Understanding Student Attitudes about the Design Process

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This paper attempts to understand why the students need so much direction for their senior design project. It was initially hypothesized that students do not perceive the design process as being valuable or necessary, and thus don't take it seriously or put in the desired effort. A survey was developed to assess student attitudes about the design process to see if the hypothesis was correct. However, the survey results show that the students perceive the steps in design process at the same level as the faculty. Hence, there is not enough evidence to support the hypothesis that students lack motivation because of not believing in the importance of the design process. Other causes of the problem such as difficulty in implementing the design processes were analyzed in a follow-up study. Results of follow-up survey indicate that students perceive certain parts of design process, such as generating specifications, as difficult to implement for their project. In addition, results indicate that students hesitate to put forth their best effort when resubmission is allowed.

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Introduction

At Penn State Behrend the capstone design course is a 2-semester 6-credit sequence. Almost all projects are industrially sponsored, and the students are allowed to select their own teams of 3-4 students. Students are also allowed to find their own project if they wish. Each team is assigned a faculty advisor, who along with two other faculty members act as a committee to evaluate the project. Team and project assignments are finalized during the first two weeks of classes in the Fall semester, and the projects culminate in a presentation at a design conference at the end of the Spring semester.

There is a sense amongst a number of faculty at Behrend that advising these projects requires more effort than it should. After all, students have spent three years learning the fundamentals of engineering. Seniors have already had significant design experience at various levels of their program and have also learned how to apply engineering science to design problems. Yet, in their capstone experience they seem lost and need more direction than one would expect.

There are several potential reasons for this discrepancy, including:

- Students not buying into the need for following the design process. Some students see the capstone design course as a waste of time. Others feel they already know the solution to the problem and just want to implement it.
- Students not really understanding how to use the design process. For example, writing specs – which to an experienced faculty member seems like a rather straight-forward process – seems to some students to be confusing.
- Students not having learned the engineering fundamentals as well as they should have. We have seen seniors in Mechanical Engineering unable to draw a simple Free Body Diagram – in spite of having done this already in at least 5 earlier courses.
- Students having a "check-box" mentality – they view each task as a hurdle to be overcome, and once that task is done they are ready to move on – whether they have jumped the hurdle correctly or not.

Anecdotal evidence suggests that at least part of the problem is that the students don't really buy into the need for the design process. Student comments in formal surveys (such as the end-of-the-semester evaluations and graduating senior surveys) indicate that a significant number of students see little value in the capstone design course; whether this is due to the course structure or a perceived lack of value of the design process is not clear. Other students have commented on the worthlessness of writing specifications and other aspects of the design process. It should be noted that our industrial partners (employers, project sponsors, etc.) and many of our former students working in industry see our year-long senior design projects as a major strength of our program and graduates, so it is something about the *process* that the students don't like

rather than an objection to the capstone project as a whole.

Literature suggests that student motivation for capstone design can be improved with industry sponsored projects and real stake holders [1,2]. Since almost all of the senior design projects at Penn State Behrend are industry sponsored, the lack of a real customer should not be an issue. Also, students are allowed to pick their own teams to help avoid the problems related to lack of motivation due to an ineffective team [3,4]. We have not tried motivating the students for the capstone projects with competition or gaming [5,6]. The competition-based motivation is difficult with our setup where the nature and scope of each project is different and we have different advisors for each project.

This paper makes a preliminary attempt to understand the problem for lack of motivation in senior design projects. To better understand the issue, it was initially hypothesized that students do not see the design process as being valuable or necessary, and thus don't take it seriously or put in the desired effort. A survey was developed to assess student attitudes about the design process to see if the hypothesis was correct, which is explained further.

Research Method

The survey was conducted to understand the perception of students about the design process followed in the senior capstone project. The specific design steps considered for this study are developing specifications, concept generation and concept selection, along with the design process as a whole. Students were asked to rate the importance of each step in the design process on a scale of 1 to 6 with 6 being extremely important. The survey is shown in Figure 1.

The survey was administered amongst the seniors who completed first semester of the senior design project course in the Fall 2013 semester. At this stage all students had written and presented a mid-semester project proposal. The project proposal includes a problem statement, specifications, design tasks for the first semester, realistic constraints, technical challenges, and identification of applicable standards. In-class lectures on concept generation and concept selection were completed at the time of the survey but not all teams had done concept generation and concept selection at this stage. Fifty-nine out of the sixty-four students responded to the survey. Students received

Survey for Senior Capstone Design

This part of the survey aims to understand your perception about the design process followed in the senior capstone design course.

Using the scale below, (*with 6 being extremely important*) please rate how important you think each of these processes are to the successful completion of the your senior design project.

Extremely unimportant	Moderately unimportant	Slightly unimportant	Slightly important	Moderately important	Extremely important
1	2	3	4	5	6

		Circle one					
1	**Developing specifications** with metrics and values	1	2	3	4	5	6
4	**Concept generation**: generating many concepts to explore the solution space	1	2	3	4	5	6
5	Judging the **concept's feasibility only after** the concept generation phase is complete	1	2	3	4	5	6
6	Using a structured process for concept selection (e.g. **weighted decision matrix**)	1	2	3	4	5	6
7	Use of a **structured design process** in general	1	2	3	4	5	6

Figure 1. Survey with Students

extra credit for participation in the survey. The data were collected anonymously and students were informed that their response would not affect their class performance to get their honest opinion.

A similar survey was administered to the faculty project advisors. Additional information regarding the years of experience for mentoring students on design projects was also collected. The survey was administered in a faculty meeting and data were collected anonymously. Ten faculty responded to the survey. Those involved in this study were excluded.

Results

Figure 2 shows the average importance of the design processes as perceived by the faculty and the students. The results from all faculty and from faculty with at least one year of design experience (which are 8 out of total 10) are plotted separately. The sample size of faculty group is relatively small. The values of perceived importance are represented as Mean ± SEM (standard error mean).

The results show that both the faculty and students have similar perceptions about the importance of developing specifications, generating many concepts to explore the solution space, and using a structured process for concept selection. The students and faculty perception differ, although not significantly at $\alpha = 0.1$, for not judging the concept's feasibility until after the concept generation phase is complete. The student's perception on using a structured design process in general is significantly lower ($p = 0.058$) than the experienced faculty. The students and faculty both perceived that developing specifications, generating many concepts to explore the solution space, and using a structured design process in general are significantly more important compared to deferring judgment on concept's feasibility and using a structured process for concept selection.

Discussion

The results show that students do believe in the importance of following a design process, and that their perceptions are similar to that of the faculty. The initial hypothesis is not supported by the results of the survey.

An interesting result from this survey is that both students and faculty view deferring judgment on design concepts to be only slightly important. One possible reason for this is that many of the projects have significant technical challenges, and unless the students fully understand the technical issues it is impossible to generate good concepts. Only by analyzing a concept is one able to fully appreciate the *technical* reasons that a concept isn't good. For example, Dyson made over 5,000 prototypes of his cyclonic vacuum cleaner before he was ready to start marketing the product[7]. In essence, his process was one of enlightened trial and error – coming up with a concept, evaluating it, *understanding* why it did or did not work, and then modifying the design.

This also points out a potential problem in the way concept generation is typically taught and explained in engineering design textbooks. Although iteration is discussed, the concept generation phase is explained as a "step" in the process. Once the students have completed that "step", they are ready to move on to finalizing the design. They view concept generation as a "one and done" process and are hesitant to cycle back even if further analysis shows that the final concept really isn't a good one. Further investigation and discussion of this issue is suggested.

Also seen from the results is that using a structured process for concept selection is not perceived as important as other steps. One of the probable reasons might be that students tend to get fixated on the solution that first occurred to them and are hesitant to accept the results of the decision matrix. This result also needs further investigation.

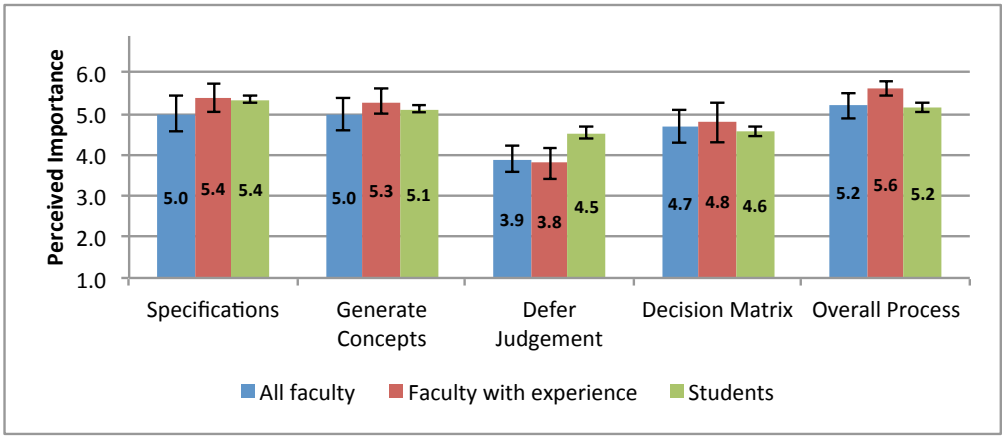

Figure 2. Results from the student and faculty survey

Since the initial hypothesis was not supported by the survey data, an additional survey was administered to the same group of students in the Spring 2014 semester to explore further reasons for lack of student motivation. Thirty-nine out of sixty-four students responded to the follow-up survey. The follow-up survey was conducted in the second semester of senior design project; at the time of the survey students were nearing the end of their projects and detailing their designs. Since students understand the importance of the process, the investigators decided to explore, in the follow up survey, whether the students find the design processes difficult. Even if the students understand the importance of the design processes they might face difficulty in actually implementing it to their respective projects.

In the follow-up survey, students were asked to rate the difficulty of each of the design processes. Students reported that generating specs is significantly more difficult (p-value < 0.01) than the overall structured process, concept generation, and concept selection(see Figure 3). Also, they reported that deferring judgment is significantly harder than the overall structured process. Students were also asked if they had a job lined up post graduation that affected their motivation. However, the prospect of lined-up job did not interfere with their motivation for senior design. Students were also asked if they think they are prepared with the fundamentals for their senior projects. Most students think they are well prepared on their fundamentals.

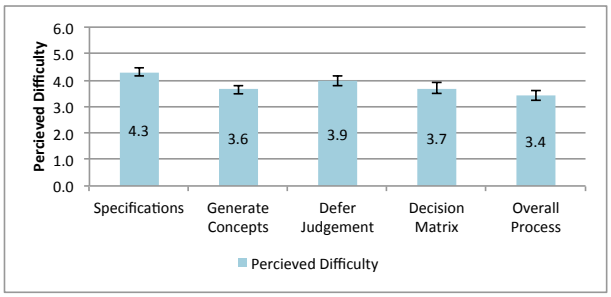

Figure 3. Results from the follow-up study

One of very interesting findings from the follow-up survey was the response to the question on how important they think it is to put in their best effort (a) when they turn in an assignment that will be graded in general, and (b) when the turn in the first attempt of an assignment that will be graded and they know that revising and resubmitting is allowed. A paired t-test was conducted between these two responses. The students' perception of putting in their best work is significantly lower (p-value < 0.0001) when revision and resubmission is allowed. This result indicates that the students might be viewing the iterative process of senior design as allowing a "second chance" and thereby producing a lack of motivation to put in their best efforts.

Conclusions

This paper aims to investigate the reasons for lack of motivation amongst students to put their best efforts into the design process. One of the possible causes for the lack of motivation was that the students do not believe in the importance of following the design process in the capstone design course. The authors conducted a survey to understand the student and faculty perception on the main steps in the design process. The survey results showed that the students perceive the steps in design process at the same level as the faculty. Hence, there is not enough evidence to support the hypothesis that students lack motivation because of not believing in the importance of the design process. Results from an additional survey indicate that students perceive certain parts of design process, such as generating specifications, as difficult to implement for their project. In addition, results indicate that students also hesitate to put forth their best effort when resubmission is allowed. Other causes of the lack of motivation will be explored in future work.

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