WIP: Mechanical engineering students' incorporation of stakeholder considerations throughout a Senior Design course sequence

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Abstract

The purpose of this work-in-progress is to share preliminary results of student responses to a stakeholder-focused engineering design task. Engineering design is a complex process that requires engineers to go beyond solely meeting technical design constraints. How a design interacts within the environment and society is a crucial aspect that also needs to be taken into account early within the design process. Moreover, considering stakeholder needs and limitations throughout the design process is an integral part of reducing risks and assuring the overall success of a design throughout its operation. This work-in-progress is a part of a larger longitudinal study that explores the experiences of mechanical engineering undergraduates in a two-course Senior Design sequence. In particular, this paper presents preliminary results of an analysis of students' consideration of stakeholders within their own design process as they address an engineering design task. Data was collected across two semesters from 97 students within a large public university through a survey that included an open-ended submarine design scenario. Although students' design considerations varied, a trend of students prioritizing vehicle specific factors and constraints over stakeholder considerations was apparent. Additionally, students' total breadth of considerations decreased or experienced little change across the course sequence. Overall, this work-in-progress describes preliminary results of the students' responses in hopes of providing insight into how students' consideration of stakeholders evolves within a design course. The overarching objective is to gain a more comprehensive understanding of students' design approach and the pedagogical and individual factors that impact it.

Motivation

Design is an essential aspect to not only facilitating daily life through innovation and invention, but it is the key to creating blueprints for solving some of the world's most complex challenges. Designers are faced with the constant need for reiteration and reframing as they work towards meeting the often-evolving constraints and specifications of a project. One of the most challenging factors designers must account for is the consideration of stakeholders. Stakeholders are defined as all individuals who affect and/or are affected by the design and design process [1]; hence, they play a major role in contributing to the effectiveness of a design. Stakeholder needs, safety, behaviors, and preferences when interacting with a design will impact what considerations engineers must consider when designing. Overlooking these needs not only can be detrimental to the overall effectiveness of the final design, but more critically, can have adverse social, cultural, and safety ramifications [2], [3].

Design is progressively becoming the backbone of fostering a holistic engineering education as experts and the ABET Accreditation Criteria underline the significance of a student's ability to "apply engineering design" (from Criterion 2), "use engineering judgment" (from Criterion 6), and "recognize ethical and professional responsibilities" (from Criterion 4) in a variety of global context [4]. Modeling a genuine design experience requires overcoming multifaceted obstacles such as forming realistic design constraints, providing adequate stakeholder accessibility, and creating an atmosphere that provokes empathy towards stakeholders. Additionally, both students and educators face many challenges balancing, experiencing, and creating this design experience with the demands and limitations of an engineering curriculum.

Additionally, research indicates that during a design process, technical and logistical aspects of a design (e.g., performance, scheduling) can be prioritized while stakeholder considerations (e.g., ergonomics, maintainability) can be overlooked [5]–[7]. Understanding how students perceive and incorporate stakeholder needs and values within their design process is an underexplored yet essential step towards assuring the advancement of engineering design education. Moreover, this understanding will allow for the assessment and assurance that students gain holistic and well-balanced experiences that they carry into industry practices.

This work-in-progress is part of a larger investigation exploring the overall student experience within the redesign of a senior design mechanical engineering course sequence. More specifically, this work-in-progress describes preliminary results of student responses to a proposed design scenario that will provide insight into potential discrepancies between how students incorporate stakeholder considerations within their design process and the curricular intentions. Moreover, this paper aims to establish a fundamental understanding of how students' consideration of stakeholders evolves over time to better serve as a resource for improving engineering design education and better equipping students for the dynamic challenges within industry.

Background

Studies of design and explorations of engineering students' pathways in industry support the need to determine how to better prepare students to incorporate stakeholder considerations into design. In an *IEEE Spectrum* article titled "What keeps engineers from advancing in their career," Hinkle [8] outlines four pieces of advice for early career engineers, one of which is to

> *Know your stakeholders. This can be much more difficult than knowing your customers, who are a subset of your stakeholders. The broad definition of a stakeholder is anyone who is affected by your work in any way, or who affects your work in any way. Think about that, and you'll start to realize the impact you are having on the world. It's probably much bigger than you realized if you haven't thought about stakeholders this way. You can't have relationships with that many people, so at least build rapport with three or four of your most important stakeholders who aren't customers (p. 1).*

This perspective aligns with the outcomes of the 1999 Harvey Mudd Design Workshop, comprised of engineering design educators and researchers, that illustrate how "design is replete with "people" issues, both personal and social" and instructors need to "give attention to the Humanist Engineer: include culture, values, and the notion of intent in the academic program," [9, p. 293]. Self-reports by senior design students illustrate a low level of confidence in their ability to understand how broader social contexts impact engineering practice [10].

As a result, there is a movement within some fields of engineering to design learning environments which place a higher value on the needs and limitations of stakeholders [7], [11]–[15]. At the undergraduate level, the purpose of these approaches and experiences is to allow students to interact with the stakeholders throughout the design process and complete a design that, in many cases, can be delivered to the client for future use [14]. Through these experiences, students are gaining valuable insight into the importance of stakeholder considerations within design [14], [16] and the "impact of engineering solutions in a global, economic, environmental,

and societal context" [4, p. 4]. Yet, this movement has generally been restricted to fields such as product design, service learning, first-year engineering, industrial design, and computer science.

Explorations outside those fields have been limited. For example, while some aerospace design curricula instructors have created opportunities for students to interact with specific clients and/or end-users, such as the case of human-powered aircraft [17]–[22], stakeholders considerations are commonly limited to quantitative measures as surrogates for those stakeholder considerations that can be clearly defined and quantified [23], [24]. As a result, there is a need for continued development of engineering design courses to better enable engineering students' to understand, design with, and design for stakeholders.

Examinations of students' awareness of and valuing of stakeholders illustrate a diverse set of student personas, from technology-centered perspectives that have limited awareness of and empathy for stakeholders to an empathic design perspective [14]. Currently, these examinations have predominantly focused on small numbers of individuals using individuals or group semi-structured interviews [14], [25], [26], cross-sectional snapshots of a single class using open-ended questionnaires [27] or an outside-of-class performance task [10], [28]–[31]. A few studies have explored students' assignments, examining them at the end of a course [7] or over the course of a semester [32]. Additional longitudinal and cross-cohort studies are needed to understand a larger population of students and changes in students' perceptions over time. This study is beginning to examine the perceptions of students from multiple cohorts over a two-course senior design sequence within mechanical engineering and to connect the results to the pedagogical design of the course by examining multiple cohorts of students within this course sequence.

Methods

Purpose

This work-in-progress is part of a larger study examining the experiences of mechanical engineering students within a two semester senior design course. The purpose of this paper is to highlight the preliminary results of an exploration of students' perceptions and incorporation of stakeholder needs and values. Students within the senior design sequence were given a survey each semester of the course that included a question designed to elicit their perceptions about stakeholders. In particular, this survey question and the methods described in this section seek to answer the following research question: *How do mechanical engineering students' incorporation of stakeholder considerations, as a part of their design process, develop throughout the course of a senior design sequence?*

Research Site and Sample

This research is currently being conducted at a large public university in the southeastern United States. In 2019, the mechanical engineering department engaged in a complete redesign of its senior design course sequence. The motivation for the redesign was multifaceted: (1) increase the number of client-based projects and industry-partnerships in the course, (2) scaffold aspects of the problem definition phase of design in the first semester of the course, (3) increase support for student teams throughout the project, and (4) engage students in thinking more explicitly about the implications of their work. The new version of the course is divided across two semesters,

Senior Design 1 (SD1) and Senior Design 2 (SD2). The first semester is a lecture- and workshop-based course that provides students with opportunities to engage in in-class activities as well as individual- and group-based assignments that are designed to strengthen their skills and expose them to new concepts in engineering design (e.g., ethics, problem definition, stakeholder exploration, ideation). At the beginning of the first semester, students are also placed in teams (using a team formation survey) for their year-long client-based senior design project. Thus, in the second semester, while there are still some in-class activities focused on the project, the students spend the majority of their time working with their teams. The course concludes with a large community-wide poster session to celebrate the student teams' accomplishments.

Within the redesign, particular activities were implemented in SD1 to help students consider stakeholders and the overall context of their projects. For example, during the problem definition module within the course, teams needed to articulate the different stakeholder groups for their project and in some cases, instructors prompted them to examine the needs of the stakeholders in more detail. Later in the course, in the "understanding the impact of your design" module, student teams explore the global context of their work and the implications of their designs on individuals, society, etc. Each of these modules aligned with components of the design report that SD1 teams worked on during the first semester and completed in SD2.

To examine the experiences of students within this course sequence and to look at differences before and after the major redesign and subsequent smaller changes, the study participants are divided into groups. These groups, which will be referred to as cohorts, are characterized according to when, in the academic year, participants are enrolled in the SD course. In this work-in-progress, we are focused on four cohorts: Cohort 0, Cohort 1A, Cohort 1B and Cohort 2. Further indication of when each cohort took SD1 and SD2 as well as what iteration of the redesign each cohort underwent at the time can be seen in Figure 1. It is relevant to note that Cohort 0 took the course sequence prior to the redesign of SD.

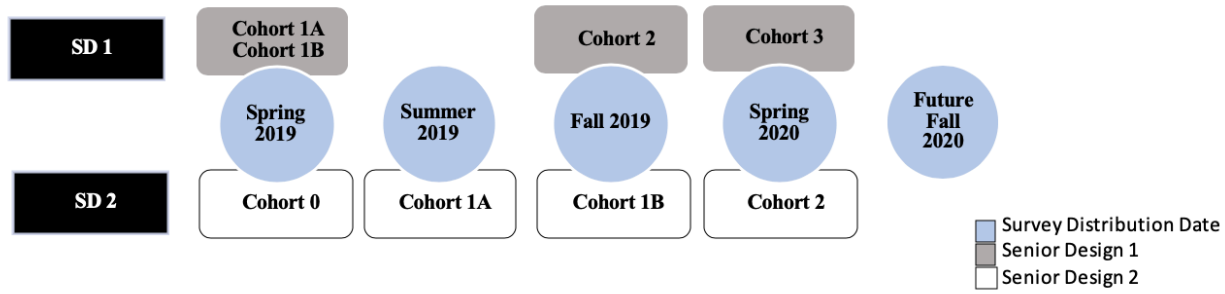

Figure 1: Cohort and Survey Distribution Timeline

Of those students within the cohorts, the response rates varied. Cohort 0 consisted of 116 students and 23 participated in the study (20% response rate). For Cohort 1A, 21 of the 28 students participated in the spring (75%) and 16 in the summer (57%). Since the students did not have to include their names or partial IDs on the survey, only 10 responses (36% response rate) could be matched across the semesters. For Cohort 1B, 26 of the 40 students agreed to participate in the study (65%) and 18 in the fall (45%). While only 14 responses (35% response rate) could be matched across semesters, the sample represents the same response rate as Cohort 1A. Cohort 2 consisted of 103 students, yet in the first semester of the course, only 12 students agreed to

participate in the study. For this analysis, data were analyzed for participants who completed both surveys in SD1 and SD2 and whose responses could be matched (with their name or partial ID), since we sought to understand change across semesters. Future analyses will examine all the data in aggregate.

Table 1: Number of Participants per Cohort
(*These two cohorts enrolled in the same section of SD1 but took SD2 in different semesters)

Cohort Name	Cohort 0	Cohort 1A*		Cohort 1B*		Cohort 2
Class	*SD2 Spring 2019*	*SD1 Spring 2019*	*SD2 Summer 2019*	*SD1 Spring 2019*	*SD2 Fall 2019*	*SD1 Fall 2019*
Class Size	116	28	28	40	40	103
# of Participants	23	21 (10 matching)	16 (10 matching)	26 (14 matching)	18 (14 matching)	12

Data Collection

A survey was distributed at the halfway point (6th or 7th week of a 14-week term) of the semester as part of a mid-semester feedback opportunity. Students received the survey via a Qualtrics survey manager link and either completed it in-class or at home. It was not mandatory for students to respond to the survey.

As part of the survey, students were asked to provide responses to a scenario-based design task, originally created to capture students' connections between design requirements and the stakeholders who can be affected by the design (e.g., operators, maintainers, users, non-users, etc.) [7]. The prompt for the task is as follows:

> *"For this problem, imagine you are an employee at AeroAquatics, Inc, a submarine design firm. Based on a recent design challenge, upper management has tasked you with heading up the conceptual design of a new personal submarine. The submarine will be used by researchers (and other customers) to perform solo deep dives in the ocean." Prior to the first team meeting, upper management asked you to prepare a list of factors that will be important to consider for the project. Please list the factors that the team should consider.*

Analysis

To examine the breadth and depth of students' responses, Coso [7] developed a coding scheme based on the categorizations used to evaluate solutions to a commonly used design task in engineering design education, the Midwest Flood Problem. This design task has been used to examine the perceptions of students and practicing engineers as they identify different considerations necessary to design a retaining wall system for the Mississippi River [29], [33], [34]. In both coding schemes, each student's response is classified with a Design Consideration categorization and a Frame of Reference categorization. For the AreoAquatics Problem, Design Considerations represent the object of focus of the student's response, which could be the *submarine*, the *surroundings*, or the *stakeholders* (see Table 2).

Table 2: Design Considerations Description

Design Considerations	Description
Submarine	The submarine itself, but specifically the non-user focused systems, the technology which could be used, and the locations where the submarine might operate
Surrounding	The environment surrounding the submarine, which includes aquatic life, the ocean ecosystem, etc.
Stakeholder	These focus on the various stakeholders, ranging from the design of the submarine controls (operator) to market research (potential customer) to considerations affecting maintainers and competitors.

The Frame of Reference categorization is used to define the type of design criterion being described, which could be *technical*, *logistical*, *natural* or *social* (see Table 3). Both categorization schemes also included a *no code* category, which was used for responses that did not apply to any category or fell outside the realm of the study being conducted. Figure 2 was used to group pairings of Design Considerations and Frames of Reference into overarching categories: *Considers Stakeholder*, *Considers Context*, and *Vehicle Specific*. These categories were used to explore how the emphasis of design considerations changed over time as students moved from SD1 to SD2.

Table 3: Frame of Reference Description

Frame of Reference	Description
Technical	Technical or engineering vocabulary, design issues, decisions about having the submarine
Logistical	Cost, funding, construction process, maintainability issues, resources needed
Natural	Water, topography, animals, plants, weather, weather predications, damage caused by sub on environment
Social	People, safety, concerning people, towns, living areas, fields of engineering and education, markets

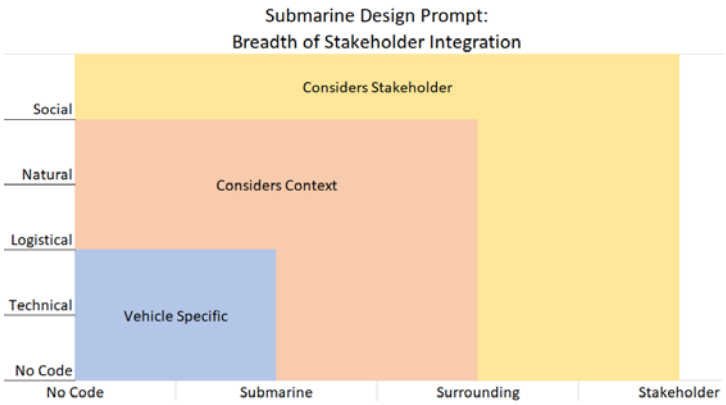

Figure 2: Categories for Analyzing Breadth of Discussion within Submarine Design Scenario

An example of a student's response across both semesters is included in Table 4. When conducting the analysis of Alexis's (pseudonym) response the researchers split the response into separate considerations or segments. For example, Alexis, a student in Cohort 1B, included the following statement, "What negative impacts the design may have on the environment or on the people using it." This statement can be broken up into two segments, (1) "what negative impacts

the design may have on the environment," and (2) "or on the people using it". The first segment would be coded as *surrounding* for its Design Consideration with *natural* as the Frame of Reference. The second segment would be given the code *stakeholder* for its Design Consideration with *logistical* as the Frame of Reference.

A Kappa test was used to assess interrater reliability between members of the research team [29], [35]. For responses from each cohort, ten responses were coded by three members of the research team. Their codes were compared, and Kappa was calculated. If Kappa was below 0.8, the team discussed each of the codes in depth, expanding on the definitions of codes and examples of those codes in the codebook as needed. Then the team independently recoded the ten responses. Once the team achieved a Kappa of 0.80, they discussed any discrepancies in their coding and finally, divided the remaining responses among the research team. As responses were coded, the existing codebook was updated and expanded upon to include examples of the different codes from this data set, with the research team convening to discuss general trends as well as questions and disagreements about the codes.

Table 4: Example of Student Response

Alexis	
SD1 Spring 2019	What about the prior submarines have worked in the past. Who is it going to be used for. What negative impacts the design may have on the environment, or on the people using it.* What material should be used for the different higher pressures levels. Safety measurements that can prevent the submarine from breaking. The budget and cost for the entire project. How much time will be spent on each phase of design.
SD2 Fall 2019	- How big can the submarine be - How many people can the submarine hold - What are current restrictions on the designs of submarines - How deep will the submarine go - What material will the submarine be made out of - How will the submarine prototype be tested before its manufactured - How will the submarine prototype be tested after its manufactured - How will this submarine interact with the environment that its around. How will it effect the other fish? How will it effect coral reefs? - What are some safety features that can be installed in the submarine? - What is the estimated budget for the first prototype? - How much will it cost to test the prototype? - How can we save money on the testing? Can we test the submarine using 3D simulation software? - What is the estimated budget for the entire project?

With the implementation of a priori coding based on Coso's work [7], the research team was able to synthesize student responses and group them based on their focus on design details (or vehicle specific considerations), context and stakeholders (see Figure 1). Once all responses for a cohort were coded, they were placed onto bubble plots to facilitate the visualization of trends within the data. The bubbles represent the percentage of codes within each Design Consideration and Frame of Reference pairing.

Preliminary Results

The focus of this section is to share the preliminary results regarding how students' awareness and perception of stakeholders changed over the two-semester course sequence. Specifically, this section includes an analysis of the changes in Cohort 1A and Cohort 1B, and an analysis of two specific student cases to illustrate the trends seen in the results.

Looking first into the transition from SD1 to SD2, Table 5, Figure 3 and Figure 4 depict how students' consideration of the different aspects of design changed over time. The only responses considered in this analysis were from students who completed both surveys and their responses could be matched across the surveys. In Cohort 1A (spring/summer enrollment), there were a total of 93 coded considerations analyzed in the students' responses. Out of those 93, 48 of those considerations (48%) were vehicle specific considerations while context and stakeholder considerations were only mentioned 15 (15%) and 30 (30%) times, respectively. As this cohort moved into SD2, the number of total considerations decreased to 78, meaning that students considered fewer aspects of the design during SD2 than they did in SD1. Yet, the trend seen in SD1 remained, with 39 of those considerations being vehicle specific (45%), and only 18 context considerations (22%) and 21 stakeholder considerations (25%). As a result, stakeholder considerations decreased by 5% as students went from SD1 to SD2, while vehicle specific considerations decreased by 3% and context considerations increased by 7%. Although there was a 3% decrease in vehicle specific considerations, the students' responses were still greatly focused on the vehicle itself, with 45% of the responses being vehicle specific during SD2.

In Cohort 1B (spring/fall enrollment), there were a total of 135 considerations analyzed in the student's responses during SD1. Of those 135, 73 were vehicle specific considerations (53%) while context and stakeholder considerations were only mentioned 23 (17%) and 39 (28%), respectively. In SD2, Cohort 1 B considered more aspects of the design with a total of 147 considerations. As observed before, these considerations were mostly vehicles specific considerations, with 91 of the considerations being vehicle specific (61%), while context was considered significantly less, with only 12 (8%) considerations, in respect to other categories. Consideration for stakeholders was also low with only 44 of the 147 considerations being stakeholder considerations (29%), which is only a 1% increase from SD1 to SD2. In regards to the other considerations, as students went from SD1 to SD2, their considerations for context decreased by 9% and their vehicle specific considerations increased by 8%. Although Cohort 1B increased in total number of considerations in their responses, the considerations are mostly vehicle specific with very little consideration for context and stakeholders. Statistical analysis of the changes did not reveal any statistically significant shifts; however, given the small data set at this stage in the analysis, this result did not surprise the research team. Overall, the responses of students across both cohorts indicated that as they move from SD1 to SD2 their focus becomes more on the vehicle itself, with relatively few considerations for context and stakeholders.

Table 5: Number and percentage of each type of consideration in responses from all cohorts (*These two cohorts enrolled in the same section of SD1 but took SD2 in different semesters)

	Cohort 0		Cohort 1A*				Cohort 1B*				Cohort 2	
	SD2 Spring 2019		SD1 Spring 2019		SD2 Summer 2019		SD1 Spring 2019		SD2 Fall 2019		SD1 Fall 2019	
Vehicle Specific	68	64%	48	48%	39	45%	73	53%	91	61%	82	74%
Considers Context	11	10%	15	15%	18	22%	23	17%	12	8%	14	13%
Considers Stakeholders	24	23%	30	30%	21	25%	39	28%	44	29%	14	13%
Total Number of Considerations	103		93		78		135		147		110	

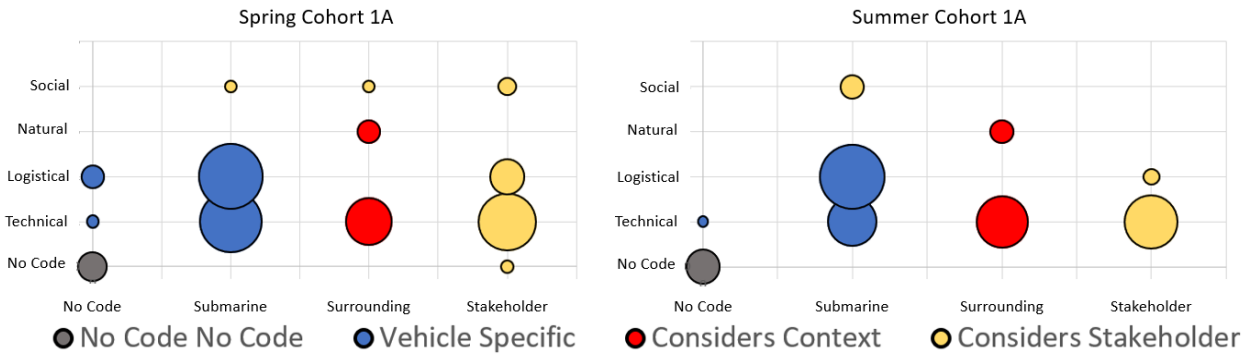

Figure 3: Breadth of Considerations in Cohort 1A

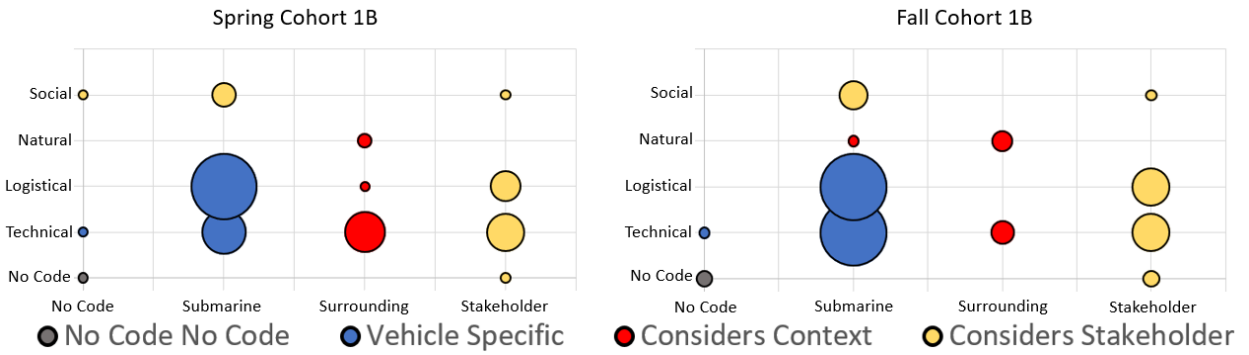

Figure 4: Breadth of Considerations in Cohort 1B

While the cohort-wide analysis provides one illustration of the change in students' perceptions, the cohort-wide trends were not consistent across each student. Looking more closely at Taylor's and Alexis's responses provides insight and examples of the general trends observed in Cohorts 1A and Cohorts 1B. Taylor's responses, as illustrated in Table 6 and Figure 5, highlight the first case, where the student considers stakeholders equally or almost equally throughout their time in the Senior Design course sequence. In SD1, Taylor had a total of 19 considerations in their response. Taylor's total number of considerations during SD1 was high compared to the mean number of considerations for SD1 in Cohorts 1A and 1B, which had means of 9.8 and 9.79, respectively. Of those 19, 7 of them were vehicle specific considerations (37%), and 6 for both context and stakeholder considerations (31%). Taylor considered all aspects of the design almost evenly, and even had a high consideration for stakeholders. As Taylor moved into SD2, the number of considerations in their response dropped to 16 but they continued to consider stakeholders as much as other parts of the design. Like in SD1, Taylor's total number of considerations during SD2 was above the means for SD2 in Cohorts 1A and 1B, 8.5 and 10.27 respectively. Of the 16 considerations, 4 of them were vehicle specific considerations (24%), and 6 for both context and stakeholders (35%). For Taylor although less considerations were mentioned as they moved through the Senior Design course sequence, they continued considering stakeholders throughout. The desired general trend was either this consistent consideration of stakeholders or an increase in stakeholder considerations over time.

These preliminary results, however, yielded trends more closely compatible with those found in Alexis' response (shown in Table 6 and Figure 5). During SD1, Alexis had a total of 8

considerations in their response, 2 of which considered context (26%) and 3 for both vehicle specific considerations as well as stakeholder considerations (38%). Alexis's total number of considerations during SD1 were around the mean for the cohorts (Cohort 1A mean: 9.8, Cohort 1B mean: 9.79). As Alexis continued into SD2, their total considerations increased to 16, which was above the mean for the cohorts (Cohort 1A mean: 8.5, Cohort 1B mean: 10.27). Yet, their considerations for stakeholders decreased substantially, and their considerations became much more vehicle specific. Out of the 16, 11 considerations were vehicle specific (69%), only 3 were context considerations (19%), and only 2 were stakeholder considerations (12%). This example illustrates the instances where a student moved from SD1 to SD2 and while the total number of considerations increased, very few considerations were stakeholder considerations and the majority of their considerations were vehicle specific.

Table 6: Number and percentage of each type of consideration for Taylor and Alexis

	Taylor				Alexis			
	SD1 Spring 2019		SD2 Summer 2019		SD1 Spring 2019		SD2 Fall 2019	
Vehicle Specific	7	37%	4	24%	3	38%	11	69%
Considers Context	6	31%	6	35%	2	26%	3	19%
Considers Stakeholders	6	31%	6	35%	3	38%	2	12%
Total Number of Considerations	19		16		8		16	

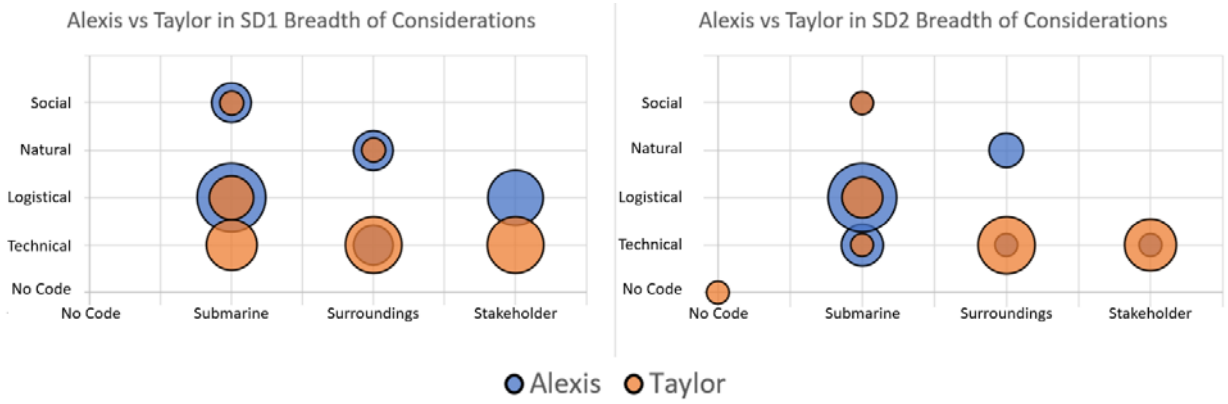

Figure 5: Breadth of Considerations from Taylor and Alexis

Overall, the results indicate that students' considerations of stakeholders did not improve significantly as they move through their Senior Design course sequence, which stands in contradiction to what was expected by the instructors since the course sequence included lessons tailored to emphasize the importance of stakeholder considerations in design. An example of what was hoped for in the results was shown with Taylor, where the student considered stakeholders consistently as they moved from SD1 to SD2. Instead, students tended to consider other aspects of design as they moved through their Senior Design Course sequence. An example of this trend was found in Alexis's responses, where they equally focused on all aspects of design initially, but as they moved into SD2, they began to consider vehicle specific aspects of the design much more than they did other aspects of design.

Limitations

While this paper presents preliminary results from a larger study that is still in progress, it is important to note a few limitations about the work. First, the voluntary nature of the survey led to lower response rates in some semesters than others. Moving forward, the survey will be distributed during class and as part of a larger feedback opportunity in attempts to improve the response rate. The timing of the surveys at the mid-semester was selected to capture student perceptions after completing part of the course. Yet, students' perceptions may have been different if the survey had been distributed at a different time. In addition, the amount of time students received to input their responses into the survey may have felt restricting to some students, affecting the quality of their responses. In the future, more ideas on how to better structure or distribute the survey to reduce possible fatigue will be implemented. Lastly, as this a work-in-progress, the sample size used for analysis is relatively small and from a single institutional and departmental context. As the study continues, the research team will be able to increase their understanding of this course along with the overall transferability of the results.

Conclusion and Future Works

The purpose of this study was to begin to examine how students' perception and incorporation of stakeholders in a design developed during a two-semester senior design course. A survey containing an open-ended design prompt was distributed to undergraduate mechanical engineering students at a large public university. The design problem asked students to list factors that they would consider when solving the problem presented to them. After analyzing their responses, preliminary results showed that students tended to consider stakeholders less as they moved into the second semester of Senior Design and had limited consideration for stakeholders throughout both semesters. Other considerations such as vehicle specific considerations were described more commonly within the responses. This outcome was not what was expected as the course included activities and assignments designed to emphasize the importance of stakeholder considerations within a design. Looking ahead, these results illustrate the need to examine how course activities and project structure emphasize the importance of stakeholder considerations *throughout* the design process. Given that engineering starts and ends with people, it may be helpful to have students reflect on the impacts of their design work on stakeholders and the environment at different phases within the design process. Lastly, this result also highlights the need for the broader engineering design curriculum within senior design and possibly earlier required courses to examine how to better support students' thinking about the implications of engineering and its relationship to society.

The lack of deep consideration for stakeholders seen in the preliminary results of this work in progress is consistent with previous studies of students from a large public institution. Researchers found that learning activities focused on stakeholders supported students' awareness of stakeholder considerations, but that effect was limited to the short-term for most students [7]. By the end of the final semester of the two-semester course sequence, some teams considered stakeholders, a few very deeply, while most teams did not deeply consider the project's stakeholders [7]. In this study, four reasons were attributed to this difference: (1) lack of explicit stakeholder requirements or focus within team design project requirements, (2) evaluation/assessment strategy, (3) differences between the first and second semester task and authority structures, and (4) availability of tools (e.g., design tools, stakeholder integration techniques) and resources (e.g., time, information about stakeholders, etc.) [7]. The implications

of the preliminary results described in this work-in-progress suggest a need to explore these four, and other, potential reasons for the decrease in considerations of stakeholders within the continual improvement of this mechanical engineering senior design sequence.

As more data is collected during Spring 2020 and Fall 2020 semesters, the research team will continue to analyze students' responses to the open-ended design challenge discussed in this work-in-progress. This analysis will allow for a further understanding of what considerations students consider when faced with a design problem. It will also determine if the trends have remained the same or have shifted from those seen in Cohort 1A and Cohort 1B, as well as whether there are differences in the trends based on gender, race/ethnicity, or other factors (e.g., previous design experiences, career plans). Future work stemming from this research will also delve into understanding why students seem to prioritize other considerations at the expense of stakeholders during their engineering design process. Exploring the remainder of the survey will give an insight on how students perceive, experience, and define engineering design as well as how these perceptions and experiences can impact a student's design experience. Future work will also explore the changes made during the redesign of the two-semester Senior Design course and how these specific changes may have impacted students' experiences in the course as well as their design processes and consideration of stakeholders. This work-in-progress and all future work stemming from it can be a resource for researchers and educators interested in understanding a student's engineering design experience and the pedagogical and individual factors that can impact it.

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