AC 2009-2312: ONE SIZE DOES NOT FIT ALL: IMPACT OF VARIED FRESHMAN DESIGN EXPERIENCES ON ENGINEERING SELF EFFICACY

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One size does not fit all: Impact of varied freshman design experiences on engineering self-efficacy

Abstract

This paper presents results of a two year pilot program in freshman design. The program's goal was to create a variety of project-based learning, or PBL, freshman experiences in design and complex problem solving as a means of energizing a fundamentals-focused math and science freshman curriculum. A second goal was to develop students' self-efficacy in a range of abilities associated with engineering including design, problem solving, innovation, communication, teamwork, application of fundamental engineering and math concepts, teamwork, and being able to consider social impacts in technology in design. A third goal was to examine impact of different types of subjects by gender. The final goal was to discern if any gains in self-efficacy were sustained over time.

An engineering self efficacy survey tool was developed for this study, with an expanded set of engineering self efficacy measures, that permit a more nuanced portrait of the impact of different types of engineering curricular experiences on student self efficacy. While preliminary, student responses to the survey showed that hands on, rigorous, engineering design experiences leading to original design prototyping led to greater impact on men students' self efficacy than other types of design subjects. Student responses also showed that, while women students were energized by participation in PBL subjects, with more choosing engineering as a major compared to non-PBL women, the impact of women's self efficacy was only in design-innovation, compared to PBL men whose self efficacy was impacted in nearly all areas.

Perhaps most interesting of all were the changes in student self efficacy by mid-sophomore year for all students whether they participated in freshman design subjects or not. By mid-sophomore year, student self efficacy decreased from end of freshman year levels for all students, regardless of gender, for all ability measures.

By taking a longitudinal approach to the study, and implementing the survey tool over 3 periods (pre freshman, post freshman, and mid sophomore year) with the same student groups, the results also illustrate that gains in self efficacy, after an engaging freshman experience, are not permanent, nor do gains only increase over time. Rather, the value of self efficacy measures of engineering students, if implemented over several periods, is that they can reveal the roller coaster ride of students' engineering self confidence in response to positive and negative curricular experiences.

Introduction

In developing a variety of freshman project based learning (PBL) design experience, the goal was to energize a lecture-based freshman year of math and science subjects. Also, by permitting students to choose from a range of design subjects rather than only one general design subject for all, students potentially would be more motivated to learn in subjects closer to their interests.

The drawback to the development of a variety of freshman design subjects is that not all subject designs can lead to similar impacts on key engineering abilities. How broadly, one may ask, can the concept of "design" be stretched to cover widely varying subject conceptions? For example, how does a subject where students work together on thinking, in an engineering design sense, about solutions to global warming compare with a more traditional engineering design subject where students work on the design of remote controlled dirigibles. While the former may be more exciting to students, and more motivating, what impact will it have on engineering abilities?

An experiment with this question in mind was used as a baseline in developing a wide range of freshman design subjects that could attract not only students interested in engineering as a major, but all freshmen enrolled at the institution. The overall structure of the subjects was a loosely structured design "process." The subjects would also need to stress the development of teamwork, as well as written and oral communication abilities.

Measuring impact on student abilities after completing the widely varying types of pilot PBL subjects was another problem to solve. With the primary goal of energizing the freshman year's lecture based experience, and strengthening students' confidence in their abilities, a survey of ability self efficacy was developed.

A choice of a survey design that employed a self efficacy scale of confidence in ability to perform a task was based on Bandura's theory of self efficacy. Bandura's key contention about the role of self efficacy in individual development was that a person's confidence in his or her abilities would directly impact his or her course of action. Students engage in tasks in which they feel competent and confident and avoid those in which they do not. The stronger students' sense of self-efficacy, the harder they will try in face of adverse situations. As a result of these influences, self-efficacy beliefs can strongly determine a student's level of accomplishment (Bandura, 1997).[2] With respect to engineering study, students who are more confident in their engineering-related abilities, particularly in math, design and understanding of technical concepts, would be more likely to pursue, and stick with, a major in engineering.

Previous Work

Bandura (1997) showed that an individual's self efficacy could be increased by mastery experiences, experiences where one's confidence in ability to successfully and competently complete an authentic task. Ponton (2001)[12] pointed out that engineering subjects could be intentionally designed to incorporate such mastery experiences. The authors argued that students gain a sense of mastery in engineering practice from comprehensive subjects that permit students to engage in tasks that require the synthetic decision making and comprehensive design projects of real-world engineering.

Hutchinson (2006)[7] developed a survey tool to deeply investigate factors that influence engineering students' engineering self efficacy, and its connection with learning environment. The survey questions examined 9 factors that might influence students' confidence in their success in engineering: understanding/ learning, drive/ motivation, teaming, computing abilities (students were surveyed in a computing freshman subject), help with academics, working on assignments, problem solving abilities, interest/ satisfaction, and grades. The study used a mix of closed and open ended questions to gather from students the particular tasks that led to a student's sense of self efficacy for each factor. The study found that understanding/ learning was the most important factor, being cited by 70% of men and 55% of women. This factor was followed by, in order, drive/motivation, teaming, and computing abilities, and problem solving. A key theme running through students' sense of engineering self efficacy for every factor was the "ease" with which they could use a given ability in their engineering studies. With respect to understanding/ learning, for example, students cited understanding concepts, being able to learn and apply concepts quickly. For teaming, students cited working with other students in a team in general, but also in a manner where students supported one another in working on a problem. With respect to problem solving abilities, students again cited the ability to work through problems without any difficulty as a factor in self efficacy.

This study drew on Hutchinson's (2006)[7] work by listing tasks for a set of ability factors, and asking students to rate their confidence to perform that task, rather than provide students with an open ended opportunity to lists those tasks. The questions in this study drew out students' sense of understanding of concepts, ability to apply concepts quickly in several of the factor areas noted by Hutchinson (2006), namely teaming, problem solving. In this area, a composite factor of engineering including computing, math, and application of technical concepts was developed in place of computing used in the Hutchinson study.

In Prince's (2004)[13] comprehensive review of active learning in engineering education, Prince noted the difficulty in measuring the impact of problem based learning. The wide variety of subjects that fit under the definition of such subjects is one of the key issues that adds to this difficulty. Finally, he noted that PBL has been shown to have little effect on technical test scores, however, he found evidence that problem based learning subjects can work best in developing students problem solving and innovative, creative thinking abilities. This study incorporates project based learning with a eye to connecting technical material with projects in engineering. One aspect of the project is to determine if students' engineering self efficacy increases as a result.

Studies have argued that exposing students to engineering design activities during their freshman year will provide the sort of multi-dimensional, challenging experience that provides a base for many important skills students need for success in engineering (Ambrose 1997, Dym 1994; Masi 2003, Olds et al. 1990, Petroski 1998, Wayne 1999).[1,5,9,10,11,14] This study took the work of these authors into account in the creation of freshman subjects to not only motivate students in active learning experiences, and improve skills.

While many studies examined how curricular innovations, particularly PBL style interventions, impact student confidence and motivation, there is little work that considers how students' sense of confidence varies over time. Hutchinson (2006)[7], at the time of their study, implemented the engineering self efficacy tool in only one time period. Others have taken a longitudinal approach. Besterfield-Sacre (2001)[3] looked at attitudes about engineering, and confidence in engineering skills for women and men at the beginning and end of their freshman year. This study found that women's confidence in their abilities decreased from the beginning of their freshmen year to the end, while men's confidence remained unchanged. Brainard's (2001)[4] six year longitudinal study of a cohort of students found that, while male students' confidence in their abilities increased over their years of engineering study, women student's confidence decreased. Felder (1995)[6] also found declines in women's performance in engineering programs.

The Association of Women and Men in Engineering survey instrument, Longitudinal Assessment of Engineering Self-Efficacy, was developed to, per its name, longitudinally assess students' self efficacy in engineering (Marra, 2005).[8] That survey tool examined the experience of learning environment and its impact on learning. General questions, 4 in total, examined engineering-related learning outcomes for math, physics, and chemistry, important questions about core subjects important to freshman retention in engineering majors. However, deeper questions about learning outcomes in freshman design subjects, many of which are now integrated in engineering curricula across the United States, are not included.

This study brings together these streams of engineering education research, improving engineering self efficacy via targeted instructional design of freshman design subjects, development of usable tools for measuring engineering self efficacy, and longitudinal tracking of engineering students' self efficacy. In doing so, this study asks two questions: can a varied set of broadly defined freshman design subjects be designed specifically around authentic design tasks that positively impact student self efficacy on a specific set of tasks associated with engineering practice? Can that definition of freshman design experience be broadened and still have impact? If so, can students' improved engineering self efficacy be sustained over some period of time after the freshman design experience?

Freshman Project Based Learning Design Subjects

A wide range of freshman design subjects were developed that could attract not only students interested in engineering as a major, but all freshmen enrolled at the institution. The overall structure of the subjects would include a loosely structured design "process" that included the steps: 1- consider user needs, budget and scope, 2- set constraints, 3- gather information on problem, 4-develop ideas for solution, 4-choose best solution given constraints, 5-develop prototypes if possible. The subjects would also need to stress the development of teamwork, as well as written and oral communication abilities.

Subjects were developed that included civil engineering projects in New Orleans, transportation systems, how to slow rainforest deforestation by developing technology ideas in farming or logging for local populations, toy design, remote control dirigible design, underwater robots, and energy efficient vehicle design. Other subjects were drawn from bioengineering. In one subject, students used introductory knowledge of biotechnology processes to solve posed problems.

The subjects differed in one key aspect: whether they included hands-on design and prototyping. In several of the subjects, hands on design and prototyping was feasible, such as toy design, dirigibles, underwater robots, and energy efficient vehicles. In others, this was not possible, such as the New Orleans civil engineering project, or rainforest deforestation. And in others, such as the biotechnology project, the concept of hands on design and prototyping is not part of the design process.

Table 1 summarizes the different types of freshman PBL design subjects.

Table 1. Freshman PBL Design Subject Descriptions

PBL Subject Types	**Description of Typical Projects**	**Project Process**
A) Engineering design type A	Hands on engineering design projects leading to physical prototypes.	Step by step engineering design process is followed.
B) Engineering design type B	On paper engineering design projects focus on large scale problems in information infrastructure or transportation.	Step by step engineering design process is followed.
C) Large scale global/ technical or urban problems	Class works together in defining, breaking down into parts, suggesting solutions to major global technical problems, such as Rainforest deforestation, or New Orleans after Katrina.	Group problem solving process focuses on investigation of problem, seeking pertinent information on solutions, conveying solution ideas to wide audience.
D) Engineering science	Theory based analyses of engineering science problems drawn from bioengineering, biomedicine.	Problems posed are approached with introductory knowledge of biological technologies applied toward possible solutions.

Design Survey Tool

To test impact, all freshmen were given a written survey at the beginning and end of their freshman year, and at the mid-point of their sophomore year.

The survey tool was developed with the goal that it would provide a more nuanced portrait of the impact of freshman design experiences on student self efficacy over time. The survey tool included ability questions in 7 areas important for engineering design: teamwork, oral presentation, writing, engineering technical concept use and engineering math, design process and innovation in design, problem solving, and understanding the social aspects of technology. For each area, specific tasks were listed that are common, and recognizable to freshmen, for each ability area. The survey was tested with freshmen in the previous academic year. While additional survey items were included in the survey for each ability area, a subset of tasks for each item were found to be key as measures of self-efficacy. A total of 17 self efficacy questions were used in the analysis. Table 2 lists the number of survey items for each self-efficacy measure, and the reliability coefficient for that measure. Table 3 lists sample survey items.

The survey asked students to rate their freshman teaching-learning experience as well as self-efficacy in an expanded set of measures for each ability area. A Bandura-type confidence scale was used where students were asked to rate their confidence in completing a task on a 11 point scale (0 – 10) where 0= no confidence at all and 10=very high confidence.

Table 2. Freshman PBL survey subscales reliability and minimum and maximum response values

Self-efficacy subscale item	No. of items	Cronbach's Alpha reliability coefficient	Scale minimum and maximum response values
Teamwork	3	.839	0 – 10
Oral presentation	2	.760	0 – 10
Writing	2	.861	0 – 10
Engineering	2	.792	0 – 10
Design-Innovation	3	.828	0 – 10
Problem solving	3	.717	0 – 10
Social aspects of technology	3	.740	0 – 10

Table 3. Freshman PBL survey – sample subscale items

Self-efficacy variable	Sample item
Teamwork	Make sure a team sets ground rules for how the team will work together.
Engineering	Recognize and understand the key organizing principles (laws, methods, etc.) underlying an engineering problem.
Design-Innovation	Quickly grasp the limits of a technology well enough to judge whether a project should use it.
Problem solving	Evaluate and choose between 2 courses of action

In the pre-freshman survey, students were also asked about their planned choice of major (students do not choose a major until the end of their freshman year). In the final survey, they were asked which major they had chosen. The pre-freshman data on choice of major was used to choose subjects for the experiment.

Experiment

The experiment was designed to measure students' self efficacy in 7 areas, via survey, as a result of completing a PBL freshman design subject. The first part of the two-part experiment consisted of a pre and post freshman year survey in the freshman year, as well as students' completion of the PBL freshman design class (for the experimental group). The second part of the experiment included having students complete the written survey again in the mid point of their sophomore year.

Part 1: Pre – post freshman year surveys

Freshmen were given the option of taking the freshman PBL subjects or the traditional freshman curriculum of math and science subjects. Random assignment of students to subjects was not possible. In survey analysis, student characteristics of gender and choice of engineering major was controlled. Also, a paired sample test was used to compare pre and post experience means.

A total of 402 students who planned to major in engineering completed both the pre freshman year and post freshman year survey whether they participated in a freshman PBL design subject or not. Survey response was over 65% for the pre and post survey, with no statistically significant difference between the class population and the survey population. A total of 103 students were in the experimental group, the students who completed PBL freshman design subjects. Of these, 62 completed Type A design subjects while 45 completed Type B design subjects. A total of 299 students were in the control group, students who did not complete a PBL subject. Table 4 shows the number of students by experimental and control group.

Table 4. Experimental and Control Groups for PBL Subject Experiment

	Men N	**Women N**	**All N**
Experimental Group: Total who completed PBL Subjects	52	51	103
• PBL Subject Type A (Hands on Design and Build Projects)	38	24	62
• Completed PBL Subject Types B,C,D (On Paper Design Projects and Biotechnology Analysis Projects)	18	27	45
Control Group: Total who did not complete PBL subjects	158	141	299

Part 2: Mid- sophomore year survey

A smaller subset of the experimental and control groups completed the survey again at the mid point of the sophomore year to measure whether student self efficacy six months after the completion of the PBL freshman design subject. The choice of mid sophomore year was chosen since students had just completed the first term of the core of their engineering majors.

Results

To analyze the data, mean scores were computed using paired sample tests for each of the 4 groups, PBL women (women who completed a PBL subject), PBL men, non PBL women, and non PBL men.

Post freshman year self efficacy for PBL and non PBL groups

PBL women versus non PBL women: The results of the pre and post freshman year survey show that all PBL women, made gains in self efficacy measure of design-innovation ($t(47) = -1.94$, $p<.05$. All other self efficacy measures, teamwork, oral presentation, writing, engineering, problem solving, and social aspects of technology showed no changes. Table 5 summarizes the results for PBL women. In contrast, there were no changes for non PBL women (Table 6).

The post freshman year subscale mean of design-innovation for PBL women was higher than that for non PBL women, $t(135)=2.95$, $p<.05$. All other subscale means are not different in the post freshman period.

Table 5. PBL Women: Pre and post freshman year subscale means

Self-efficacy variable	Pre freshman year Mean	Post freshman year Mean	N
Teamwork	7.22	7.38	47
Oral presentation	7.11	7.19	47
Writing	7.28	7.46	47
Engineering	7.55	7.13	47
Design-Innovation	6.54	7.10*	47
Problem solving	8.01	7.85	47
Social aspects of technology	8.12	7.78	48

* Increase from pre to post freshman year, $p < 0.05$

Table 6. Non PBL Women: Pre and post freshman year subscale means

Self-efficacy variable	Pre freshman year Mean	Post freshman year Mean	N
Teamwork	7.19	7.04	134
Oral presentation	7.05	6.94	137
Writing	7.03	7.05	137
Engineering	6.91	6.92	134
Design-Innovation	6.48	6.63	132
Problem solving	7.77	7.76	138
Social aspects of technology	7.76	7.74	138

* Increase from pre to post freshman year, $p < 0.05$

PBL men versus non PBL men: The results of the pre and post freshman year survey show that all PBL men made gains in 6 out of 7 self efficacy measures: teamwork $t(49)=2.59, p<.05$, writing $t(50)=-3.66, p<.05$, oral presentation ($t(50)=-2.85, p<.05$ engineering $t(50)=-1.99$, $p<.05$, design-innovation ($t(48) = -3.88$, $p<.05$, and problem solving $t(50)=-2.21$, $p<.05$. There was no change for social aspects of technology. Table 7 summarizes the results for PBL men. In contrast, there were no changes for non PBL men (Table 8).

All post freshman year subscale means of design-innovation for PBL men were higher than that for non PBL men, except for social aspects of technology.

Table 7. PBL Men: Pre and post freshman year subscale means

Self-efficacy variable	Pre freshman year Mean	Post freshman year Mean	N
Teamwork	7.27	7.81*	49
Oral presentation	7.03	7.67*	50
Writing	7.00	7.80*	50
Engineering	7.65	8.00*	50
Design-Innovation	6.95	7.66*	50
Problem solving	7.95	8.31*	50
Social aspects of technology	7.58	7.74	51

* Increase from pre to post freshman year, $p < 0.05$

Table 8. Non PBL Men: Pre and post freshman year subscale means

Self-efficacy variable	Pre freshman year Mean	Post freshman year Mean	N
Teamwork	7.34	7.23	151
Oral presentation	7.39	7.30	152
Writing	7.36	7.26	151
Engineering	7.99	7.62	152
Design-Innovation	7.38	7.31	152
Problem solving	8.22	8.09	157
Social aspects of technology	7.89	7.75	157

* Increase from pre to post freshman year, $p < 0.05$

Self efficacy impact and type of PBL Subject

A statistical test was also made using paired samples to investigate whether different types of PBL freshman design subjects had varying levels of impact on student self efficacy by gender. The types of PBL subjects are listed in Table 1. It was found that there was no difference in impact by PBL subject type on women students. There was, however, a significant impact on men. In fact, the key difference in impact for men was the presence of hands on design and prototyping activity in the PBL subject. This type of PBL subject was Type A PBL subject, described in Table 1. The other types of PBL subjects, Types B,C, and D, which only had on paper design or biotechnology analysis projects, had no impact on men's self efficacy. Tables 9 and 10 summarize the results.

Table 9. PBL Men in Type A PBL Subject: Pre and post freshman year subscale means

Self-efficacy variable	Pre freshman year Mean	Post freshman year Mean	N
Teamwork	7.20	7.78*	38
Oral presentation	7.05	7.93*	38
Writing	7.03	7.94*	38
Engineering	8.07	8.39*	38
Design-Innovation	7.15	7.91*	39
Problem solving	7.88	8.33*	38
Social aspects of technology	7.52	7.78	38

* Increase from pre to post freshman year, $p < 0.05$

Table 10. PBL Men in Type B,C, and D PBL Subject: Pre and post freshman year subscale means

Self-efficacy variable	Pre freshman year Mean	Post freshman year Mean	N
Teamwork	7.57	8.12	18
Oral presentation	6.76	7.09	18
Writing	7.17	7.64	18
Engineering	7.96	8.00	18
Design-Innovation	6.83	7.20	18
Problem solving	8.30	8.35	18
Social aspects of technology	7.56	7.70	18

* Increase from pre to post freshman year, $p < 0.05$

Choice of major

Students were asked their choice of planned major at the beginning of their freshman year, and at the end when they actually chose their major. A higher percentage of both PBL women and men chose engineering at the end of their freshman year than at the beginning (increase from 74% to 83% for men and from 69% to 73% for women). In contrast, a lower percentage of both PBL men and women chose engineering at the end of their freshman year than at the beginning (decrease from 67% to 59% for men and 59% to 48% for women). Table 11 summarizes the results.

Table 11. Percent freshmen planning on an engineering major: pre versus post freshman year

PBL versus Non-PBL Groups	Men Percent planning on engineering major		Women Percent planning on engineering major	
	Pre freshman year	Post freshman year	Pre freshman year	Post freshman year
Took PBL subject	74%	83%	69%	73%
Did not take PBL subject	67%	59%	59%	48%

Retaining self efficacy gains

The self efficacy survey was given again at the mid point of the sophomore year to both PBL and non PBL students to investigate whether students retained any gains in post freshman year self efficacy. Again, paired samples were used in the analysis of means. Only students who responded to all 3 surveys: pre freshman, post freshman, and mid term sophomore were included in the paired sample analysis. Because of the smaller response, students could only be grouped by whether they had completed a PBL subject or not, rather than by gender. The results were organized as 3 "periods" of time: Period 1, pre freshman; Period 2, post freshman, and Period 3, mid sophomore year. Only 5 of the 7 subscale measures were included in the analysis: teamwork, writing, engineering, design-innovation, and oral presentation.

The results for non PBL students showed that there was no change in self efficacy for any of the subscale measures for the pre to post freshman year periods. In contrast, student self efficacy declined by the mid sophomore year for 3 measures: writing, engineering, and design innovation.

The results for PBL students showed that there was an increase in self efficacy for the pre to post freshman year period for all measures: teamwork, writing, engineering, design-innovation, and oral presentation. Similarly to non PBL students, there was a decrease in all measures from post freshman year to mid sophomore year. Table 12 presents a summary of these results.

Table 12. Subscale means for PBL and Non PBL Students at Three Time Periods

Self-efficacy variable	NON PBL MEN AND WOMEN (N=95)			PBL MEN AND WOMEN (N=42)		
	PERIOD 1: Pre freshman year	PERIOD 2: Post freshman year	PERIOD 3: Mid sophomore year	PERIOD 1: Pre freshman year	PERIOD 2: Post freshman year	PERIOD 3: Mid sophomore year
Teamwork	7.08	7.10	6.80	7.34	7.84*	6.65**
Writing	6.94	6.89	6.04**	7.38	8.05*	5.98**
Engineering	7.40	7.25	6.33**	7.97	7.91*	7.02**
Design-Innovation	6.84	6.86	5.75**	7.24	7.66*	6.31**
Oral Presentation	6.86	6.72	6.85	7.00	7.80*	7.02**

*   significant increase from previous period, $p<.05$
** significant decrease from previous period, $p<.05$

While the PBL group subscore means for all measures were statistically higher than those for non PBL group in the post freshman year period, the subscore means all declined to statistically equivalent levels in the mid sophomore year period.

While the results are too small to compare by gender, a preliminary analysis indicates that all subscore means declined for both men and women in a similar manner from the post freshman year to mid sophomore year period.

Summary and Discussion

The new survey tool developed, with 17 questions for measuring student self efficacy of 7 abilities related to engineering design, was shown to be effective in capturing changes in student self efficacy. It proved effective in discerning impact on self efficacy as a result of specific types of design subject experiences, as well as tracking changes in self efficacy over periods of students' undergraduate education.

Women students who participated in freshman PBL subjects made less self efficacy gains than men students. Women's self efficacy only increased for design-innovation while men's self efficacy increased for teamwork, oral presentation, writing, problem solving, and engineering. Neither group improved in self efficacy for understanding of social aspects of technology. In contrast, there was no change for non PBL women or men's self efficacy for any measure in the pre to post freshman year period.

This study found, in fact, that both men and women's design-innovation self efficacy were improved by their PBL experience.

Active, hands on, authentic experiences, such as the freshman PBL subjects, did have a significant impact on men and women's self efficacy (Prince 2004). Men's self efficacy increased for nearly all measures as a result of the authentic nature of the hands on design and build experience. This highly motivating experience clearly impacted PBL men's sense of confidence in 6 of the 7 self efficacy measures in this study. A higher percentage of men chose engineering as a major after completing PBL subjects compared to non PBL men.

Women's self efficacy only increased for the subscale mean, design-innovation. Prince (2004) suggests that PBL subjects may be best at developing students' problem solving and innovative, creative thinking abilities, hence this may partially explain why impact was limited to just this area for women students. However, it is important to note that this study also showed an increase in women's choice of engineering as a major after completing PBL subjects compared to non PBL women. Hence, the PBL experience was shown to be a significant motivator for choosing engineering.

In contrast, both men and women who did not take a PBL subject, not only showed no changes in self efficacy for all measures after taking a traditional set of subjects in math, physics, and chemistry, but also declined in their interest in engineering as a major.

Another explanation for PBL women's different reaction to the PBL experience compared to PBL men might be that the PBL design subject is only one among a full freshman year that still includes traditional subjects in math, physics, and chemistry. For women, perhaps, the negative effects of their entire freshman experience downplayed the impact of the freshman PBL experience, making the entire experience similar to that of other non PBL students. Taking the entire freshman year experience into account, PBL women may not feel that their engineering or problem solving self efficacy increase.

A number of studies found a decline in women's engineering self efficacy during their freshman year compared to men, as well as during ensuing years of women's undergraduate education (Brainard 1998, Felder 1995, Marra 2005).[4,6,8] This study found that while women's self efficacy did not drop during the freshman year for PBL or non PBL women, it did drop during the sophomore year, a period of intensive engineering core subjects in students' majors. However, PBL and non PBL men's self efficacy dropped for nearly all measures as well.

One explanation of the sophomore year decline for men and women students may due to students' sense of what is considered efficacy in carrying out a task in engineering. Huchinson (2006)[7] noted that students often mentioned the ease and speed with which a problem could be solved, a technical concept thought of and applied as the key aspect of self efficacy for problem solving, understanding/learning in engineering, and computing. That students hit their sophomore year core engineering subjects and found the difficulty of complex technical problems that were not so easily solved with speed and ease apparently shook their confidence.

Another explanation of the sophomore year decline is that few of the students in this study were working on hands-on design subjects during their first term sophomore year, just before taking the mid year sophomore survey. Lack of such an exciting, active learning experience, integrated with the core subjects, could have impacted sophomore year students' sense of confidence in their abilities.

Undergraduate students' confidence in their abilities, both men and women, can be remarkably volatile, as they react to positive and negative engineering curricular experiences. The survey tool developed for this study will be implemented again at the end of students' sophomore year, and again in their senior year. Continuing to closely track engineering curricular experiences via a tool with specific measures of self efficacy in engineering and design, will permit greater clarity in discerning which experiences have greatest impact on self efficacy.

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