Students' Perceptions of the Differences Between Design and Non-Design Classes

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Engineering design classes represent one of several different ways to reform engineering education to make it more responsive to the needs of industry and students. In design classes, students work in collaborative teams to develop a solution to an open-ended problem - one having several feasible solutions. The open-ended - problems incorporated in design classes are real-world, practical problems typical of those many young engineers will encounter in their first few years of practice. Thus, design classes fall into a growing category of classroom experiences that provide opportunities for students to engage in authentic activities, those of their intended profession. However, goals of design classes differ markedly from those of traditional engineering (non-design) classes which raises questions not only about students' perceptions of design classes, but also about how students' perceptions of what constitutes "real" engineering coursework constrain students' design work. As suggested by Tonso and Catalano (1995), taken-for-granted past practices - such as traditional coursework - constrain reform in engineering education. As part of a larger research investigation into the development of engineering identities among students participating in design work (Tonso, in progress), I am studying how engineering students are embedded in engineering education, what constraints exist to students' becoming engineers, and how those constraints vary due to gender, age, or prior experiences. The survey reported in this paper represents a portion of my efforts to investigate these constraints by studying students' perceptions about design and non-design engineering classes.

The Survey

In the survey (Figure 1), students gave demographics information (age, sex, citizenship, ethnicity, SAT or ACT scores, high school and college grade-point averages) and then responded to the same set of 13 statements first considering their experiences in core (non-design) classes and then considering their experiences in design classes. A five-point Likert scale was used, ranging from 1 = "strongly disagree" to 3 = "neither agree nor disagree" to 5 = "strongly agree." There were 274 students surveyed during the 1995 spring semester: 71 freshmen in design classes, 70 freshmen in non-design classes, 62 seniors in design classes, and71 juniors or seniors in non-design classes. Because the engineering core classes that students take in their senior year are often different for each engineering specialty, I surveyed juniors enrolled in a core engineering class required of all students and not one specific to an engineering specialty. By administering the survey in core and design classes meeting concurrently, I eliminated the possibility that a student might complete more than one survey.

Analysis of the data used statistical procedures to compare selected means using two-sample T-tests. Prior to executing the two-sample T-test, a two-sample F-test for variances was run to determine if the variances were equal or not, and then the appropriate T-test (assuming equal variances or assuming unequal variances) applied. In the tables that follow, μ refers to the mean for the data set and P the one-tail probability that the two means differ enough to be statistically significant. In addition to comparing students' responses about design and non-design classes, statistical analysis focused on contrasts between women and men students, across academic level (first-year versus third- and fourth-year classes), and on whether students were enrolled in design or non-design classes when they took the survey.

Comparison of Students' Responses for Core and Desire Classes

Students gave distinctly different responses for 10 of the 13 items, comparing core to design classes using the T-test. For the other three items, students perceived core and design classes similarly.

Figure 1. Survey, Spring 1995

Questionnaire: Comparing Core Classes and Design Classes in the Engineering Curriculum (Spring 1995)

Age ________ Sex ________ Year in College ____________ Citizen of __________________

Ethnicity: African-American Hispanic Asian White Other ________

SAT or ACT Scores and GPA's (Please estimate these and write NA if you cannot recall.):

Math ________ Verbal ________ GPA - High School ________ GPA - College __________

Core Classes

Consider your experiences in the vast majority of your classes - "core classes" such as required Physics, Chemistry or Mathematics classes, as well as Statics, Thermodynamics, or Fluids - where the bulk of the course involves listening to professors lecture, working textbook problems for homework, and taking hour exams. Please indicate the extent to which you agree or disagree with the statements below. Circle the number on each scale that best reflects your feelings about the corresponding statement. The alternatives range from 1 (strongly disagree) to 5 (strongly agree).

For these kinds of CORE CLASSES:	strongly disagree		neither agree nor disagree		strongly agree
1. The course covers material that I will need as an engineer.	1	2	3	4	5
2. I learn about how to communicate with other engineers.	1	2	3	4	5
3. The important learning is rules, facts, and methods.	1	2	3	4	5
4. I usually do my assignments alone.	1	2	3	4	5
5. High grades indicate my engineering skill.	1	2	3	4	5
5. I will use what I learn as an engineer.	1	2	3	4	5
7. Professors teach what I will need to know as an engineer.	1	2	3	4	5
8. Working with other students is cheating.	1	2	3	4	5
9. It is important to be able to work fast.	1	2	3	4	5
10. Problems have only one way to get an answer.	1	2	3	4	5
11. Professors know the best way to answer a problem.	1	2	3	4	5
12. Problems have one right answer.	1	2	3	4	5
13. My high school math and science classes were like this class.	1	2	3	4	5

Design Classes

Now think about your experiences in your design courses - such as the required entry-level or senior design classes and summer field sessions (for those students far enough along in their studies to have taken them). Please indicate the extent to which you agree or disagree with the statements below.

For these kinds of DESIGN CLASSES:	strongly disagree		neither agree nor disagree		strongly agree
14. The course covers material that I will need as an engineer.	1	2	3	4	5
15. I learn about how to communicate with other engineers.	1	2	3	4	5
16. The important learning is rules, facts, and methods.	1	2	3	4	5
17. I usually do my assignments alone.	1	2	3	4	5
18. High grades indicate my engineering skill.	1	2	3	4	5
19. I will use what I learn as an engineer.	1	2	3	4	5
20. Professors teach what I will need to know as an engineer.	1	2	3	4	5
21. Working with other students is cheating.	1	2	3	4	5
22. It is important to be able to work fast.	1	2	3	4	5
23. Problems have only one way to get an answer.	1	2	3	4	5
24. Professors know the best way to answer a problem.	1	2	3	4	5
25. Problems have one right answer.	1	2	3	4	5
26. My high school math and science classes were like this class.	1	2	3	4	5

Comparisen of Core Classes With Desire Classes

Finally, comment on what is different about how core classes versus design classes prepare you for engineering work.

Students agreed that they will use what they learned in both core and design classes as engineers. Students disagreed that high grades indicate engineering skill and that working together with other students is cheating. For seven of the 10 items with statistically significant differences in means, students' responses indicated either agreement or disagreement for both core and design classes, though student perceptions differed in degree. Students *agreed* that

- the courses cover material that will be needed as an engineer (more strongly for core classes)
- that professors teach what will be needed as an engineer (more strongly for core classes)
- that they learn to communicate with other engineers in both core and design classes (more strongly for design)

Likewise, students *disagreed* that

- professors know the best way to answer a problem (more strongly for design classes)
- that problems have one right answer (more strongly for design classes)
- that their college classes are like their high school math and science classes (more strongly for design classes)

However, for three of these 10 items showing statistically significant differences in the means of student responses, students agreed in the case of one kind of class and disagreed for the other. Students *agreed* that

- the important learning in core classes is "rules, facts, and methods," but disagreed that this is the case for design classes
- they usually do assignments alone in core classes, but disagreed with this statement for design classes
- one must work fast in core classes, but disagreed for design classes

Table 1. Students' perceptions of core and design classes, T-test analysis

Survey Item (n = 274)	Core μ	Design μ	P l-tail
The course covers material that I will need as an engineer.	3.81	3.60	0.01**
I learn how to communicate with other engineers.	3.15	3.79	<.001**
The important learning is rules, facts, and methods.	3.55	2.92	<.001**
I usually do my assignments alone.	3.44	2.42	<,001 **
High grades indicate my engineering skill.	2.60	2.66	0.28
I will use what I learn as an engineer.	3.65	3.74	0.13
Profs teach what I will need to know as an engineer.	3.47	3.27	0.003**
Working with other students is cheating.	1.72	1.60	0.10*
It is important to be able to work fast.	3.14	2.83	<.001**
Problems have only one way to get an answer.	1.78	1.73	0.28
Professors know the best way to answer a problem.	2.51	2.16	<.001**
Problems have one right answer.	2.33	1.83	<.001**
H. S. math and science classes were like this class.	2.56	1.87	<.001**

** Significant at the 0.05 level. * Significant between 0.05 and 0.10 levels.
(Answers >3 indicate agreement and <3 disagreement.)

Gender Analvsis

Of the 274 students, 70 were women and **202** were men, roughly the same ratio as that campus-wide. Statistically significant differences emerged for four core-class items and three design-class items.

For core classes, women students agreed to a lesser extent than their men colleagues that the course covers material needed as an engineer and that professors teach what will be needed as an engineer. Women students disagreed more than their men colleagues that professors know the best way to answer a problem and that problems have one right answer. Taken together, women's responses on these three items suggest that women are somewhat more skeptical of the traditional engineering curriculum, and its delivery, than their men colleagues.

For design classes, women students agreed more than their men colleagues that they learn how to communicate with other engineers. In contrast, women students disagreed less than their men colleagues that the important learning in design classes is "rules, facts, and methods." Women student engineers indicated that they were more likely to work alone on design-class tasks than their men colleagues. This contradicts earlier research on this campus (Tonso, 1993) indicating that women students embraced the group work in their design classes

Table 2. Gender comparison using the T-test

For CORE Classes			Comparison of Responses for Women and Men (n_w=70, n_m=202)	For DESIGN Classes		
μ_w	μ_m	P 1-tail	Survey Item	μ_w	μ_m	P 1-tail
3.66	3.87	0.04**	Covers material that I will need as an engineer.	3.50	3.64	0.17
3.20	3.13	0.31	I learn how to communicate with other engineers.	3.93	3.75	0.09*
3.49	3.57	0.26	The important learning is rules, facts, and methods.	2.74	2.98	0.05**
3.36	3.46	0.27	I usually do my assignments alone.	2.16	2.51	0.02**
2.49	2.64	0.17	High grades indicate my engineering skill.	2.65	2.66	0.47
3.56	3.69	0.15	I will use what I learn as an engineer.	3.85	3.70	0.11
3.29	3,54	O.001**	Profs teach what I will need to know as an engineer.	3.25	3.28	0.43
1.83	1.68	0.18	Working with other students is cheating.	1.66	1.59	0.31
3.06	3.17	0.24	It is important to be able to work fast.	2.72	2.86	0.20
1.70	1.81	0.22	Problems have only one way to get an answer.	1.79	1.71	0.27
2.24	2.61	0.003**	Professors know the best way to answer a problem.	2.06	2.20	0.18
2.09	2.41	0.02**	Problems have one right answer.	1.91	1.81	0.25
2.54	2.56	0.46	H. S. math and science classes were like this class.	1.74	1.92	0.11

** Significant at the 0.05 level. * Significant between 0.10 and 0.05 levels.
(Answers >3 indicate agreement and <3 disagreement.)

and found it more rewarding than their men colleagues. Though additional research would be needed to expand on this finding, there may be an undercurrent of "aloneness" that women face to a greater extent than men on engineering campuses. It seems especially unfortunate that this would be the case in design classes where group work is promoted to a greater extent than in core classes.

Grade-Level Analysis

Survey respondents were almost evenly divided between first-year (n= 140) and third- or fourth-year courses (n = 134). I compare the students enrolled in the first-year classes (μ_f) to those enrolled in the junior- and senior-level classes ($\mu_{j\text{-}s}$), without differentiating between juniors and seniors (Table 3).

Table 3. Grade-level comparison using the T-test

For CORE Classes			Comparison of Responses from Students in 1st-Year vs 4th-Year Classes (n_1=140, n_4=134)	For DESIGN Classes		
μ_f	$\mu_{j\text{-}s}$	P 1-tail	Survey Item	μ_f	$\mu_{j\text{-}s}$	P 1-tail
3.83	3.80	0.39	Covers material that I will need as an engineer.	3.52	3.68	0.10*
3.22	3.07	0.14	I learn how to communicate with other engineers.	3.68	3.91	0.02**
3.53	3.58	0.33	The important learning is rules, facts, and methods.	2.92	2.92	0.49
3.34	3.54	0.09*	I usually do my assignments alone.	2.57	2.27	0.02**
2.69	2.50	0.07*	High grades indicate my engineering skill.	2.59	2.73	0.15
3.69	3.61	0.24	I will use what I learn as an engineer.	3.75	3.73	0.45
3.51	3.44	0.22	Profs teach what I will need to know as an engineer.	3.24	3.30	0.33
1.74	1.69	0.33	Working with other students is cheating.	1.66	1.55	0.18
3.10	3.18	0.28	It is important to be able to work fast.	2.82	2.83	0.45
1.70	1.87	0.09*	Problems have only one way to get an answer.	1.76	1.70	0.29
2.33	2.70	0.001**	Professors know the best way to answer a problem.	2.01	2.32	0.005**
2.17	2.49	0.01**	Problems have one right answer.	1.83	1.83	0.48
2.59	2.51	0.29	H. S. math and science classes were like this class.	1.95	1.79	0.10*

** Significant at the 0.05 level. * Significant between 0.10 and 0.05 levels.
(Answers >3 indicate agreement and <3 disagreement.)

For five core-class and four design-class items, the students in first-year and third/fourth-year classes answered differently.

- Students in upper-division classes agreed more that they did core-class assignments alone.

- Students in upper-division classes disagreed more than those in first-year classes that grades indicate engineering skill.
- Students in first-year classes disagreed more that problems have only one way to get an answer, that professors know the best way to answer a problem, and that problems have one right answer.

Though students at both levels of study persisted in their disagreement, these last three items seem to indicate that over time student engineers shift toward a sense that there is one way to get *the* one right answer to a problem and that professors know best about this.

For design classes, students in upper-division classes agreed more that design classes cover material needed as an engineer and that they learn to communicate with engineers in design classes. However, students in first-year classes disagreed more that design-class professors know the best way to solve a problem. Students in upper-division classes disagreed more that their design classes are like their high school math and science classes.

Kind of Class Influences on Survev Responses

Students surveyed were split almost equally between core (n= 141) and design (n= 133) classes. In Table 4 below, μ_c refers to the mean for those students who took the survey while enrolled in a core class, while μ_d refers to the mean for those students who took the survey while enrolled in a design class. At issue is whether being in one kind of class or the other when the survey was taken influenced students' perceptions of each kind of class.

There appears to be a certain amount of "pride of ownership" in the responses. For instance, overall (Table 1), students agreed more that core classes covered material needed as an engineer. When commenting on core classes, those enrolled in both core and design classes agreed that core classes cover the material needed as an engineer. However, when commenting on design classes, those enrolled in design classes agreed more strongly that design classes cover material needed as an engineer, than those enrolled in core classes.

Something of a "my-prof-can-whip-your-prof" response came when asking students whether their professors teach what students will need as engineers. Students in core classes, commenting on core classes, were more positive than students in design classes commenting on core classes. In mirror-image, students in design classes, commenting on design classes, were more positive than students in core classes commenting on design classes.

Table 4. Kind of class where survey taken, analysis using the T-test

Commenting on CORE Classes			Comparison of Responses from Students in Core vs Design Classes (n_c=141, n_d=133)	Commenting on DESIGN Classes		
μ_c	μ_d	P 1-tail	Survey Item	μ_c	μ_d	P 1-tail
3.78	3.84	0.30	Covers material that I will need as an engineer.	3.29	3.92	<.001**
3.00	3.30	0.009**	I learn how to communicate with other engineers.	3.67	3.92	0.02**
3.63	3.47	0.09*	The important learning is rules, facts, and methods.	2.82	3.02	0.07*
3.49	3.38	0.25	I usually do my assignments alone.	2.46	2.38	0.29
2.71	2.48	0.04**	High grades indicate my engineering skill.	2.62	2.70	0.28
3.64	3.66	0.43	I will use what I learn as an engineer.	3.55	3.93	<.001**
3.57	3.37	**0.02****	Profs teach what I will need to know as an engineer.	3.11	3.43	**0.003****
1.66	1.77	**0.20**	Working with other students is cheating.	1.62	1.59	0.39
3.08	3.20	0.17	It is important to be able to work fast.	2.72	2.94	0.06"
1.81	1.76	0.35	Problems have only one way to get an answer.	1.81	1.66	0.11
2.64	2.38	0.01**	Professors know the best way to answer a problem.	2.17	2.15	0.44
2.52	2.13	**0.003****	Problems have one right answer.	1.92	1.75	0.10*
2.53	2.58	0.37	H. S. math and science classes were like this class.	1.92	1.83	0.24

** Significant at the 0.05 level. * Significant between 0.10 and 0.05 levels.
(Answers >3 indicate agreement and <3 disagreement.)

Students enrolled in design classes agreed more that they learned how to communicate with other engineers in both core and design classes. Likewise, though students in both core and design classes agreed that they would use what they learned in core classes as an engineer, students in core classes agreed slightly less strongly that they would use what they learned in their design classes, while students in design classes agreed more strongly that they would use what they learned in their design classes.

Summary

There are subtle differences in students' perceptions of core and design classes. Students' perceive that

- core classes cover somewhat more material needed when students become engineers and that professors in core classes teach that material,
- design classes develop students' engineering communication skills,
- important learning in core classes, but not design classes, is "rules, facts, and methods," and
- they work with other students on design-class assignments, but not those in core classes.

Women student engineers appear somewhat more skeptical of traditional engineering courses and tend to work with other students in design classes less than their men colleagues. It appears that as students progress through their undergraduate coursework, they shift toward a sense that there is one way to get one right answer and that professors know best about this. Taking the survey while enrolled in a core class tended to deflate slightly students' sense of design classes, while taking the survey while enrolled in a design class tended to inflate slightly design-class responses. This was particularly evident when students evaluated whether their professors teach what students will need to know as engineers.

The survey results begin the task of unraveling the constraints that core (or traditional) engineering classes place on students' perceptions about their design classes. However, these survey results tell only a partial story. Considering that on most engineering campuses design classes account for fewer than 10% of the undergraduate coursework, the sheer amount of time spent in core classes could overwhelm the design classes. Other information will be necessary to further tease out these complex issues. In other facets of my larger research project, I attend design classes with student engineers and listen as they make decisions about their design work. One of the strands of these discussions focuses on how little time can be devoted to their design work because of the time demands of their other, non-design classes. In addition, I interview students from the design classes in private where they again report that time constraints and pressure to do well in their core engineering classes limit their design-class work. When I complete the larger research project, I will be better equipped to explain just how these two kinds of classes interact while students are developing engineering identities.

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