# Assessment of a Novel Learning Block Model for Engineering Design Skill Development: A Case Example for Engineering Design Interviewing

**Maria R. Young, University of Michigan**

Maria Young is an assistant director of the Center for Socially Engaged Design at the University of Michigan (UM). She is also program manager of the UM Global Health Design Initiative. Maria holds a B.S.E. in biomedical engineering from the University of Michigan (2014) and an M.S. in human nutrition from Columbia University (2015). Maria has experience applying qualitative research methods to understand a community's cultural context and design needs. She also has substantial experience using design ethnography and building sustainable partnerships within intercultural settings. Maria has led the development of the Socially Engaged Design Academy at UM, aiming to provide students with an on-demand training program to hone skills imperative to designing appropriate technologies for every context.

**Dr. Shanna R. Daly, University of Michigan**

Shanna Daly is an Assistant Professor in Mechanical Engineering at the University of Michigan. She has a B.E. in Chemical Engineering from the University of Dayton (2003) and a Ph.D. in Engineering Education from Purdue University (2008). Her research focuses on strategies for design innovations through divergent and convergent thinking as well as through deep needs and community assessments using design ethnography, and translating those strategies to design tools and education. She teaches design and entrepreneurship courses at the undergraduate and graduate levels, focusing on front-end design processes.

**Dr. Sara Lynn Hoffman, University of Michigan**
**Prof. Kathleen H. Sienko, University of Michigan**

Kathleen H. Sienko is an Arthur F. Thurnau Professor, Miller Faculty Scholar, and Associate Professor in the Departments of Mechanical and Biomedical Engineering at the University of Michigan. She earned her Ph.D. in Medical Engineering and Bioastronautics from the Harvard-Massachusetts Institute of Technology (MIT) Division of Health Science and Technology, and holds an S.M. in Aeronautics & Astronautics from MIT and a B.S. in Materials Engineering from the University of Kentucky. She co-directs the UM Center for Socially Engaged Design and directs the Sensory Augmentation and Rehabilitation Laboratory, Laboratory for Innovation in Global Health Technology, and Global Health Design Initiative.

**Madeline A. Gilleran, University of Michigan**

Madeline Gilleran is an senior undergraduate student at the University of Michigan, majoring in Mechanical Engineering and completing International Minor for Engineers. She is involved in the Engineering Global Leadership Honors Program, a specialization within the Honors Program that integrates coursework from the Ross School of Business. She plans to complete her bachelor's degree in December 2017 and will likely complete the sequential undergraduate study program, completing a masters in mechanical engineering in December 2018. Her research interests include engineering education as well as sustainable energy and transportation systems.

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## Introduction

Human-, user-, and context-centered design processes require in-depth knowledge of stakeholders, end users, and broader contextual constraints, respectively[1]–[3]. Non-traditional engineering methods, including qualitative research methods such as interviewing and observing, are important methods frequently used by design practitioners to generate data throughout the design process; this is particularly true during the front-end phases of design, and former studies have shown that the success of new products depends upon how well the front-end design phases are executed. These non-traditional engineering skills cannot typically be mastered through standard undergraduate engineering curricula. Although recognized as core to human-, user-, and context-centered design processes, engineering students often gain surface-level theoretical exposure to these topics and don't have access to educational resources that provide detailed information about best practices or faculty mentors with in-depth expertise on these topics [4]. Further, because students frequently engage in design activities outside of the classroom and at different points in their academic careers, novice design practitioners would benefit from on-demand access to training materials and hands-on learning opportunities coupled with real-time feedback regarding performance to practice these challenging skills.

We have designed, implemented, and researched a learning block model that combines an online learning platform with face-to-face practice and real-time evaluation. Each learning block consists of five distinct components. First, students complete a 'Prior Knowledge Review' where they answer questions to assess their current skill level and motivations. Next, students are presented with "Core Content," a collection of resources from multiple disciplines. The third step is a "Knowledge Check" of close-ended and open-ended questions with feedback given from a remote grader. In the fourth step, students are presented with an "Application" task, in which they are prompted to take the knowledge they have learned and apply it to a given design challenge. Students must meet with a coach to present their "Application" task outcomes and receive real-time feedback. Finally, the "Reflection" serves as the final part of the block when students ruminate on what they have learned and consider how they will apply their newly honed skill in the future.

In an initial study of this learning block model, we evaluated the effectiveness of two learning blocks focused on design interviewing, the most commonly used interaction method that enables engineering designers to deeply understand users' and stakeholders' experiences and needs, and is foundational for accurately defining the design problem and developing engineering specifications. Using interviewing as a test case to assess the learning block model, this paper outlines preliminary findings in two areas: (1) types of learning gains following completion of the learning blocks and persisting gaps in student knowledge and (2) student perceptions of the learning block model itself.

## Background

### *Human-, user-, and context-centered design processes*

Numerous design methodologies emphasizing engagement with end users and more broadly, stakeholders have been developed to discover and explicitly address the specific needs and wants of end users and stakeholders [1]. Context-centered design processes extend beyond the immediate end users and stakeholders and more broadly stress the roles of social, cultural, economic, and environmental factors in the process of creating new products, technology, and systems. These design processes have been shown to promote the development of more innovative and relevant ideas, and increase the likelihood that a given design can be successfully implemented and that its production can ultimately be sustained. Several studies have outlined the importance of incorporating these broader contexts into design decision making to ensure sustainable and appropriate technologies [3], [5]–[8]. For example, Nest, a thermostat design company acquired by Google for $3.2 billion in 2014, traces its success back to its research into both consumers' patterns of thermostat use and their broader interest in energy conservation [9].

While the ability to gather contextual data and factor it into design decision-making is at the heart of design thinking's iterative approach, this process requires proficiency in a number of non-traditional engineering skills, including conducting observations, performing interviews, and eliciting design drivers from a diverse set of stakeholders. Competence in these areas can offer a significant advantage during front-end design. Although this design stage is, by its very nature, characterized by uncertainty and evolving ideas, mistakes related to product requirements can have high costs in terms of both time and capital, and such errors may ultimately lead to the failure of products that don't meet real needs of their intended users ([10].

The importance of these non-traditional engineering skills can be illustrated by failures in the design of the Segway[11] and medical devices in low-and-middle-income countries [12]. In the case of the Segway, designers conducted tests in multiple settings but did not focus on meeting the actual needs of any specific group of stakeholders. As a result, the product never gained real traction in the marketplace. In the case of healthcare in low-and-middle-income countries, designers have focused primarily on simple adaptations of medical devices already widely used in high-income countries. Such adaptations, however, frequently have had limited effectiveness and adoption because, despite their technological merits, their designs did not take into account the specific needs and resources of health care systems in low-and-middle-income countries [12].

### *Gaps in Education Resources*

Despite a clear need for these non-traditional engineering methods, these methods are not commonly taught in undergraduate engineering programs [4], [13]. This leads to novice engineering designers not possessing a robust skillset of non-traditional engineering design skills, which is imperative to design technologies that address specific needs within unfamiliar contexts [5]–[8]. Engineers are left to gain competency in these skills 'on the job' and oftentimes do not engage fully in the front-end design of products. If they do engage, difficulties arise when engineers must conduct interviews, lead focus groups, perform observations, and utilize other qualitative research methods that involve interaction with diverse groups and individuals. Recent studies have shown that

engineering students struggle to identify and incorporate social factors at multiple stages in the design process, including eliciting product requirements and translating them into engineering specifications [14], [15]. By incorporating systematic educational models into curriculum, engineering designers would more efficiently enter the workforce ready to tackle design problems from the broadest contexts. It is important to note, that it is important for students to not only be aware of these socially engaged design techniques, but also to have hands-on meaningful practice to improve their competency.

This gap in engineering education can be traced back to several related factors. First, engineering faculty members face both knowledge and time constraints. In many cases, they lack the social science training to teach these skills; however, even individuals with adequate background are often not able to effectively cover this additional material alongside traditional engineering content in their courses. Second, administrative processes at universities make adding new courses and/or updating current offerings to incorporate socially engaged design content a long, difficult process that requires significant investment from faculty members. Third, non-traditional engineering skills may not fit sequentially into engineering curricula. Students are typically most motivated to acquire these skills when confronted with the challenges of specific design projects, which they may encounter through both traditional coursework and co-curricular opportunities. Because of these factors, educational programs related to socially engaged design need not only to be accessible to faculty for incorporation into their existing courses, but also accessible for students seeking supplemental training for projects outside the classroom.

*Importance of Interviewing in Engineering Design*

Stakeholder interviews represent a key opportunity to bridge the gap between designers and users, in order to robustly understand the contexts that will impact technology design implementation. Several studies have shown evident that interviewing is a key ethnographic technique designers may adopt to bridge the divide between themselves and the potential users of their designs [16]. Skillfull interviewing is especially important because face-to-face time with stakholders is often limited, making it necessary for designers to captilize and retrieve as much quality information as possible. Thoughtful preparation before conducting an interview allows a designer to benefit most from the interview. The quality of information elicitied is largely determined by the questions asked alongside the actions of the interviewee. Utilizing an interview guide (or “protocol”) and subsequently performing observations while interviewing are two strategies that lead to an increase in the quality of information [17]. Effective interviewing is not an inherent ability, but instead a skill that must be learned and honed through practice.

A previous study identified a series of best practices that can be used to assess interview quality with regard to elicitation of user requirements and specifications in an engineering design context. Practices exhibited in high-quality design interviews include (1) encouraging deep thinking, (2) developing rapport with interviewees, (3) avoiding misinterpretations, (4) being flexible and opportunistic, (5) verifying the conclusions drawn from interviews, (6) defining goals at the outset of interviews and allowing interviewees to conclude with their own questions and insights, (7) using projective questions, (8) using co-creative strategies, (9) introducing domain knowledge, (10) having interviewees teach the designer, (11) exploring contradictions in stakeholder requirements, and (12) asking interviewees to break expert tasks in their component steps.

*Socially Engaged Design Academy Learning Block Model*

The Socially Engaged Design Academy (SEDA) was created to meet the challenges of incorporating non-traditional skills into traditional engineering curricula. We designed, developed, and researched a "learning block model" in which each "block" focuses on the development of a specific socially engaged design skill. Blocks cover skills including crafting design interview protocols, conducting design interviews, performing observations, eliciting user requirements and engineering specifications, and performing a life cycle assessment. The learning blocks support and supplement the classroom teaching of engineering faculty without requiring major changes to the core curriculum. At the same, they offer engineering students the flexibility to engage with the material at whatever point it best serves their needs, while also incorporating personalized feedback to help students absorb the content and refine their knowledge of these topics.

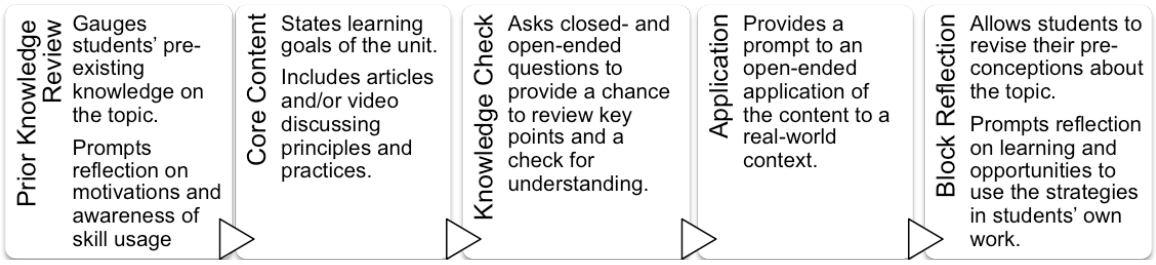


Figure 1. Socially Engaged Design Academy (SEDA) Learning Block Model

The learning block model integrates asynchronous online learning and face-to-face interactions and was developed by incorporating best practices in educational research. Upon creating a SEDA account, students are able to track and monitor their progress throughout the stages of completing individual learning blocks. Each block consists of five components: (1) The "Prior Knowledge Review" asks students to reflect on their preconceptions and their motivations for learning about the topic. (2) The "Core Content" outlines the learning goals for the block, supplies readings and videos from multiple disciplines to guide students through key aspects of the topic, and introduce real-life examples. (3) A "Knowledge Check" uses a combination of closed-ended and open-ended questions to evaluate students' grasp of the material. Remote feedback is given through the online platform by trained graders. (4) The "Application" requires students to apply the concepts introduced in the block to a real-life design scenario, and students are given personalized feedback to revise their initial responses. Students meet in person with a coach to practice and have their skills evaluated. (5) A "Reflection" allows students to think critically not only on how their pre-existing ideas about the topic have been challenged or expanded by the material in the block, but also to consider future applications of this material in their own work.

Methods

*Study Design*

To pilot the use of the SEDA learning block model and perform a preliminary evaluation of its effectiveness in teaching design interview techniques to novice interviewers, participants were recruited for a pilot study that incorporated the use of two separate learning blocks: "Crafting Design Interview Protocols" and "Conducting Design Interviews." The aim of the pilot study was to investigate student perceptions of the SEDA learning block

model, assess student skill improvement in interviewing, and ultimately gain feedback to inform learning block content and interface iterations. Each participant was asked to complete a pre-block and post-block interview task in which they prepared an interview protocol and conducted an interview with a proxy stakeholder. After completion of the post-block task, participants were interviewed by a study team member. During this follow-up interview, participants were asked about their experience progressing through the learning blocks as well as their opinions on the learning block model overall. The interview also included questions specific to learning gains and future application of newly developed stakeholder interviewing skills.

*Study Participants*

Participants were recruited through targeted emails to undergraduate and graduate engineering students. Qualifications included being enrolled as a current student majoring in an engineering discipline and reporting to have "No experience" or "Little Experience" in user interviewing. Seven total participants were recruited. Five participants were female, and two participants were male. Two participants were graduate students, and five participants were undergraduate students. Several engineering disciplines were represented, including two mechanical engineering majors, two biomedical engineering majors, one materials science and engineering major, one industrial and operations engineering major, and one civil and environmental engineering major. Five participants reported having "a little experience" with user interviewing, while two reported having "no experience" with user interviewing. Three participants listed one or two examples of significant extracurricular design experience, and five did not list any. Six out of the seven participants reported that they were involved in an extracurricular engineering design student group. Learning block submissions from five additional students who had completed the two specified learning blocks outside of the pilot study were compiled with the submission from pilot study participants to include a total of twelve participants when analyzing block submissions.

The study protocol was approved by the University's Institutional Review Board. Voluntary participants provided written informed consent and were compensated 100 USD for approximately 12 hours of their time.

*Pre- and Post- Learning Block Interviewing Task*

Each participant completed one pre-block and one post-block interview task. During each of these tasks, participants were given one of four prompts containing a design problem description and vague preliminary constraints. The four prompts differed in focus area (portable hygiene device, food delivery container, martial arts equipment, and home organization system) but were consistent in quality and the level of detail in the information provided. Participants were given twenty minutes to develop an interview protocol using no outside information and were then directed into a private room where a study team member served as a proxy stakeholder, where they were given twenty minutes to conduct an interview. Four different study team members were utilized, each serving as a stakeholder for a separate task. Prompts and stakeholders were randomized so that each stakeholder was used an equal number of times in pre- and post-block interview tasks and stakeholder pairings remained consistent across all participants. An example of one of the task prompts is included below.

*Example Task Prompt*

TASK: Fruit Fairies

Introduction:

Imagine you are on a design team and after performing research and holding informational meetings with your client you develop the need statement below. You want to gather additional information to better understand the need, so that you can refine the design problem, develop design requirements and constraints, and eventually generate preliminary ideas.

Preliminary need statement:

Fruit Fairies needs a container design to transport food to subscribers of their business on a weekly basis.

Background:

Fruit Fairies is a new startup company that allows students to subscribe to have healthy foods delivered to their doorsteps once a week. Customers use the website to create a "basket" with their favorite fruits, vegetables, and other healthy snacks. The basket is then delivered every Sunday afternoon.

The Fruit Fairies team is unsure about what the optimal packaging for the deliveries should be. Cardboard boxes, paper/plastic bags, and foam containers are some of the possibilities they've tried. The container needs to be large and durable enough to carry the food items along with two frozen water bottles that keep the produce cold.

You've been hired as a consultant to further investigate the problem, evaluate and prioritize needs, and then generate suggestions for the design. You have the opportunity to interview Densu, co-founder of Fruit Fairies.

Instructions:

Use the given papers to draft an interview protocol to prepare for your interview with Densu. Your job is not to design a solution right now, but to understand the problem in depth as well as the requirements and constraints of the design context. You have 20 minutes to prepare a design interview protocol with questions, then you will be able to set up your interview space. Afterwards, you will have 20 minutes to interview Densu.

*Data Collection and Analysis*

Several data sources were analyzed following completion of the study. The learning block model provides our team with useful data points for each user as responses to the "Prior Knowledge Review", "Knowledge Check," "Application", and "Reflection" are automatically archived. We cross-compared participant responses to the "Prior Knowledge Review" and "Reflection" submission. Through these responses, we aimed to understand what effect the completion of a learning block has on participants' understanding of specific skills and their competency level. Additionally, participants' responses to the 'Knowledge Check" portion were examined in comparison to their "Application" task to understand the difference between a student's ability to respond correctly to a quiz question on a certain topic and their ability to apply that knowledge to a given task.

Pre-and post-block interview tasks and follow-up interviews were audio recorded. Pre- and post-block interview tasks were also video recorded. Audio recordings were transcribed and analyzed by study team members. The pre- and post- block interviewing task transcripts were analyzed using a coding system of best practices for high-quality interviews identified in a previous study. The follow-up interview transcripts were analyzed using an iterative inductive coding methodology. Study team members identified key themes across interviews of all

participants and cross-compared until no additional themes emerged. Learning block submissions including "Prior Knowledge Review", "Knowledge Check", and "Reflection" were exported and organized so that key themes and clusters of meaning could be identified for each participant and as a group.

## Findings

### *Knowledge Check Submissions*

Key themes identified from the "Knowledge Check" component of the "Conducting Design Interviews" block included users' understanding of the importance of maintaining neutrality and setting up comfortable interview settings in advance. The "Knowledge Check" included a scenario in which a stakeholder was expressing opinions that they, as the interviewer, disagreed with. Participants identified several strategies, including "asking neutral questions" and "maintaining positive body language," as possible techniques to utilize in conversations with an interviewee whose views vary greatly from their own. Responses all focused on maintaining neutrality to receive quality information, with one example submission stating, "Regardless of your feelings, you must find out as many details as to why that person feels differently than you do. Ask neutral questions that allows the interviewee to keep control over their emotional response to each question."

When asked how they would prepare for an interview, participants took into account several factors, including interviewees' schedules and convenience, interview location and setting, and consultation of previous research on the interview subject. One participant stated, "I can prepare for [an interview] by doing research on lightweight sustainable cars and preparing an appropriate interview protocol. I could offer to meet [the interviewee] somewhere and sometime that is convenient for [him or her] or offer to conduct a Skype interview. If I'm meeting [the interviewee] somewhere [he or she] decides, I could let [him or her] know that somewhere quiet, private, and comfortable is important."

Furthermore, participants were able to adequately process the information given to them in the "Core Content" sections and apply their new knowledge to basic skill-building assessment questions for both the "Crafting Design Interview Protocols" and the "Conducting Design Interviews" learning blocks.

Learning gains for the "Crafting Design Interview Protocols" block centered on students' understanding of more and less effective ways to frame design interview questions. One of the key issues addressed in "Core Content" component of the block was the difference between closed-ended and open-ended questions, with an emphasis on the ways that open-ended questions can lead to longer and higher quality responses from stakeholders. After encountering this material, all participants were able to successfully convert a series of closed-ended questions to open-ended questions in the "Knowledge Check". We also saw evidence of participants' ability to apply this knowledge in the interview protocols they created for the pilot study tasks. For example, Participant A self-identified as a novice interviewer, with no experience developing a design interview protocol prior to participating in this pilot study. In the protocol written for the pre-block task, 14 of the 18 questions listed by Participant 10 were framed as yes-or-no questions. After completing the block, however, Participant A

demonstrated a more refined approach in the protocol for the post-block task, implementing the learning block's suggestion of using "tell me about" prompts as an alternative to closed-ended questions.

A second key issue addressed in the "Core Content" was the importance of building rapport. When asked for reasons they should avoid "why?" questions in the "Knowledge Check", participants demonstrated a clear awareness of the ways such questions can make interviewees uncomfortable and lessen the quality of their responses. For example, Participant A responded, "Avoiding why questions is important because it can imply judgment, and can cause the interviewer to miss out on information. Instead, it is beneficial to not make people 'defend themselves', by asking them to tell you about their experience instead." Similarly, Participant B, who identified having previous design experience through co-curricular programs noted, "Asking "why" questions limits the response to what is considered appropriate to be said and makes the interviewee feel somewhat defensive about the practice being asked about, as they're being told it's necessary to justify it. A better way to phrase questions [is] to ask about how similar subjects are viewed or how an imaginary scenario involving the practice would be perceived and responded to." We observed that participants generally avoided "why" questions in both the pre- and post-block tasks.

*Comparison between "Prior Knowledge Review" and "Reflection"*

The learning block model asks a repeating set of questions in the 'Prior Knowledge Review' and again in the "Reflection." Therefore, students are given the opportunity to reflect on their initial responses and edit them after completing the learning block. When comparing between a participant's "Prior Knowledge Review" and "Reflection", submissions were categorized as no meaningful comparison before/after, minimal or no prior knowledge beforehand to some understanding, no/minimal prior knowledge to significant understanding and some prior knowledge to significant understanding.

Several key themes emerged while comparing each participant's "Prior Knowledge Review" to his or her "Reflection." Overall, despite the participants' differing initial skillsets, all participants demonstrated understanding of interview protocols following completion of the learning blocks. In their responses to Question 1 (tabulated in Table 1 below), five participants showed no meaningful comparison before/after, three participants showed minimal or no prior knowledge beforehand to some understanding, one participant showed no/minimal prior knowledge to significant understanding, and three participants showed some prior knowledge the significant understanding. We did not see cohesion in the types of knowledge gains across participants in these groups. Overall, the majority of participants exemplified learning gains in using a strategic interview structure and utilizing meaningful questions types.

Table 1: Question 1, What do you know about creating interview protocols?

| | Prior Knowledge Review | Reflection | Learning Gains |
|---|---|---|---|
| Participant C (minimal/no prior knowledge to some understanding) | "Not much I didn't have any formal training on this. | "Interview protocols are important before conducting an interview. It is a plan that guides both interviewee and interviewer to be efficient using limited time. An effective protocol can help the interviewer to gain a complete sense of the situation and rich understanding." | Efficient use of interviewing time, deepened understanding of context |
| Participant D (some prior knowledge to significant understanding) | "Nothing formal. The knowledge I have was gained from first-hand experiences performing interviews. My basic format is to (1) learn background knowledge, (2) assess the needs and requirements, (3) develop ideal and intermediate solutions and constraints/steps associated with each and finally (4) leave with some sort of timeline or task list." | "There are a few broad sections under which to write questions – kick off, building rapport, grand tour, reflection, and wrap up. Though the protocol doesn't need to be structured extremely rigorously, this flow should be used as a guide to the protocol. Furthermore, questions should be written in an open-ended way to allow the interviewee freedom to answer the question without being lead to an answer." | Strategic interview structure, rapport building, meaningful question types, avoidance of bias/leading questions |

Participants also demonstrated a more detailed understanding of the components of an interview protocol. Example submissions to Question 2, shown below, illustrate how participants were able to build upon their original submission to add more detailed components to their baseline knowledge before completing the block. Based on Question 2 submissions, two participants showed no meaningful comparison before/after, two participants showed no/minimal prior knowledge to some understanding, two participants showed no/minimal prior knowledge to significant understanding, and six participants showed some prior knowledge the significant understanding. Students were able to more accurately express the need for a protocol to include a strategic structure (n=6), allow for the interviewer to gain rapport with the interviewee (n=5), utilize specific question types (n=4), provide a written introduction and conclusion (n=3), and cue reminders for follow-up questions (n=3).

Table 2: Question 2, What should be included in [interview protocols]?

| | Prior Knowledge Review | Reflection |
|---|---|---|
| Participant A (some prior knowledge to significant understanding) | "Background questions to learn about the person, through questions related to specific information trying to be attained, and an opinion portion." | "An introduction, "kick off" questions, questions to build rapport, grand tour questions (main, general, high informational questions), follow up mini tour, structural, or contrasting questions, with reflective or personal/emotional questions towards the end, and ending with a conclusion. The script for the intro, conclusion, highlight questions, and key points for each question for follow up with each question." |
| Participant C (no/minimal prior knowledge to significant understanding) | "Not sure." | "Introduction and kick offs. build rapport. evoke stories. explore emotions. grand tours and mini tours. question statements. wrap ups and reflections and thank" |
| Participant E (no/minimal prior knowledge to some understanding) | "Questions you want answered" | "Questions you want answered. Questions about participants' demographic backgrounds. |

We also found that participants were able to communicate the main purpose and important components of an interview protocol from their responses to Questions 3 and 4. Responses focused on the various stages of an interview as well as the importance of preparing ahead of time before conducting an interview. We also found that for students who initially indicated having some prior knowledge, they were able to expand to a more significant understanding and cited the important of a protocol maintaining consistency across interviews (n=3), supporting a set of diverse questions (n=4), maintaining a structure and flow (n=3), and maintaining neutrality (n=3).

Table 3: Question 3, What is the purpose of an interview protocol?

| | Prior Knowledge Review | Reflection |
|---|---|---|
| Participant I (some prior knowledge to significant understanding) | "To make sure that the content of the interview was gathered in a reliable and accurate way so that it can be used as research and data." | "To facilitate helpful answers for the interview (ex: asking open-ended questions) and make the interviewee feel comfortable. To make sure that the content of the interview was gathered in a reliable and accurate way so that it can be used as research and data." |

Table 4: Question 4, What are 3 important things to keep in mind when conducting an interview?

| | Prior Knowledge Review | Reflection |
|---|---|---|
| Participant D (some prior knowledge to significant understanding) | "1. The comfort of your interviewee 2. The social space in which you are conducting the interview (idea of social context, background of interviewee, etc.) 3. The order and quality of questions to gain desired information." | "1. The comfort of your interviewee (quiet and private room, using corner position) 2. The social space in which you are conducting the interview (idea of social context, background of interviewee, not judging the interviewee implicitly or explicitly during the interview) 3. The order and quality of questions to gain desired information (pilot testing the interview protocol, proper probing questions)" |

*Follow-Up Interview*

Several key themes emerged during analysis of the follow-up interviews that were completed with a study team member. Participants were better able to identify best practices in crafting interview protocols and conducting design interviews, as well as demonstrate a wider range of contexts in which they may apply their design interview skills. Participants also noted that the knowledge they had gained from the blocks was different from the content of typical engineering curriculum but believed this content was valuable for engineers and lacking from traditional engineering curriculum. In regards to learning block improvement, several participants desired access to additional sample interview protocols on varied design topics and demonstrated preferences for more video content within the blocks.

As mentioned previously, participants displayed the ability to identify best practices in crafting interview protocols and conducting design interviews. In particular, participants noted that they had learned to ask open-ended questions, avoid leading questions, and be comfortable with silence during the interview to allow the interviewee to speak. For example, Participant C noted she learned how to "ask those open ended questions and don't be…that specific…" and "leave enough space for the interviewee to fully tell the story." Participant D said "asking the questions in an open ended and…non-leading…way is very important." Participant A said "letting the person kind of take over from there, is really important, so asking open questions and asking, you know, inviting questions early on." Participants also noted that they learned that questions should be asked in a certain order, with easier questions near the beginning to build rapport. Participant F said he learned about "easing into the actual interview and, like, starting off easy and then, like, getting into the meat of it." Participant G said if he were "talking to someone about a sensitive topic, like to not jump straight into it, but like kind of like knowing ways how to do that, and like importance to like building rapport first." Participant D said to "start with the lighter questions then you move on and as you continue they become a little more content dense and a little more involved." Several others made similar comments in the follow-up interview.

Participants were also able to identify a wider range of contexts in which they might apply their design interview skills. Many participants noted the relevance of these skills to their engineering coursework, such as senior design, or extra-curricular activities including student project teams and volunteering work. Participant F said

that, regarding applying block content to design classes, that "it would be important there trying to get a better understanding of, like, what you're designing and why." Participant A noted that improved interviewing skills might increase his interest in working on international projects by saying "especially [in] international communities…it's a different culture, and being able to have the ability to [conduct] an effective interview" In addition to connecting the skills from the learning block to their student career, participants suggested that that this skill would be advantageous as working professional. Participant D said these blocks would be beneficial for "essential future professional interviews" and Participant C noted the future impact "in your future career when you need to find out about the need from your customer."

Another theme that emerged from the follow-up interviews was participants' awareness of how the knowledge they had gained from the learning blocks was different from the content of traditional engineering curriculum. Participants' comments suggest that while non-traditional in engineering, qualitative research and social science skills are important to develop to be successful as an engineering designer. Participant C stated that engineering education includes significant training on how to analyze data but "we lack those things that teach you [how] to interact with a person." Participant B said that "the structure, right now of engineering courses doesn't really leave that much room for like, user…centric thought processes." Participant A compared it to the study of psychology and stated that it was "a different way of learning than engineering right now."

Learning block content areas of improvement were also revealed through the follow-up interviews. Several participants commented on their desire for access to additional sample interview protocols on varied design topics. Participant H said "I didn't really feel prepared structurally. I understood what types of questions to ask, but structurally there weren't many examples" and Participant G stated he would appreciate "having some sort of, like, example that I know that will be interview protocol." Participant B stated that he didn't "see a sample protocol" and "an actual protocol would have been nice to see". Several participants also noted a desire for more video content. Participant F stated he would "incorporate more of a video" and he "enjoyed the video." Participant G suggested "somehow providing something I think more visual." Participant A said that "you can read about interviews for you know like 4 hours…but…if all you have to do is watch one really good one… [it] helps just as much."

## Discussion

The goal of this initial pilot study was not to generalize across a larger population, but rather to gain an initial understanding of the impact of learning block usage by a small number of students to allow us to refine the model as well as the specific blocks on engineering design interviewing. In completing the pilot study, we were able to assess the features of the learning block model and facilitate iteration so that we can maximize learning for students of multiple experience levels. Data compiled and analyzed in this study are now being used to inform future block model and content iterations.

Several points of data collection from different sources allowed us to triangulate data, and key themes across data sources were drawn from each portion of the learning block model as well as student conceptions before and after

completing the learning block. In comparing the "Prior Knowledge Review" to "Reflection" components of the block, we were able to assess the overall themes and conclusions students drew from the information they were presented and the techniques they practiced. Through analyzing several examples, we saw distinct knowledge gains – from a participant initially providing no knowledge on a topic to later contributing a robust definition. We were also able to see participants who originally stated a vague understanding of interviewing best practices report a specific and clear response with evidence based claims. Participants A, C, D, and I above all displayed this level of vague to clear understanding. For example, Participant F specifically initially stated broad ideals to consider including the "comfort of your interviewee". However, in his "Reflection" response these ideals expanded to state "comfort of your interviewee" includes a "quiet and private room" and the use of "corner position" seating arrangement. Participant I also expanded from considering "order and quality of questions to gain desired information" to "pilot testing the protocol" and asking "proper probing questions." By identifying best practices instead of overall qualities in engineering design interviewing such as Participant I displayed, students were able to translate this knowledge to usable and strategic skills. They were able to not only understand the qualities of a strong interview, but also practice techniques that increase the probability that their interviews will be high-quality.

Collecting data from participants at a variety of time points and through several different mediums also allowed us to have a clearer understanding of different types of students who could engage with the model and the design content and their respective potential learning block outcomes. As described above, several participants noted having no prior design experience while others had gained experience through co-curricular activities. It is important to note that participants who showed some understanding during the prior knowledge review and had studies interviewing in some context in the past, including Participant G, were able to expand upon their existing knowledge and apply it in the post-block active task. On the other hand, participants who came in with very little knowledge of interviewing and identified no previous experience building skills in this area demonstrated a beginner understanding of topics.

We suspect that differences in backgrounds of students also correlate to their motivations for taking future learning blocks. While participants were recruited and compensated for completing the learning blocks in this study, follow-up interviews revealed curricular, co-curricular, and professional development motivations for completing future learning blocks. The majority of participants were involved in some co-curricular design project and stated the direct applicability of design interviewing to their work on those teams. This study is an important step in understanding students' perspectives of the learning block model and the model's impact on design education.

*Potential Impact and Dissemination of SEDA Learning Blocks on a Larger Scale*

The learning blocks are being adopted as part of the educational mission of the Center for Socially Engaged Design, a newly formed initiative in the University of Michigan's College of Engineering. We will share the development and outcomes of our work through our web presence, social media, design events, and speaking engagements. We have already begun to utilize the learning blocks heavily within the College of Engineering's Mechanical Engineering Capstone Design course, and we are investigating opportunities to further expand within

the University. The learning blocks are intended to be used by hundreds of students on campus (e.g., co-curricular project teams and design competition participants) who are currently engaged in socially engaged design work and have been actively seeking education on socially engaged design techniques. An internal report revealed that faculty members want to engage more students in socially engaged design work but feel that preparing these students is challenging due to a lack of time and expertise (Sienko, 2014). The learning blocks that have already been developed are currently being advertised to faculty as resources available to them and their students at no cost.

Eventually, we hope to share the learning block content beyond the University as well, and we will work to increase awareness and provide access to students and faculty through our website, existing networks, conferences, and national email announcements to targeted groups. In the future, national and international dissemination will be supported by the web and social media presence of the Center for Socially Engaged Design. Our long-term goal is that these learning blocks will be used by programs that provide access to socially engaged design techniques at other domestic and international universities.

## Conclusion

Non-traditional engineering design methods are necessary to ensure that designers have a robust understanding of the social, cultural, environmental, and economic contexts that impact technology design and implementation. For one example, it is imperative that engineering students are effectively taught interviewing methods so that they are able to successfully elicit this contextual information from a variety of communities and individuals. Stakeholder interviews are an integral technique in human-, user-, and context-centered design processes that can be utilized in a variety of design situations and industries. The Socially Engaged Design Academy (SEDA) learning block model combines the convenience and scale of asynchronous online learning with the value of face-to-face, hands-on training to support of the development of important engineering skills. This initial pilot study of two SEDA learning blocks, “Crafting Design Interview Protocols” and “Conducting Design Interviews,” allowed us to show an impact of the learning block model on students of different experience levels and preliminarily understand student reactions to progressing through the learning block model. Limitations of interview-specific content were revealed, and the findings will be used to improve future iterations of these learning blocks. Future work includes researching the impacts of several other learning blocks within the Socially Engaged Design Academy to understand the learning gains and gaps of other skills, as well as to gain a more comprehensive understanding of the learning block model’s usability. Follow-on studies will confirm whether improvements made based on information from the current study were successful in meeting student needs. Additionally, continuing to monitor and research student design practices after they complete the learning blocks will allow us to understand the true impact of the learning block model on our efforts to arm engineering students with a robust skillset of socially engaged design techniques.

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