Investigating design canvases impact on student performance

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Abstract

This complete research paper describes efforts to better understand the impact of problem framing tools on first-year engineering students' problem framing skills, as well as efforts to improve these tools. The first year of an engineering undergraduate program is an integral part of the students' academic development. Although the first-year engineering (FYE) community lacks universal learning objectives and course outcomes, these courses commonly introduce students to the university and profession while also covering professional and engineering skills. At Ohio Northern University, students experience and practice problem framing and solving skills. The students utilize problem framing canvases that guide them through initial steps of a design process. Four canvases help the students identify an opportunity statement, stakeholders, and design specifications. The canvases were initially developed at Ohio Northern University to encourage FYE students to connect stakeholders to the problem statement. The canvases later expanded to support engineering problem framing in high school classrooms and were revisited, again, to enable a user-centered and informed design. While the canvases are theorized to aid the design process, their direct impact on students' education development is still being investigated.

This study aims to understand how the problem framing canvases impact FYE students in their introductory engineering courses. Approximately twenty-five volunteer students, placed into groups of four to six students based on a range of factors, completed study activities. The groups completed a set of canvases based on a design prompt. Artifacts from the design prompts were evaluated using a predeveloped rubric. Students were given the opportunity to express their opinions about the design canvases and FYE course in focus groups. Researchers conducted the design prompt activities and focus groups at both the beginning and end of the 2024 spring semester.

Researchers observed and analyzed a variance in student group performance based on the grouping factors. Students provided critical feedback in the focus groups that is being used to refine the canvases to promote a streamlined design process.

Introduction

Since the early 2000s, there have been numerous and repeated calls for changes to engineering education with the aim of ensuring that graduates are prepared to be successful contributors to the field (e.g., [1]-[3]). Many universities responded to this call by developing first-year engineering (FYE) courses, and by 2013, nearly 60% of engineering programs had adopted some kind of FYE course [4]. These FYE courses lack universal learning objectives and course outcomes, but commonly introduce the students to the university and the engineering field [5], and have also been shown to be a critical factor in non-technical skills such as belonging and identity within engineering (e.g., [6], [7]).

One common feature of many FYE courses is a design project. Challenges often arise when instructing students on essential problem framing skills, such as defining constraints and

evaluation metrics, due to students' limited experience and eagerness to get into the "real engineering" work of designing and building. This often leads to ill-informed designs as novice designers fail to consider the needs of those who they are designing for, miss critical aspects of the design, or simply re-create already existing technologies, among other challenges. As stated in ABET student outcome 2, students must attain *"an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors"* [8]. The ability to fully define a problem, including constraints, evaluation metrics, project stakeholders, and more is key to fulfilling this student outcome, and FYE courses offer a place to develop a firm foundation.

In order to support students' development of problem framing skills, a tool known as "problem framing canvases" ([9], [10]) have been implemented within Ohio Northern University's FYE courses. This tool offers students scaffolding to guide them through the beginning stages of the design process, including recognizing an opportunity, understanding the needs of the stakeholders, and developing constraints and evaluation metrics with which to measure the success of their final project [10]. This paper describes the first phase of a study seeking to better understand the impact that this tool has on the students' problem framing skills and to gather feedback from the students on ways that these tools may be further developed in the future.

Study Context

Ohio Northern University is a small, teaching-focused university in a rural area of the midwestern United States. The university has an enrollment of approximately 3,000 students, with approximately 750 of those students enrolled in the college of engineering. The college of engineering offers six undergraduate-only majors: civil and environmental engineering (CE), computer engineering (CpE), computer science (CS), electrical engineering (EE), engineering education (EngEd), and mechanical engineering (ME). In addition to these six majors, first-year students may enroll in the engineering exploratory (EXP) program, which allows them to defer declaring their major until the end of their first year.

Ohio Northern University employs a common first-year engineering program [5] via a two-course sequence, typically beginning in students' first semester on campus. These courses, Foundations of Design 1 and 2 (FoD), focus on the design process, including problem framing, engineering design tools such as computer-aided modeling programs, prototyping skills, teamwork, technical communication, and more. FoD1 is taken by all college of engineering students, and all students who are not majoring in computer science must take FoD2. Both courses are heavily project-based. Students gain experience with framing theoretical and real-life problems using the problem framing canvases to provide a firm basis for the development of their solution.

The first semester includes three related projects framed around a fictional humanitarian organization. The organization is developing a residence in rural China where a family residing on a farm seeks to develop their property to be economical, efficient, and environmentally friendly. The first project includes a site plan development and introduces the problem framing canvases by asking students to consider the needs of the family and other stakeholders. During

the second project, students 3D print scale model wind turbine blades. They use the blades to run an experiment that determines the most efficient wind turbine dimensions. Third, the students are given multiple categories (such as “automated planter”, “creek cleaner”, “greenhouse control system” and others) to design a product that could improve the day-to-day life of the residents. Students submit a prototype of their product, a report, and poster that describes their design process and markets their product. Students are expected to assess stakeholders’ needs and connect these needs to other problem framing elements.

During the second semester, students complete a semester-long design project with the goal of developing a product that can assist someone with a disability. Students have the freedom to choose their target audience and disability. Students delve deeply into problem framing using the same problem framing canvases during the second semester. The open-ended nature of the problem statement leads students to rely on the problem framing skills emphasized in the canvases. These projects offer the students the opportunity to learn how to work in groups, problem solve and develop project management skills. Ohio Northern University designed their FYE courses to enable user-centered design.

Problem Framing Canvases

The problem framing canvases are four sequential worksheets. The canvases seek to guide students though the early stages of a design process. It is intended that students use these canvases in an iterative fashion to fully define the problem before embarking on ideation, and that they return to these canvases as new information is uncovered throughout the design process. These canvases can be found in Appendix A. There are four canvases used in this study, a summary of each is included below:

- **Opportunity Recognition Canvas** guides students in exploring and interpreting the problem. The canvas promotes a circular process of examining stakeholders and their needs, wants, and pain points while seeking to narrow the design space. This culminates in an “opportunity statement” - a one sentence problem statement to concisely describe the deliverable, function, and user.
- **Stakeholder Canvas** guides the user in empathizing with and understanding the context of the stakeholder - an individual or group that is directly or indirectly affected by the problem. The canvas examines a stakeholder’s internal and external needs, wants, and pains. This canvas encourages students to develop empathy for the users and understand their situation and trials they may face and was developed from ethnographic research methods.
- **Problem Framing Canvas** is a complex canvas that covers multiple processes related to the framing of the problem space. Drawing inspiration from the value proposition canvas (a well-known tool from the business literature [11], a modified form of which may be found in Appendix A but which was unused in this study) infused with more direct elements of the engineering design process, it guides the users through consideration of the design space, in the form of constraints, evaluation metrics, and assumptions, as well as the existing market within which the solution must compete.
- **Design Specification Canvas** guides the user in considering potential attributes of their design which could be constrained or informed by design specifications. The canvas asks

students about how an attribute of their project could feasibly be quantified or measured and whether any design specifications may exist to bound those quantifications.

Methods

This multiple methods study began with recruiting participants and creating a rubric to evaluate the problem framing canvases. Following IRB-approved procedures, the participants were recruited from students enrolled in the FoD2 course in spring semester 2024. All participants were compensated for their time ($100 for completing all study activities), and their participation had no bearing on the course grade. We define this study as multiple methods, rather than mixed methods, as the data collection and analysis, as described below, does not meet the characteristics of a mixed methods study, as defined by Creswell and Plano Clark, namely *"In mixed methods, the researcher…integrates (or mixes or combines) the two forms of data and their results"* [12, p. 5]. As can be seen from the descriptions below, the results and data collection have not been integrated, and thus cannot meet the criteria for mixed methods research.

Data Collection

All participants had already completed FoD1 and had been introduced to problem framing canvases throughout that course. As part of the study, students were separated into six sets of four to five students. The objective was to achieve a mix of participant sets who were and were not currently working together as a team in FoD2 (called a "team" if they were and a "group" if they were not for the remainder of the paper) as well as a mix of their approximate academic performance as a team/group. The teams' academic performance level was determined by averaging their grade point average from the first semester and then were ranked as "high", "middle" and "low". From the remaining participants, groups were intentionally formed based on students' grade point average. The purpose of using both teams and groups was to explore the differences in experiences and outcomes of those who work together throughout the semester and those who only collaborated for the study activities. The sets of students and their demographics can be found Table 1.

Table 1. Student Group and Team Demographics

	#	*Average GPA*	*Male/Female*	*Majors*
Low Team	5	3.08	4/1	CpE (4), ME (1)
Low Group	4	2.68	3/1	CE (2), ME (2)
Middle Team	4	3.18	4/0	ME (4)
Middle Group	4	3.48	0/4	CE (1), CpE (1), CS (1), ME (1)
High Team	4	3.68	1/3	CpE (1), EE (1), ME (2)
High Group	5	3.91	3/2	CE (1), CpE (2), EXP (1), ME (1)

The data collection phase of this project took place during spring semester 2024. The timeline is shown in Figure 1. Students participated in two rounds of activities, one early in the semester and one near the end, referenced as “pre” and “post” throughout the remainder of the paper. Each round consisted of a design prompt session and focus group session. Each of these elements is described below.

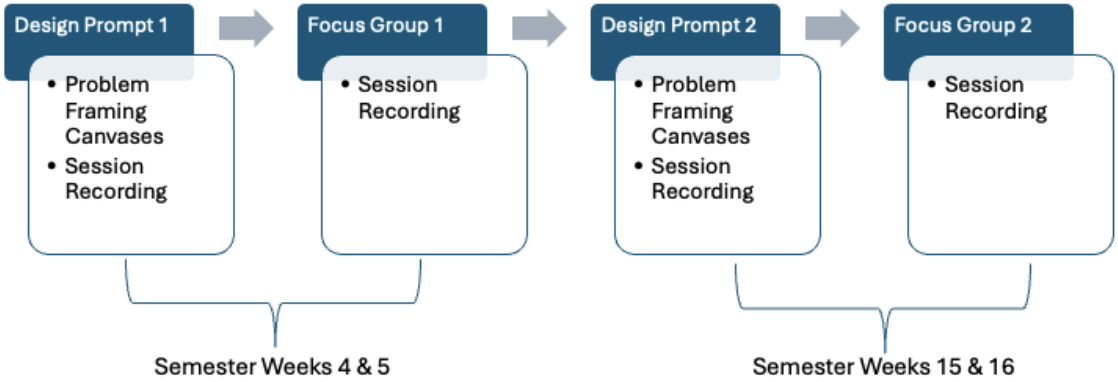

Figure 1. Data Collection Timeline

Design prompts

During the design prompt sessions, each set of students was given an open-ended problem statement and asked to work through the problem framing process. To facilitate this, a moderator introduced the project, gained permission to audio record the session, handed out materials, provided instructions, and then left the students to complete the problem framing canvases based on the prompt. The moderator left to minimize the opportunity for outside influence and to increase the likelihood of authentic representation of how students used the problem framing canvas, though remained in the area in case of questions. Students were allowed to utilize the internet for research purposes and were asked to leave all materials in the room upon completion. The completed problem framing canvases and the audio recordings were then retained by the research team for further analysis. The prompts given at each stage of the study can be found in Appendix B.

Focus Groups

The focus group session was completed typically within a week of the design prompt session. In the focus group, the moderator asked a series of questions with allowed flexibility to adjust the questions or ask follow-up questions as needed. These questions focused on the participants’ experience using the problem framing canvases, their opinions of the canvases, and how they would like to see the canvases improve. The questions from the pre-focus group and post-focus group remained consistent with minor alterations. The questions are outlined in Appendix B.

Data Analysis

The analysis began by having the transcripts from the design prompt sessions and the focus groups professionally transcribed. The transcripts were then reviewed for accuracy, and to remove identifying information.

The problem framing canvases were evaluated with a rubric developed from Crismond and Adam's *Informed Design Teaching and Learning Matrix* [13]. The rubric used five factors to evaluate the problem framing canvases and each factor is described in Table 2.

Table 2. Problem Framing Canvas Evaluation Factors

Factor	Description
Understanding the problem	Did students fully understand the problem statement and was the work within scope?
Problem solving vs. problem framing	Did students approach the problem with an open mind and explore the boundaries of the design space, without a specific solution in mind?
Skipping vs. doing research	Did students ask research questions and were those questions relevant and develop the problem framing?
Haphazard vs. managed	Did the students make connections across elements of the canvas?
Completeness	Were canvases completed with good-faith effort?

Each canvas was rated from 1, representing a beginner designer, to 5, representing an informed designer as described in Appendix C. It should be noted that, as our population was limited to first-year engineering students, we scaled our expectations appropriately, and did not compare the canvases produced by these students to what we would expect of an engineering graduate, or an experienced professional.

The rubric was refined prior to the beginning of the study using problem framing canvases from previous semesters. Two student researchers independently assessed student canvases and then compared their evaluation. In areas where they differed, they discussed their differences, adjusted the definitions included in the rubric, and assessed a new set of student artifacts. After several rounds of assessing and adjustment, the final rubric, which can be found in Appendix C, was developed. This rubric was used to assess the artifacts from the design prompt sessions within the study. Any work outside the scope of the problem statement was not considered in scoring.

Transcripts from both the design prompt and focus groups sessions were analyzed using thematic analysis [14] without set themes to allow commonalities to emerge organically. After initial analysis of individual elements was completed, the information garnered from each was looked at holistically to better understand the overall experience.

Study Limitations

This study should be understood in context of its limitations. First, the design prompts and focus groups were time constrained, and thus may not be fully representative of students' abilities or thoughts. Additionally, since the design prompts were unmoderated to avoid the influence of a more experienced designer, there is also the possibility of unequal contribution among group

members. While this could be managed during the focus groups, as the moderator could solicit input from quieter participants, this was not possible during the design prompts. While students were repeatedly assured that nothing they said in the focus group or design prompt would affect their grades, there is the possibility students may not have expressed their opinions during focus groups to align with social expectations or expectations of the moderator. It should be noted that, while 25 students participated in this study, they were divided into 6 sets of students, who then completed activities together, resulting in very small number of data points for the quantitative aspects of the study

Finally, the students who participated in this study are not representative of the college of engineering at Ohio Northern University or of engineering graduates. Approximately 44% of the study participants are women, whereas recent data on engineering degree attainment indicates that approximately 24% of bachelor's degree recipients are women [15]. Similarly, the majors represented by our participants are not representative of the college of engineering at Ohio Northern University (e.g., CpE students are overrepresented in the study). However, broadly, all first-year students take very similar sets of courses. Thus, it is not expected that the differences between our participant set, and the general population of our college significantly impact this study's results.

Results and Discussion

In this section, we will share our results and discuss the implications of these findings. Additionally, future work will be proposed.

Results

Two student researchers evaluated the artifacts from the design prompts during the summer of 2024. The scores and totals can be found in Table 3.

Table 3. Design Prompt Scores

	Understanding the Problem		Problem Solving vs. Problem Framing		Skipping vs. Doing Research		Haphazard vs. Managed		Completeness		Total		% Change
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
Low Team	5	4	4	3	3	4	5	3	4	2	21	16	-23.8
Low Group	5	3	2	3	2	3	2	2	5	3	16	14	-12.5
Middle Team	5	4	5	5	4	3	5	4	5	5	24	21	-12.5
Middle Group	4	5	4	4	4	3	4	5	3	4	19	21	10.5
High Team	5	5	4	4	3	5	4	5	5	5	21	24	14.3
High Group	4	4	4	5	3	5	3	4	4	5	18	23	27.8
Average	4.67	4.16	3.83	4.0	3.17	3.83	3.83	3.83	4.33	4.0	19.83	19.83	0

The students averaged a score of 19.8 out of 25 points both in the pre- and post- design prompt. As seen in Table 3, half of the teams saw an increase in score from pre- to post-, while the other half saw a decrease in score. We additionally evaluated each rubric factor, the averages of which can be found in Table 4.

Table 4. Average Factor Score

Factor	Pre-	Post-	% Change
Understanding the Problem	4.67	4.16	-10.7
Problem Solving vs. Problem Framing	3.83	4.0	4.35
Skipping vs. Doing Research	3.17	3.83	21.1
Haphazard vs. Managed	3.83	3.83	0
Completeness	4.33	4.0	-7.69

Evaluation factors “problem solving vs. problem framing” and “skipping vs. doing research” saw total increases in scores throughout the semester. Factors “understanding the problem” and “completeness” experienced a decrease in average scores, and “haphazard vs. managed” remained the same.

We also evaluated scores by academic performance ranking and team vs. group, as this was how students were divided to participate in the study. This data is shown in Table 5 and Table 6.

Table 5. Average score by academic performance

	Pre	Post	% Change
Low	18.5	15.0	-18.9
Middle	21.5	21.0	-2.33
High	19.5	23.5	20.5

Table 6. Average score for teams and groups

	Pre	Post	% Change
Team	22.0	20.3	-7.73
Group	17.7	19.3	9.04

Lastly, we evaluated the time it took for each team to complete the given design prompt. This was done using the audio recording from the session. This data can be found in Table 7.

Table 7. Time to complete design prompts

	Time (hh:mm:ss)			
	Pre	*Post*	*Change*	*% Change*
Low Team	0:47:46	0:24:07	-0:23:29	-49.5
Low Group	0:45:59	0:36:44	-0:09:15	-20.1
Mid Team	0:49:18	0:33:20	-00:15:58	-26.4
Mid Group	0:50:59	0:29:17	-00:21:42	-42.6
High Team	0:46:23	0:40:25	-0:05:58	-12.9
High Group	0:47:57	0:55:45	0:07:48	16.3
Average	0:48:04	0:36:36		

Additionally, focus group data were analyzed for student perception regarding the problem framing canvases.

Students understood the value of framing the problem before beginning the design through defining the needs and scope. They described problem framing as helping them learn how to think through a design process. All students agreed the canvases helped guide them through a design process during both the pre- and post- focus groups. Students agreed the canvases are beneficial to students just entering the engineering field. One student described: *"I didn't have any engineering classes in high school, so a lot of this was very helpful for developing how to think as an engineer"* [Low team, pre-focus group]. Students agreed the canvases forced them to *"slow down, [and] to not jump completely to the middle of solving the problem"* [High team, pre-focus group]. The canvases provide a foundation and set the design process in the correct direction.

Many groups utilized the stakeholder canvas to understand the problem statement. Four of six groups and six of six groups described the stakeholder canvas as helpful during the pre- and post-focus groups, respectively. Students used the stakeholder canvas to narrow the broad problem statement from FoD2 and identify their target audience. Most students considered the stakeholder canvas before generating an idea. The stakeholder canvas was praised by most groups and often described as the most helpful canvas. For one student, they described: *"[the stakeholder canvas] helped us put us in the shoes of the individuals who we're researching… learning what do they value, what are the biggest problems they face, what is their budget and what are their biggest concerns?"* [Low team, pre-focus group]

Groups had mixed opinions on the usefulness of the opportunity recognition canvas. Students praised the opportunity statement, but most did not utilize the opportunity recognition canvas. Students *"filled [the opportunity recognition canvas] out because we had to"* [Low group, post-focus group]. They used the canvas to write their opportunity statement, but did not reference the canvas after that.

The problem framing canvas was praised by students for its functionality and organization benefits. Five of the six groups appreciated having the constraints, metrics, and assumptions all in one place. The problem framing canvas encouraged students to think critically about the problem statement. Students liked having the market alternatives on the canvas because it made them consider what other design solutions exist. The canvas allowed students to identify whether their project was viable. The problem framing canvas *"shows what the process should be leading into the next and how it all connects"* [High team, post-focus group].

Students expressed confusion surrounding the design specification canvas. While a purpose of this canvas is to guide students to determine an experiment for their design, most students did not utilize it to its full potential. Some students felt the canvas needed to be explained better. When asked about conducting an experimental performance test on a future prototype of their design, students described finding it difficult to identify an aspect to test. Groups described the design specification canvas felt repetitive due to the design decisions made in other canvases. One student described: *"I don't remember using that one, and I'll be honest, I don't really know how to use that one to its full extent. I feel like I could use it better, but we didn't really use that"* [Mid group, post-focus group]. On the other hand, some groups described the benefits of the canvas. For example, another student expressed: *"the design specification canvas makes it easy to evaluate what design you want to make and what the effect of that design would be"* [Low group, pre-focus group].

Students agreed they would utilize the concepts the canvases taught them, but they are not likely to use the canvases in the future. However, all six groups thought the canvases should be required for FoD1 and four of six groups thought they should be required for FoD2. One student explained: *"even if I never touch this, if I never see this canvas ever again, my thinking process is guided by this, because it's an organizational method"* [Low group, post focus group].

Students also provided critical feedback regarding the physical shape of the canvases. Students agreed the size and shape of the writing area acts as a constraint in and of itself and would like more space. The circular nature of the stakeholder canvas was difficult to use. Most groups described areas of the stakeholder canvas as repetitive, especially the external portion. They felt not all questions in the stakeholder canvas were applicable to all stakeholders. Students commented on feeling like they were filling out the canvases for a good grade, rather than for the value of the canvases.

Discussion

Students' comments around the problem framing canvases were generally positive and we found that students clearly recognized the importance of the concepts in the canvases. From the beginning to end of the semester, they had a greater appreciation for the canvases. They recognized that while they might not enjoy completing the canvases, the canvases help them develop problem framing skills. Students understand how to use the stakeholder and problem framing canvases and agree these canvases are the most helpful. They expressed confusion about the design specification canvas. A deeper understanding of the purpose of the design specification canvas may allow groups to develop better tests for their design. Students

appreciated having the organizational system, but agreed they needed a more functional space to write their process.

While the qualitative feedback is useful in the next stages of the canvas development, we were concerned about some of the patterns observed in the data, particularly some scores decreasing between the pre- and post- portions. While the data set is small, and therefore difficult to make well-founded statements, two factors were identified as possible contributors to this decrease. First, and perhaps most critically, as shown in Table 7, there was generally a decrease in the amount of time participants spent on the design prompt sessions. While this could be explained by participants becoming more efficient as they gained experience, given the relatively short time frame between the pre- and post- portions of this study, this likely only tells a portion of the story. We believe the most likely explanation of this decrease in time spent is the time of the semester where the second set of design prompts occurred. As shown in Figure 1, these design prompt sessions occurred late in spring semester, a time where many students have many competing priorities, such as looming exams, final projects, and more. These likely contributed to the amount of time that students were willing to spend on the design prompt sessions, and likely negatively impacted the quality of the work as well. Secondly, research by Dunning and Kruger indicates that novices in a domain tend to overestimate their competence in that domain [16]. Given that the decrease in performance is observed primarily in students with histories of lower academic performance, this effect may be at play, where students who, by our measures, are beginning designers, overestimated their abilities and thus judged their work to be more complete and more competent than an expert would. This reasoning is supported by the duration of the high team's and high group's post-design prompt exercises, which just slightly decreased or actually increased in time, respectively.

Looking at the percent change from pre- to post- it appears that the scaffolded approach of the design canvases may most benefit the teams who came into the study with higher academic achievement, as the high team and group consistently saw an increase in their scores, whereas the low team and group consistently saw a decrease in their total score. This raises concerns, however, this could be explained by what might be considered "typical" behavior for academically low and high performing students-that is, broadly speaking, high performers tend to put forth more significant effort and complete their work at a higher quality, whereas lower performers tend to do the opposite, which is also supported by the time that each team spent completing the design prompts, as shown in Table 7. This may indicate that the scaffolded approach to problem framing facilitated by the canvases is most beneficial when students put effort into completing them.

Finally, it should be noted that this study took place during the second semester, and participants had already had experience framing design problems from their first semester course. Many students come into FYE programs as true novices, having never done any design or problem framing. It would be expected that the greatest gains would occur during the first semester and so it may be more challenging to meaningfully measure change in ability during this second course.

Conclusion & Future Work

We found that participants generally found the problem framing canvases to be useful scaffolding as they learned to frame the problem. While the participants had feedback on how the canvases and our instruction around the canvases could be more impactful, they nearly universally found them to be an effective tool, and we find this to be encouraging. However, more work is needed to determine the efficacy of the tools. We are currently revising the canvases and are planning a study which includes data collection at three points of the academic year to better understand the efficacy of these tools across students' first year. Problem framing is a critical foundation to good design, and thus effective tools to support novices' learning should be developed.

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Appendix A

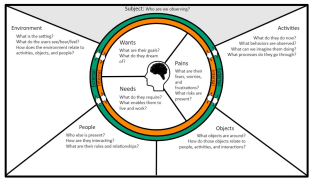
Open Questions

1

Who is affected and in what context?
For example: Students while in class

2

What do we know about them?
About the context?



Use the Stakeholder Profile Canvas to guide your research and include as many as you need as attachments. You may need multiple worksheets if the same stakeholder operates in multiple settings/contexts.

3

What are the most important perspectives gathered?
What else do we know about the situation?

4

What opportunity exists to create added value?

Deliverable → (to do...) Function → (for...) User

Stakeholder Profile Canvas

Subject: Who are we considering?

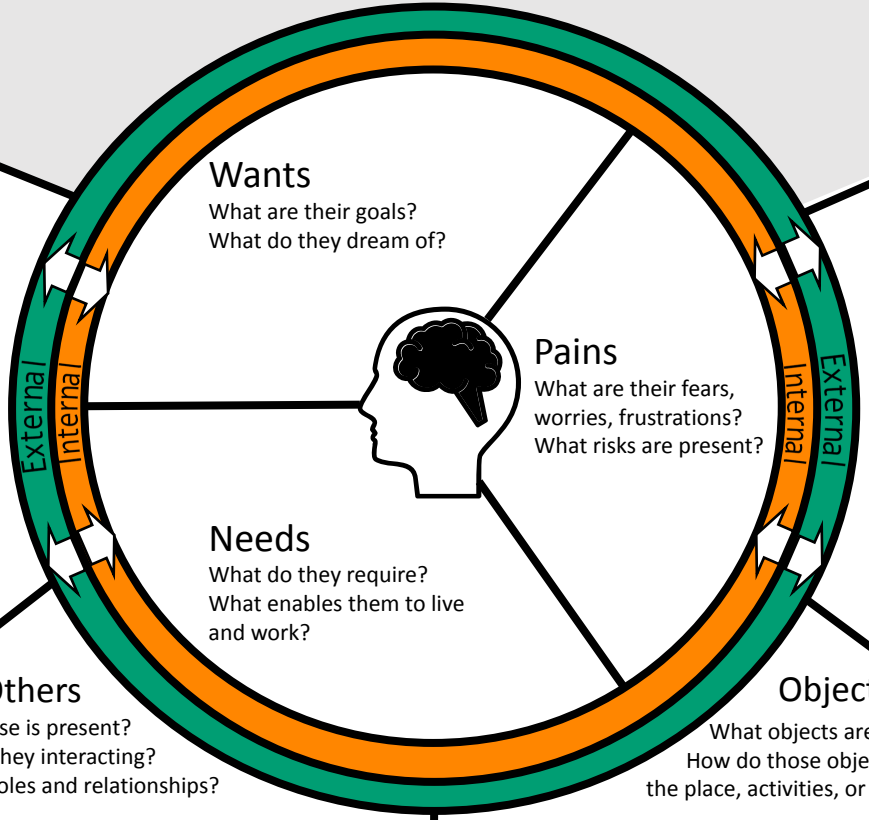
Situation: What is the setting?

Place

What are the surroundings?
What do the users see/hear/feel?
How does the environment relate to activities, objects, and people?

Activities

What do they do now?
What behaviors are observed?
What can we imagine them doing?
What processes do they go through?



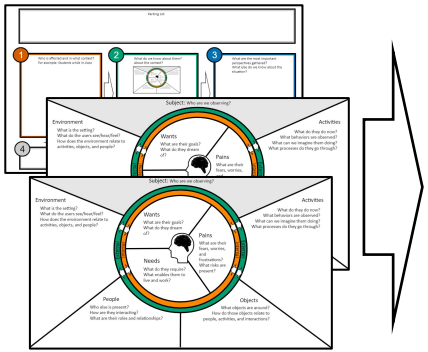
Others

Who else is present?
How are they interacting?
What are their roles and relationships?

Objects

What objects are around?
How do those objects relate to the place, activities, or others present?

Opportunity



Opportunity Statement

Based on the stakeholder profile(s), what opportunity exists to create added value?

Market

Current Alternative

What is the current approach in use by the customer?
How do they currently solve similar problems?

Market Alternatives

What products on the market today could address this need?
Are there existing products that address similar needs?

Design Space

Research Questions

What else do we need to know about the problem?

Assumptions

Based on/Because [information], it is assumed [assumption]. Therefore [design decision].

Constraints

(limitations, requirements)
Eg: no longer than 10”

Metrics

(differentiators, goals)
Eg: as light as possible

Broader Impacts

What would be the impact [3Ps] of solving this problem?

Design Specification Canvas

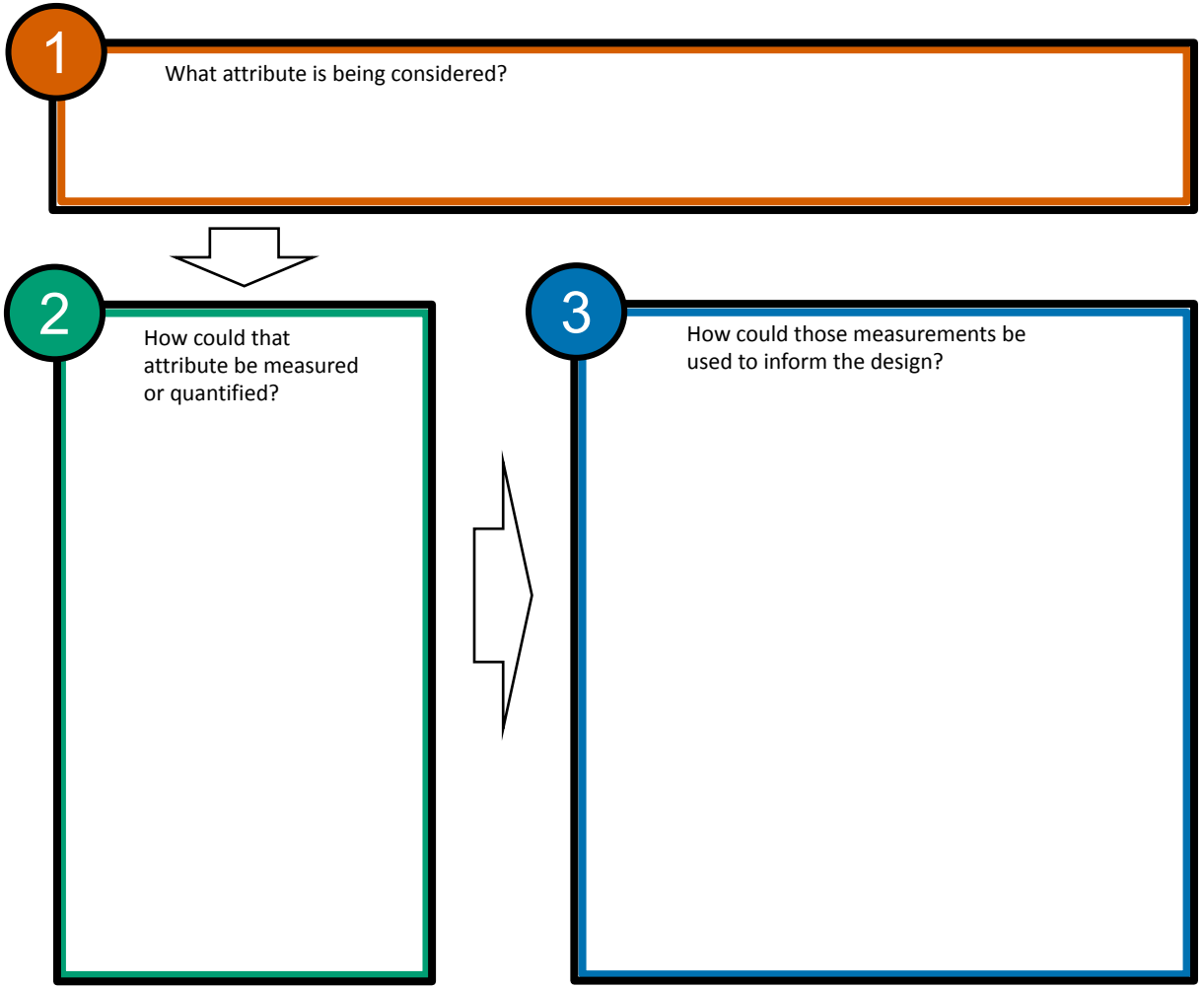
Before beginning, use a tool such as the Specification Source Model to identify attributes which are likely to be relevant to the design. For each such attribute, complete a copy of this canvas.

Box 1: List the attribute being considered.

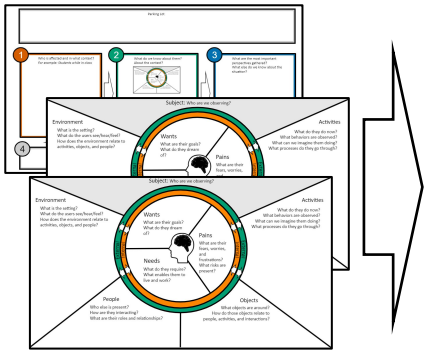
Box 2: List ways in which the attribute might be measured or quantified. Include relevant units of measurement where applicable.

Box 3: Consider which measurements or quantifications might be used to inform the design. Write out a relevant design specification for each such measurement or quantification.

- Does it represent a **limitation** on your design? If so, what is that limit?
- Will it help you **differentiate** competing ideas? If so, would the better result be higher or lower? More or less?
- Both?



Opportunity



Opportunity Statement

Based on the stakeholder profile(s), what opportunity exists to create added value?

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What is the current approach in use by the customer?
How do they currently solve similar problems?

Market Alternatives

What products on the market today could address this need?
Are there existing products that address similar needs?

Product

Features

How does your product work?
What components are involved in making it function?

Impacts

What are the impacts of the product (3 P's)?

What function(s) does your product perform?
What is the user experience like?

Functions

Key Differentiators

What sets your product apart from the competition?

Appendix B

Design Prompt Pre

For elderly persons in nursing homes, maintaining contact with extended family members is an important factor in their well-being. In an era where families are increasingly spread around the country if not the world, this presents an especially difficult challenge as face-to-face visits are impractical if not impossible. While technology provides the means for video chatting to bridge the gap, many seniors lack the experience to navigate increasingly complex devices and apps (e.g., many have never used a touch screen device). The problems are made worse by vision, hearing, and dexterity problems common in old age. A senior connectivity start-up is developing a physical device to allow seniors to quickly and easily video chat with family members and you have been tasked with providing support for this design process.

Design Prompt Post

One of the most lucrative market segments in the world of consumer products is kitchen gadgets. A celebrity chef has recently decided to launch a line of their own gadgets, specifically looking at a device for slicing food. Home chefs are often just learning to cook or experimenting with more advanced techniques in which they may or may not have any kind of formal training or experience, so there is significant opportunity to add value in how such a device is constructed and the features included. The chef is looking for designs for devices which will allow the user to slice and chop food of various size, shape, and type into slices/pieces of different shapes and sizes. Ideally the device is attractive to both novice and advanced home chefs, but is not intended for the commercial kitchen environment.

Focus Group Questions

1. Pre-Focus Group Questions:

    1.1. Consider FoD1's M1 and M3. Can you think of any specific times when it was valuable to frame the problem before generating potential solutions?
    1.2. Can you recall any of the four canvases we used in FoD1's M1 and M3?
    1.3. Did you utilize your Stakeholder Profile Canvas during your visit? If so, how?
    1.4. What value, if any, did the canvases provide for FoD1's M1 and M3?
    1.5. Can you think of an example from FoD's M1 or M3 when you made a design decision by connecting a stakeholder need to research/assumption to constraint/evaluation metric?
    1.6. Do you have any suggestions for improving the canvases?
    1.7. How likely are you to use any or all of the canvases on future design projects, even if not required or discussed as part of that course?
    1.8. Should future FoD teams be required to use the canvases, some other form of problem framing tool, or nothing for problem framing?

2. Post-Focus Group Questions:

    2.1. Consider FoD1's M1 and M3. Can you think of any specific times when it was valuable to frame the problem before generating potential solutions?
    2.2. Can you recall any of the four canvases we used in FoD?
    2.3. Did you utilize your Stakeholder Profile Canvas during your visit? If so, how?
    2.4. What value, if any, did the canvases provide for FoD2 project?
    2.5. Can you think of an example from FoD2 when you made a design decision by connecting a stakeholder need to research/assumption to constraint/evaluation metric?
    2.6. Do you have any suggestions for improving the canvases?
    2.7. How likely are you to use any or all of the canvases on future design projects, even if not required or discussed as part of that course?
    2.8. Should future FoD teams be required to use the canvases, some other form of problem framing tool, or nothing for problem framing?

Appendix C

	1-Beginning Designer	2	3-Emerging Designer	4	5-Informed Designer
Understanding the Problem	Canvases demonstrate a lack of understanding the problem statement and are out of scope		Canvases show some understanding of the problem statement, but most of the work is outside the scope		Canvases demonstrate an in-depth understanding of the problem
Problem Solving vs. Problem Framing	Canvases only focus on one approach to the problem, closed-minded		Canvases approach to the problem is surface level and underdeveloped		Canvases approach the problem with an open-mind
Skipping vs. Doing research	No relevant questions posed and do not explore the boundaries of the design space		A few questions posed, particularly of limited relevance to design		Pose well-developed research questions that explore the boundaries of the design space
Haphazard/linear vs. Managed & iterative	Canvases do not inform each other		Evidence of connection from one element to next, but some elements of disjointedness		Canvases inform each other and are well-connected
Completeness	Canvases were not completed		Canvases were completed with effort to inform the design		Canvases were used to inform the design