phase carried more weight. So while three students wrote that they learned *“to wait until more information is gathered...to start modeling ideas”* (student 8), others wrote of having learned that there is no endpoint to the information gathering phase. For example, student 5 wrote that they learned to *“continue gathering information, even towards [the] end”*, while student 7 expressed that she would *“try my hardest to avoid modeling too early, and also when I start modeling to ‘come up for air,’ so to speak and take a look at the information given and maybe the information not given”*.

4.3 Student Insight: Keep revisiting the problem (Problem Definition)

Interestingly, while information gathering and problem definition frequently go hand in hand as design activities, the relationship between design quality and problem definition activities was touched upon by comparatively fewer students. Only two students brought up the problem definition activity as a factor in design quality scores in response to Prompt 1, while another nine did so after discussion in Prompt 2. This sharp difference would indicate that

observation alone was not enough for students to make a link between problem scoping and final design quality and that discussions brought the students to surface certain kinds of insights. This was further reinforced by the relatively uniform tone of student responses which generally expressed this theme in terms of revisiting problem definition: *“It is easy to get caught up in modeling but if you don't go back to the problem, you will most likely fail to make a good design”* (student 4). This lack of variation suggests that the class discussion possibly helped shape the student responses at the language level.

4.4 Student Insight: Everybody spends the most time modelling the solution (Modelling)

Significantly, many student responses seemed to recognize that modelling—the activity which consumed the most design time—was negatively correlated with quality. For instance, student 16 offered a conclusion that *“the most important thing I learned today was that when you design a product, an idea, or anything, you have to try to not only focus on modeling”*. Seven of the students were particularly attentive to how the timelines showed modelling as the most time intensive activity for most designers in the sample. For example, students 16 and 3 respectively noted that *“even experts spend the most time/effort into modeling”* and *“modeling took up the majority of the time for most people”*. This observation—that nobody gets away with not doing a significant amount of solution modelling during design—can potentially help students demystify and better identify with the work processes of more experienced designers.

4.5 Student Insight: Breadth is the key (Breadth)

Although students linked several design process activities to design quality, the most prolific insight emerged from 22 of the 24 students linking high scores with a holistic design process in terms of activities. In effect, students were noting how the more an activity such as modelling appeared as a continuous block on the timelines, the less time was then available for other important activities. The equal split and overlap of students who chose to cover this theme in their initial observations versus their chief takeaways would indicate that this insight was both readily apparent and very important to the students.

The rich diversity of expression used around this code is another interesting feature that warrants elaboration. For instance, some students like student 12 wrote about not *‘getting stuck’* on *‘one idea’* or phase while reflecting upon their own design process: *“[I learned] that spending time on all aspects of design is critical for a quality product...This is so important to me because it is easy to get excited about a certain idea and forget what the main thing was about.”* Other students offered their conclusions through ideas regarding even distribution, revisiting, balance, and integration with respect to design activities. It is difficult to firmly conclude whether this wider variety of phrases indicates a deeper or more genuine level of engagement, but nevertheless we found this combination of frequency and diversity to be telling.

4.6 Student Insight: Iteration and transition (Iteration)

The second most systematically prevalent set of insights arose from nineteen of the students writing about how good design processes are iterative in nature. Students expressed this concept in a variety of ways. Some responses, like student 17's referred to cycling or repetition: *"There seems to be a clear correlation between the quality of the design and the ability of the designer to keep cycling through all steps of the process"*. Other responses used terms such as *'jumping back and forth'* (student 4), *'going circular'* (student 21), being *'nonlinear'* (student 19), etc.

Many students also explicitly called out the patterns they observed in high quality scores as iterative. For instance, student 3 referred to iteration directly in the context of reflecting upon his own design process: *"Also seeing the iterative steps that were made will make me feel better about stepping back and looking everything over"*. Since only eight responses contained this code in Prompt 1 versus seventeen in Prompt 2, it seems that although this was a valuable takeaway for many students, it was not initially apparent. That some amount of time or discussion was probably helpful to surfacing this insight could be explained by the fact that the iteration pattern could only be observed after absorbing all six timelines and stepping back for synthesis.

4.7 Beyond Design Insights (BDI)

Apart from the above insights, more than a third (10 out of 24) of the student responses contained elements that extended beyond learning about design processes. In many ways, these were the statements that the students wrote which did not directly address the prompts they were given, but pointed to reactions that we consider to be significant. Unsurprisingly, most occurrences of this BDI code showed up in the second response that was solicited followed a class discussion that featured research findings, further supporting our findings concerning the value of guided discovery. In this prompt, the students were asked to engage in a reflective activity where they selected the most important thing they learned in the exercise. However, there were a number of instances even during the Prompt 1 responses where some students moved past the data observation prompt and placed themselves in the situation of the designers in the exercise or attempted to give advice on what not to do. For instance, student 13's response ended with *"for me I would spend more time with [the] decision [activity] than the others did"*.

One of the most frequently expressed BDI takeaways at an overall level was an appreciation for *'show don't tell'*, which tied into several other themes. For instance, the quote for the title of this paper shows this participant expressing this appreciation while tying it into what we interpret as a kind of preparation for future learning: *"Super valuable! Much more compelling to see real data, detail, makes me believe, instead of tuning out 'prescribed' info, can't trust how they derived it b/c don't know. Spend another day in our class talking about this research please!"* (student 22). Elsewhere, student responses alluded to how stepping outside of these processes and reflecting upon them might affect their confidence or future

decision making. For example, student 3 wrote of having learned “*how other people spend their time in design. I didn't have any idea how others did it. Seeing what parts were the most important for the quality score will definitely shape the way I design in the future*”, while student 10 noted, “*I now realize that spending time at this process will pay off*”.

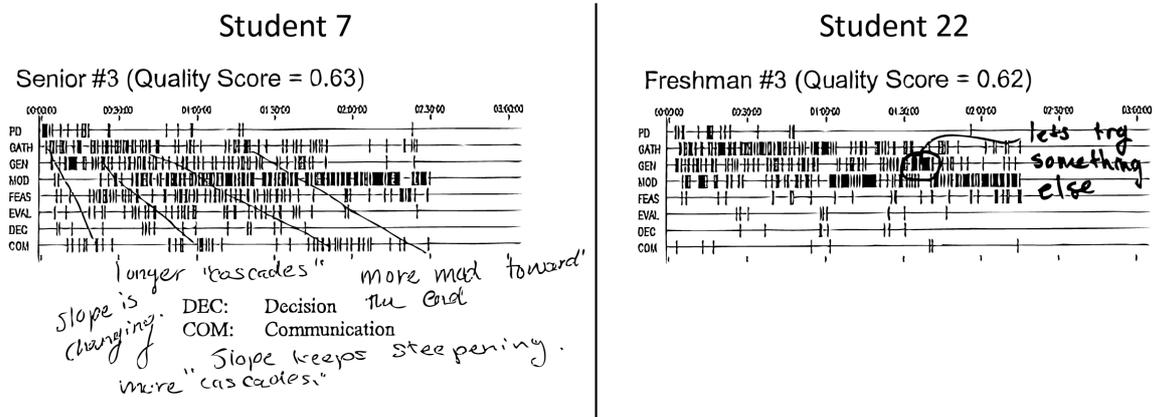


Figure 6 – Partial scans of student 7 and 22’s written annotations upon the design timeline handouts

Reviewing student responses from this broader perspective also helped us notice how students were making meaning of the timelines outside of the prescribed spaces and prompts that they were given. Some clear instances of this came from three of the students annotating and sketching directly on their copies of the design timelines to discover additional insights. For instance, in the image scans above (Figure 6), we can see student 7 attempting to map design to a shape by considering the geometric gradient or slope of senior 3’s design process. Likewise, student 22 attempts to project certain patterns within the timelines onto design behaviours such as pivoting. These more visual attempts at discovery can help us appreciate the different modalities and behaviours students were engaging in to arrive at their discoveries.

5. Discussion

The students in this study succeeded in discovering six meaningful insights about the design process, as described in the findings section. The students’ ability to arrive at such insights confirms that guided discovery was possible and corroborates previous work (Borgford-Parnell, 2010). As alluded to in the introduction, we believe that students discovering and articulating their insights will be helpful for them in future design activities. Specifically, being able to recognize effective strategies means that there is potential for them to monitor and adjust their own design activity with increased confidence. For example, seen from a high level perspective, the students’ insights focus on the significance of spending time and how that time is spent. Implementing that insight may position students to monitor how they are spending time, recognise when they are not spending time effectively (e.g., spending a great amount of time in modelling), and make executive level decisions

about how to spend time going forward (e.g., deciding to revisit the problem definition or gather more information).

The distribution of students' insights was not the same for the two prompts. Prompt 1 guided students to articulate their observations, and Prompt 2 guided them to reflect and articulate what was most important to them. Examining the findings, we can see that there were three patterns of change: (a) an insight being prevalent for Prompt 1 and not prevalent at Prompt 2 (e.g., Time), (b) an insight not being prevalent for Prompt 1 and being prevalent for Prompt 2 (e.g., Iteration and Problem Definition), and (c) a balanced pattern in which an insight was equally prevalent for both prompts (e.g., Breadth and Gathering Information). Surfacing these patterns of change helps us better understand the guided discovery process over time in terms of what was easy for individual students to discover early on versus what they could discover with discussions with peers and the educator. Additionally, we better understand what discoveries students recognize early on but later replace by more interesting insights, as compared to students early discoveries that continue to retain their importance. This way of framing different types of guidance can help with the design of future guided discovery activities, and also raises questions about how different prompts might facilitate different discoveries.

As the descriptions of the student comments that made up the content of the code categories indicate, there was an indication that for some students, their insights were somewhat personal in nature (for example, insights related to identity, to imagined future design activities, and to a sense of personal relevance). This is interesting because such personal positive reaction may increase the likelihood that these insights are not ephemeral, but rather, become the principles that students later use to ground their own design processes. Interestingly, the prompt of "the most important thing you learned" does not necessarily facilitate such personal reactions—learning for students can often be associated with the type of knowledge that is tested by tests and explained in textbooks. Given that the prompt did not ask students to provide insight into their personal reactions, the observation that one-third of the responses featured such a personal dimension might actually be an underestimation of the personal reactions being felt by the students in this project. This leads us to wonder what we might have observed if the prompts had been different. For instance we might have surfaced even more personal insights with prompts such as "What would you do differently if you were in a future design situation?" or "Do you think of yourself as a designer?" or "Did today's activities influence your thoughts about yourself as a designer?"

6. Limitations and Future Research

One limitation of the study is that our understanding of what the students discovered is mediated entirely through what they wrote on the sheet of paper they were given. Seeing that some students actually made annotations directly on the timelines themselves suggests that we also need to consider other artefacts and ways that students might have been

engaging with the timelines. One possible means of capturing some of these additional interactions would be to video-record the instructional event. This would make it possible to discern any unscripted questions and interactions that took place between the students and the educator. Additional attention to those interactions could help in scripting the guidance process so that it is done in a more explainable and repeatable manner. Finally, given the time-constrained nature of the activity, it was not possible to follow the students into an actual design activity and see if their new insights helped them be successful. Future research can explore whether the student insights from the shorter exercise described in this paper will be helpful for students over a longer term.

7. Conclusion

In this paper, we document what we learned about using guided discovery to help student designers develop insights about design processes that are based on data and findings from prior research. This paper contributes to the evidence-base for the specific guided discovery activity that is laid out here. Our findings lead us to believe that design educators who try to repeat the activity with their students may discover that additional affordances occur when there is shared vocabulary and shared reference for ideas such as problem solving and design process over time. This activity represents one example of creating an activity where students interact with real data and have the opportunity to discover patterns that they may later leverage in their own design work. Seen as an example, this can help other educators create similar guided discovery activities and suggest future research directions into the use of guided discovery.

Acknowledgements: We would like to gratefully acknowledge Terri Lovins for her assistance on this paper and the students who participated in this study. This work was supported by the National Science Foundation (grants RED-9358516 and ROLE-0125547), the Boeing Company, the Center for Engineering Learning & Teaching at the University of Washington, the Mitchell T. and Lella Blanche Bowie Endowment, and The Leona M. and Harry B. Helmsley Charitable Trust.

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