Integrating an Effective Freshman Seminar Experience into a First Year Engineering Design Course

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Abstract – **Students at Penn State University planning to major in engineering are pooled together into a general engineering advising cohort for their first two years. Penn State campuses are required to have a First-Year Engagement Plan for incoming freshmen. This can take various forms, but one common method is to require students to complete a first year seminar (FYS) course as part of their initial 27 credits scheduled at Penn State University. The FYS is taught in sections of not more than 25 students and seeks to engage students in learning while acclimating them to the post-secondary academic community with high expectations, demanding workloads, and other features of the transition to life in college. It has long been said within the School of Engineering at Penn State Behrend that first year engineering design courses often get low student rating of teaching effectiveness scores possibly because students don't see the value in the course and the students are new to providing these ratings. For this reason, it has been common practice for engineering department heads to refrain from assigning junior faculty to teach the first year engineering design courses. It was common for instructors of this course to receive below average course quality ratings. In the past year, two junior faculty members were assigned to teach this course. The instructors collected satisfaction data on the lecture and recitation sections of the course. The feedback was overwhelmingly positive. At the end of the fall semester, 93% of students agreed or strongly agreed that they were aware of the fields of engineering available to them in the university, and 90% stated that the course introduced them to the tools and resources available at this university. The faculty members received average ratings of 5.7 and 6.1 out of 7.0 for course and instructor quality respectively in the student course satisfaction ratings for the engineering design recitation.**

Index Terms – engineering design, first year seminar, student satisfaction, freshman engineering

BACKGROUND AND MOTIVATION

The authors of this paper are actively engaged in teaching and advising in the Mechanical & Industrial Engineering Department at Penn State Behrend. Increasingly students going off to post-secondary institutions are showing interest in science, technology, engineering, and mathematic disciplines because of what they have been told by family members, teachers, and school counselors about potential careers after college. It was clear to the authors that incoming freshmen students at Penn State Behrend were not very well informed about the broad range of engineering majors and the wide range of career opportunities available to engineering graduates.

The authors wanted to do their best to be able to inform incoming freshmen students about the broad range of engineering majors and career opportunities available to engineering graduates. In addition to meeting with visiting families, volunteering at engineering open houses, hosting engineering major nights, and summer advising, the authors felt that it was necessary to engage and inform freshmen students in the engineering design (EDSGN 100S) course. In addition to educating the students about the engineering design process, the authors felt as though the EDSGN 100S course should inform the students on the importance of gaining on the job internship and co-op experience along with teaching them about the broad range of engineering majors leading to a huge array of careers after graduation. Since students at Penn State only apply to a major in their fourth semester, the course would also serve to help students develop a relationship with faculty members to help advise and mentor them on the entrance to major process.

INTRODUCTION AND LITERATURE REVIEW

All Penn State campuses are required to have a First-Year Engagement Plan (FYEP) for their incoming freshmen students. Each campus can choose the format to meet the objectives of the FYEP, but many of the larger campuses have chosen to require that all first year students at their campus complete a first year seminar (FYS) course. It is in this course that first year students have an opportunity to learn more about a specific major and the career opportunities that exist for graduates of that major. While most of the FYS courses are offered as a 1-credit course in the fall semester, at Penn State Behrend, engineering students receive their required FYS requirement as part of a required 3-credit EDSGN 100S (Introduction to Engineering Design) course. The course is broken down into three distinct parts: lecture, recitation, and computer lab. The engineering project work is completed in the recitation portion of the course. All of the authors of this paper have taught the recitation portion and/or the lecture portion of the EDSGN 100S course. The EDSGN 100S course is offered twice per year, during both the Fall and Spring semesters. The capacity of each recitation and computer lab section of the course is typically set to 25 students per semester so that students can build a relationship with an engineering professor and other students early in their academic career. In the past year, the course was given special emphasis by the authors of this paper and the curriculum was delivered in a manner to more actively engage the students in their work and inform the students about an array of engineering majors. It was also determined that the instructors should emphasize the importance for the first year students to attend career fairs and networking sessions in an effort to gain on the job training through co-op and internship opportunities.

The authors agreed that the students had to see the importance of the EDSGN 100S class, and they had to be actively engaged in the class in an effort to motivate students to spark classroom discussion and create a level of excitement about engineering. The authors felt as though student self-motivation should be their top priority for setting the classroom tone. The thought was if students were motivated by the topics covered in the class and the excitement of the instructor for the course material, they would ultimately be excited about engineering and the recitation projects and they would be actively involved in the recitation.

I. Student Learning Preferences and Motivation

The authors went into the 2016-2017 school year with a goal of increasing the motivation of the students in the EDSGN 100S course while incorporating an informative and valuable first year experience. The authors agreed that addressing different student learning styles and motivation would go a long way in promoting student self-learning and interest in the course. Dr. Richard Felder, et al., have shown that classroom instruction is challenging, because each student is very different in his or her individual strengths and weaknesses, motivation, and accountability. These researchers have shown that each student has his or her own specific learning preference [1]. The Felder and Silverman learning styles assessment was created to assess student learning preferences by asking a series of questions regarding perception, sensing, processing, and understanding [1-3]. The Felder learning styles assessment instrument was used in studies on science, technology, and engineering students at Aalborg University in Denmark, Iowa State University, Michigan Technology University, Tulane University, Penn State University, and the University of San Paulo. The results of all the students showed similar results in that science and engineering students were predominantly Active, Sensing, Visual, and Sequential learners [1,4-5].

The authors of this paper met weekly during the semester to discuss upcoming course content for the recitation portion of the EDSGN 100S course. The authors brainstormed in great detail about the manner in which the recitation material should be presented to the students as the literature points to delivery mode being most important to setting the classroom tone in a manner in which the students would become motivated and want to self-learn and become actively engaged and interested in the course content and course projects. The authors attempted to address the dominant learning styles in the recitation by presenting the students with a mix of teaching modes including interactive power point presentations, in class experimental work, and two large group design projects.

II. Improving Student Motivation

A large body of work has shown that allowing students to work on a topic that relates directly to their every day lives will improve student motivation, leading to increased self learning [6]. It is the job of educators to take the subject matter they have a full understanding of, and translate it into a series of lectures, case studies, and activities that connect with the "real-world" students live in each and every day. Examples of such activities that connect with this "real-world" include case studies, current events, field trips, and industry/ alumni speaking events and discussion panels [2,6]. The engineering education literature has shown that model eliciting activities, problem-based learning, and cooperative learning are teaching methods educators can use to increasingly motivate students by showing them direct connections of the subject matter to the "real-world" they will be faced with after graduation [7-10].

In addition to trying to motivate the students in the EDSGN 100S class through relating class material to real-world applications and future careers, the authors also felt as though it was of utmost importance to create a classroom atmosphere where the first year students felt welcome at any time to approach the instructor with questions or concerns while in the course and after the course ended.

III. Instructor-Student Interaction and Student Interest

A body of work completed by Austin (1993) discovered that the interaction between educators and students was one of the most significant factors in predicting beneficial change in students' academic advancement, personal growth, and satisfaction with their education [9, 11]. Aside from connecting course material to the "real world", it is the job of the educator to show sincere passion and interest in the subject matter they are teaching to the students. A professor that is lively and shows sincere interest in the subject matter can grab students attention, engaging them in the material and ultimately motivating the students to want to learn the material [6,7]. The engineering education research has shown concrete evidence that addressing learning styles, relating course material to the "real world", being approachable, showing the future applications of the subject matter post-graduation, and showing excitement for the material are all ways to increase student motivation and self learning. Work has also been carried out on the potential benefits of a first year freshman engineering seminar experience.

IV. Benefits of Freshman Engineering Seminars

Previous work has shown that a number of benefits can be derived from a freshman engineering seminar experience. This body of work has shown that by combining the freshman seminar course with other freshman course schedules, the students are helped with test-taking strategies, teamwork, and presentation skills in other freshman courses [12-13]. It has also been shown that freshman engineering projects as well as project-based learning courses increase student retention [14,15]. In terms of selecting a major field of study, freshman seminar courses have been shown to motivate students to want to pursue degrees in engineering [16]. In addition, a body of work has shown that freshman year course selection will impact student major preference and retention [17].

The prior research has shown a great deal of evidence suggesting that a freshman engineering seminar is an important course for a variety of reasons ranging from establishing faculty mentors to major selection and retention. With all of this in mind, the methods of course delivery were discussed in great detail each week prior to delivering the weekly course recitation as the recitation is the meat of the engineering project work in the course.

COURSE TOPICS, OBJECTIVES, CONTENT, AND GRADING

The 3-credit EDSGN 100S course meets three times a week. The three class meetings include a 50 minute lecture, a 90 minute recitation, and a 110 minute computer lab experience.

I. Course Topics

The course topics covered across lecture, recitation, and computer lab are broken table below:

Topic		*# of periods*
1.	*Overview of the engineering design process*	1
2.	*Product dissection*	4
3.	*Customer needs analysis and product specifications*	2
4.	*Concept generation and selection*	4
5.	*Teamwork and project management*	4
6.	*Engineering ethics*	1
7.	*Academic integrity*	1
8.	*Engineering education and the engineering profession*	2
9.	*Design projects, reviews and presentations*	8
10.	*Budgeting*	1
11.	*Excel*	3
12.	*PSpice*	1
13.	*Sketching & Drawings*	3
14.	*Solid modeling: Autodesk Inventor*	7

II. Course Objectives

After completing the EDSGN 100S course topics, a student should be able to do the following:

- Conceptually design a system, component, product, service, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- Apply knowledge of basic science and mathematics to engineering
- Design and conduct basic experiments, as well as analyze and interpret data
- Participate effectively in small teams
- Identify, formulate, and solve engineering problems
- Communicate effectively using written and graphical forms and oral presentations
- Demonstrate professional and ethical responsibility
- Use software tools relevant to engineering practice
- Understand solutions and designs in context of overall systems

III. Course Content and Activities

As mentioned, the lecture, recitation, and computer lab each meet one time per week during a 15 week semester. In addition to accomplishing specific course objectives mentioned above, the lecture and recitation curriculum was set up to expose the students to various engineering disciplines while engaging them in the engineering design process with two large engineering design projects. All students have the same instructor for the lecture portion of the EDSGN 100S course. There is only a single section of lecture offered for all students enrolled in the EDSGN 100S course during fall and spring semesters. The lecture is held on Monday, prior to all weekly lab and recitation sections.

The course lecture breakdown is shown in Table 1:

TABLE I
WEEKLY LECTURE TOPICS FOR EDSGN 100S.

Week	Lecture (Mon)
1	Introduction to Engineering & Engineering Design
2	No class – Labor Day (Fall) or MLK Day (Spring)
3	The Engineering Design Process
4	Product Specifications
5	Concept Generation
6	Concept Selection & decision analysis
7	Advising & Scheduling
8	Intro to Project #2 & Teamwork
9	Engineering Careers & Majors
10	Project Management
11	Technical Topics for Project#2
12	Sustainability & Globalization
13	Academic Integrity & Engineering Ethics
14	Special Topic
15	Jobs, Internships & Co-Ops

Students enrolled in the EDSGN 100S course must enroll in a section of recitation and computer lab. When the students register for recitation and lab, they complete the computer lab and recitation portions of the course with the same group of students. Although, the instructor for the recitation and computer lab will not be the same person. The students typically have three different instructors for lecture, recitation, and computer lab in the EDSGN 100S course.

The main focus of the recitation portion of the course is learning the engineering design process and learning project team management skills through a series of two group engineering design projects. The first project is a re-design of an electric toothbrush while the second project involves the design of a renewable energy water well to supply an underdeveloped village in the world with clean water. The course recitation breakdown is shown in Table 2:

TABLE II
WEEKLY RECITATION TOPICS AND ACTIVITIES FOR EDSGN 100S.

Week	Recitation (Tues/Wed/Thurs/Fri)
1	Icebreakers, Introduction, World Class Engineer, Customer needs analysis lecture
2	Evaluate assignment on Engineering Fields
	Form teams for Project#1
	Project #1 – Redesign of an electric toothbrush
	Receive toothbrushes
3	*Dissection, Analysis and Operation of Electric toothbrush- Measure current, sound and oscillation*
4	*Product dissection lab - Technical Analysis and Operation of Electric toothbrush- Measure current, sound and oscillation*
5	Review concept generation
	Product dissection lab – Determine internal structure and operation of electric toothbrush
6	Presentation preparation
	Review concept selection & decision analysis
7	***Project #1 Presentations***
8	Form teams, Select project location, introduce & discuss project, Team Contracts
9	Review of Alternative Energy & Electricity
	Developing Specifications for project #2
10	Project scheduling & Planning Exercise,
	Alternative Energy Lab #1: Solar
11	Alternative Energy Lab #1: Solar
12	Electrical/mechanical topics related to project#2
	Alternative Energy Lab #2: Wind
13	Alternative Energy Lab #2: Wind, Technical topics
14	Design review, project status & update
15	***Project #2 Presentation***
	Project#2 notebooks due

The recitation lab activities and projects are also strategically designed to introduce first year students to an array of engineering disciplines. By completing the toothbrush redesign project, students learn mechanical engineering (ME) concepts through design and specifications, electrical engineering (EE)/computer engineering (CMPEN) through circuit concepts and voltage/amperage measurements, and industrial engineering (IE) concepts through data collection, data analysis, ergonomics, and manufacturing processes. Figure 1 shows a senior faculty member working with students on project #1 (toothbrush re-design). The students are looking at designs of individual toothbrush components, creating a bill of materials, and also taking current and amperage measurements.

PHOTO COURTESY: PENN STATE BEHREND
FIGURE 1
EDSGN 100S RECITATION WEEK #4: PRODUCT DISSECTION LAB.

By completing the renewable energy source water well project, students are not only exposed to ME, EE, CMPEN, and IE concepts, but also architectural/ civil engineering (AE/ CE) through the design of a water tower and a control hut. The need to understand water tables and well drilling helps to introduce the students to petroleum engineering (PETRO) concepts. They will also explore energy engineering (ENENG) concepts through the lab activities and design work on wind and solar energy. In addition, they will explore chemical engineering (CHEM E) and environmental engineering (ENVENG) concepts when discussing water treatment and filtration. In Figures 2 and 3, first year engineering students are carrying out recitation lab activities on solar and wind power to help them understand renewable energy options they will use to design renewable energy water wells for their second major design project in the EDSGN 100S recitation.

FIGURE 2
EDSGN 100S RECITATION WEEK #11: ALTERNATIVE ENERGY SOLAR LAB.

FIGURE 3
EDSGN 100S RECITATION WEEK #13: ALTERNATIVE ENERGY WIND LAB.

The main focus of the computer lab is to introduce first year engineering students to software tools relevant to engineering practice. One of the tools taught to the students is Microsoft Excel. A significant portion of the computer lab is spent on learning how to create sketches, drawings, and 3D models in Autodesk Inventor. The course curriculum is set up so that students can actively apply their Microsoft Excel, sketching, drawing, and Autodesk Inventor skills on recitation labs along with project #1 (toothbrush) and project #2 (water well). The course computer lab breakdown is shown in Table 3:

TABLE III
WEEKLY COMPUTER LAB TOPICS AND ACTIVITIES FOR EDSGN 100S.

Week	Subject
1	Excel Formatting
2	No Lab (Labor Day Fall/ MLK Day Spring)
3	Excel Functions
4	Excel Graphing & Mathcad
5	Introduction to PSpice
6	Isometric Sketching
7	Engineering Drawings
8	Orthograpic Projections
9	Autodesk Inventor Chapters 1 & 2
10	Autodesk Inventor Chapters 3 & 4
11	Autodesk Inventor Chapters 5 & 6
12	Autodesk Inventor Chapters 7 & 8
13	Autodesk Inventor Chapters 9 & 10
14	Autodesk Inventor Chaptes 11 & 13
15	Wrap-up - no new lesson

IV. Course Grading

As shown in Table 4, course grading is weighted heavily on the course projects carried out in recitation and recitation lab assignments, which are a culmination of the tools learned in lecture and computer lab. The recitation accounts for 45% of the grade while lecture and computer lab account for 25% and 30% of the final course grade respectively.

TABLE IV
EDSGN 100S GRADING BREAKDOWN.

Lecture and Recitation	**70%**	**Graphics and Computer Skills**	**30%**
Class Participation	5%	Reading Quizzes	5%
Lecture Quizzes (5)	20%	Skills Quizzes	10%
Recitation Assignments	10%	Skills Assignments	15%
First Design Project	15%		
Second Design Project/ Case Study	20%		
		Total	100%

RESULTS AND DISCUSSION

The following quantitative results shown in Figure 4 and Table IV were collected over the span of 1 year (2 semesters) in the EDSGN 100S class for first year students at Penn State Behrend.

Students were asked to respond to five main questions regarding the effectiveness of the seminar portion of the EDSGN 100S course. The five questions were:

(1) I can describe what engineering is, including the engineering design process and the role math and science play in engineering.
(2) I am aware of multiple fields of engineering available at Behrend and University Park.
(3) I am aware of the learning tools and resources available to succeed at Penn State.
(4) Through this course, I have developed relationships with faculty and students in engineering.
(5) I am aware of my responsibility as part of the Penn State community.

The students were asked to respond by rating their agreement level with the statements in (1)-(5) above:
Strongly Disagree/Disagree/Neutral/Agree/Strongly Agree.

The results of the EDSGN 100S student responses are shown in Figure 4. The feedback was overwhelmingly positive. At the end of the fall semester 93% agreed or strongly agreed that they were aware of the fields of engineering available to them in the university, and 90% of students agreed that the course introduced them to the tools and resources available to succeed at Penn State.

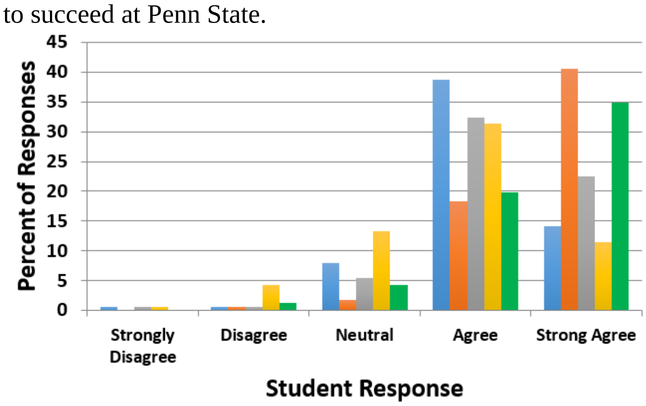

FIGURE 4
ENGINEERING SEMINAR EFFECTIVENESS DATA.

As discussed in the introduction, the authors of this paper set out to put their best foot forward on the delivery of the course. The junior faculty members (referred to as A and B) in Table 5 met on a consistent basis to discuss course delivery and in semester feedback they were receiving from students regarding the recitation. Junior Faculty A taught the recitation during the previous year (2015/2016), but had never taught the lecture prior to Fall 2016. Junior Faculty B started teaching the recitation in Fall 2016. As shown in Table V below, the student rating of the teaching effectiveness of this FYS course was overwhelmingly positive. At the end of the semester, the students were asked to rate teaching effectiveness on a scale from 1 to 7. The lowest rating is 1 and the highest possible rating is a 7. The overall average rating for the quality of the course recitation is 5.7 while the overall average rating for the quality of the instructor of the recitation is 6.1. Both of the junior faculty members were in the second year of the tenure track at Penn State Behrend. The main comparison was completed on the recitation because this is the portion of the course where majority of the engineering project work and lab work is carried out.

TABLE V

STUDENT RATING OF TEACHING EFFECTIVENESS DATA FOR EDSGN 100S.

Semester	Course Section	Response Rate	Quality of Course	Quality of Instructor	Faculty Level
FA '16	Lecture	89%	5.37	5.99	Junior (A)
SP '17	Lecture	70%	4.92	5.73	Senior
FA '16	Recitation	95%	5.45	6.05	Junior (A)
SP '17	Recitation	90%	5.06	5.39	Junior (A)
FA '16	Recitation	90%	5.71	5.96	Junior (B)
SP '17	Recitation	47%	6.13	6.88	Junior (B)
FA '16	Recitation	79%	6.09	6.45	Senior

CONCLUSIONS

Offering both a freshman engineering design course while providing an educative and effective freshman first year seminar experience can be a difficult task. However, this work shows that by designing course content and delivering it to students in a manner that connects with their learning preferences and their current and past experiences, students can be actively engaged in the engineering design course. The structure of this course gives students the opportunity to engage in activities that load their college toolbox and help them learn about an array of engineering disciplines and learn about the resources available to help them succeed. It has also been shown that both junior and senior faculty members can provide a satisfying experience for the students in the freshman engineering seminar course when special attention is paid to course delivery. It is the hope of the authors that other engineering programs can implement the content and course delivery methodology used in this paper to improve their first year engineering course and freshman seminar experience.

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