Engaging Students in a First Year Industrial Engineering Seminar Course

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***Abstract* – All first year students at Penn State University Park must complete a 1- credit first year seminar course. Often times, students don't see the value in taking a first year seminar course and instructors may not put forth 100% effort in delivering the course. An active, engaging approach was taken in delivering a first year seminar course in industrial engineering (IE 100S). The IE 100S course was infused with active learning modules, laboratories, student tours, homework assignments, industry speakers, and the requirement for students to construct resumes and attend at least one career fair in search of an internship as freshmen. One of the main goals of the new curriculum and course emphasis was on the professional development of the freshmen students. At Penn State, students only apply to a major during their fourth semester. Engineering retention and industrial engineering retention data was collected over 8 semesters for students taking the IE 100S class. On average, 85% of the students taking the IE 100S class went on to major in an engineering major. On average, 53.2% of the students taking the IE 100S class majored in industrial engineering. The student ratings for teaching effectiveness have rated the industrial engineering first year seminar course as one of the highest rated courses in the entire college of engineering at Penn State University Park. The overall average rating for the course instructor was 6.85 out of a possible 7.0 over 8 semesters. The overall average rating for the quality of the course itself over 8 semesters was 6.78 out of 7.0. In addition to the details of the course lectures, homework assignment details and instructor learning initiatives are also provided.**

Index Terms – industrial engineering, first year seminar, active learning, freshman engineering retention rates

BACKGROUND AND MOTIVATION

The authors of this paper have combined for close to 40 years of teaching and advising in Industrial and Manufacturing Engineering at one of the largest and most historic Industrial and Manufacturing programs in the world. Both of the authors have spent many years working freshman orientation and first year student scheduling. Increasingly students going off to college are saying they would like to major in engineering because of what they have been told by parents, relatives, teachers, and guidance counselors about potential job opportunities after college. Often times, they apply to their schools of choice and state their preference for well-known engineering disciplines such as mechanical engineering and electrical engineering. It is not uncommon for students to note major preferences and interest in both engineering and business while discounting industrial engineering (the crossroads of engineering and business) as a potential major choice because of a lack of knowledge of the discipline. It is not uncommon for students to have never even heard of Industrial Engineering. If they have, they may have not looked into the major past the name: "Industrial and Manufacturing Engineering." It is not uncommon for the authors of this paper to be asked questions about students having to work "solely in manufacturing" when they graduate with an industrial engineering degree. It was clear to the authors that students were not well informed about the broad range of job opportunities available to students after graduation. It was also clear to the authors that students did not understand all of the options available within the industrial engineering curriculum. The students clearly were not well informed on the industrial engineering discipline and the seemingly endless opportunities that exist in today's global economy for industrial engineers. The authors of this paper were noticing an increasing number of students requesting transfers to industrial engineering from disciplines such as aerospace engineering, electrical engineering, and mechanical engineering in their junior year.

The authors wanted to do their best to be able to inform incoming freshman and sophomore students about the broad range of career opportunities available to industrial engineering graduates. In addition to hosting visiting families, volunteering at engineering open houses, hosting industrial engineering major nights, and hosting spend a summer day events, the authors felt that it was necessary to engage and inform freshmen students in the industrial engineering first year seminar course (IE 100S). In addition

to educating the students about industrial engineering, the authors felt as though the IE 100S course was a natural place for first year students to become actively involved with student clubs and organizations while also constructing resumes and getting out to career events. Since students at Penn State only apply to a major in their fourth semester, the course would also serve to educate students on academic advising and the entrance to major process.

INTRODUCTION AND LITERATURE REVIEW

All first year students at Penn State University Park must complete a 1-credit first year seminar 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. Both of the authors of this paper have taught the Industrial Engineering First Year Seminar course (IE 100S). The IE 100S course is offered twice per year, once during the Fall semester and once during the Spring semester. The capacity of the course is typically set to 25 students per semester so that students can build a relationship with an engineering professor early in their academic career. Four years ago, the course was given special emphasis by the authors of this paper and the curriculum was tweaked to more actively engage and inform the students about industrial engineering. In addition, it was determined that the course should serve as a vehicle to get first year students involved in engineering clubs and organizations while helping first year students to build a professional resume while searching for internship and co-op opportunities.

The authors agreed that the students had to see the importance of the IE 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 the industrial engineering discipline. 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 the industrial engineering discipline and they would be actively involved in the class.

I. Learning Styles and Motivation

Much work has been carried out on learning styles and student motivation in higher education. Dr. Richard Felder et al. have shown that classroom instruction is challenging, because each student is a unique individual with differing strengths, difficulties, enthusiasm, and accountability. Thus, each student has his or her own specific mode of learning [1]. Felder and Silverman actually created a hybrid learning style model to assess student learning styles or preferences by asking a series of questions regarding perception, sensing, processing, and understanding [1-3]. The Felder learning styles assessment instrument was used in a study performed on Science, Technology, and Engineering Majors in Denmark at Aalborg University, by Anette Kolmos and Jette Egulund Holgaard [4].

In Richard Felder's work, learning styles of many different Universities, such as Iowa State Materials Engineering, Michigan Technology Environmental Engineering, and Tulane University first and second year engineering students, as well as many other universities were analyzed in order to survey learning style preferences [1]. A similar learning styles assessment study was carried out on industrial engineering students at Penn State University [5]. In addition to the studies mentioned, Industrial Engineering student learning styles were also solely analyzed at the University of Sao Paulo [1]. All of the studies showed basically the same results. The science and engineering students in all studies were predominantly Active, Sensing, Visual, and Sequential learners.

The authors of this paper felt as though course content was important but more importantly, the authors felt as though the way the content was presented to the students was more important to setting the classroom tone in a manner in which the students would become self-motivated to become actively engaged and interested in the course content. The authors felt as though it was important to address the dominant learning styles in the classroom.

II. Addressing Dominant Learning Styles in the Classroom

Sensing learners, referred to as sensors, prefer information gathered from their senses such as visual images, sounds, and physical feelings. Sensors like facts and are inclined towards real-world applications. They are very detail-oriented and dislike abstract ideas; hence, they may struggle with science courses that have a heavy emphasis on theory [1-3,6]. Unfortunately, most engineering teaching is more favorable to intuitive learners that enjoy more theoretical and abstract ideas than sensing learners [1]. Visual learners learn more effectively through graphic materials such as posters, charts, pictures, and displays [1-3]. Verbal learners learn best through auditory descriptions and written accounts [1-3]. Most engineering courses are taught in a predominantly verbal fashion, with writing on chalkboards and verbal explanations [2-3]. Active learners prefer to take in information "actively" through conversations and physical activities. Active learners are energized by others and often have trouble studying and working alone. They do best when learning with others and sharing ideas among team members [1-3]. Reflective learners like to contemplatively take in information and reflect on ideas [1,3]. Reflective learners work best on their own or in pairs and often feel exhausted when they are working with others, especially partners they do not know well [3,7]. Sequential and global learners use entirely different processes of learning to understand concepts. Sequential learners grasp information in a series of logical steps. They like to learn information in a specific sequence and will only progress to the next step after they have mastered the previous one while global learners like to see more of the "big picture" [1-3, 8].

III. Motivation by Relating Class Material to Real-World Applications and Future Careers

Previous research has shown that allowing students to work on a topic that has meaning or relevance to them will help them become increasingly more motivated and allow them to further their interests [7]. Hence, educators must help students find an interest in class topics. Educators should implement activities focusing on "real-world" applications in the classroom. Case studies, discussions on relevant current events, and field trips are all activities that can be used to stress "real-world" applications [2,7]. Model eliciting activities, problem-based learning, and cooperative learning are several strategies that help students engage in real-life situations that will be relevant to their future careers [9, 10-12].

In addition to trying to motivate the students in the IE 100S class through relating class material to real-world applications and future careers, the authors also felt as though it was extremely important 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.

IV. Instructor Approachability and Advising

A large-scale study by Austin (1993) discovered that the interaction between faculty and students was one of the most predictive factors of beneficial change in students' academic advancement, personal growth, and satisfaction [11, 13]. Another study by Atman et. al, "Enabling engineering student successes," found that senior students' behavioral motivation, psychological motivation, motivation from a mentor, and motivation to do social good were related to how often students interacted with instructors and how satisfied students were with instructors [11]. Educators need to effectively communicate their excitement and interest in their class material. A passionate professor can make students curious about the material and motivate them to study the material more [7,9]. Litzinger et. al state that instructors should focus on stimulating interest in their subject area for all students regardless of their varying backgrounds and abilities [9]. The literature clearly shows that tying course material to future academic and career plans will show students the importance of the course and thus help with student motivation and engagement.

The IE 100S course content and course delivery was designed with all of this information covered in the introduction in mind.

COURSE CONTENT AND DELIVERY

The IE 100S class was set up such that 50% of the course grade was attendance and 50% of the grade was homework assignments. The 1-credit course meets twice a week (Tuesday and Thursday) for 75 minutes each class period for 5 to 5.5 weeks (10 or 11 classes). Each class period attended is worth 1 point. There are 5 homework assignments in the class and each homework assignment is worth 2 points. The industrial engineering discipline has traditionally been broken down into 3 main areas: Human Factors Engineering, Manufacturing Engineering, and Operations Research. The curriculum was set up to expose the students to each of the three main areas of industrial engineering.

I. Course Topics and Activities

As mentioned, the class typically meets 11 times throughout the semester. The course breakdown is as follows:

Class#1: Introduction to Industrial Engineering
In the first class period, the instructor gives the students a course syllabus that outlines the activity and location for each class throughout the semester. The instructor gives the students a copy of each of the five homework assignments along with the due date of each of the assignments. In addition, the students receive a packet of five extra credit assignments designed to help students that may have to miss a class period or a homework assignment. The introduction class presentation carried out by the instructor covers the industrial engineering curriculum, common minors completed by industrial engineering students, department statistics, and videos produced by the Institute of Industrial and Systems Engineers (IISE) to help students understand the field of industrial engineering. The instructor also uses this class period to introduce the students to the student chapter of IISE in industrial engineering.

Class #2: Manufacturing: Metal Casting
In the second class period, the students are actively engaged in manufacturing widgets, license plates, and mugs in the industrial engineering Factory for Advanced Manufacturing Education (FAME) lab. The students make sand molds and are able to pour hot molten metal into the molds to produce the parts, Figure 1. The course instructor also discusses the industrial engineering student group related to this area of industrial engineering. The student group is the Penn State University Park student chapter of the American Foundry Society (AFS).

FIGURE 1
FIRST YEAR STUDENT PARTICIPATING IN THE METAL CASTING LAB.

Class #3: Manufacturing: Machining

In the third class period, the students are actively engaged in manufacturing nameplates in a CNC machining center. The name plates are custom made for each of the students. During this class period, the instructor explains the entire process from design to set up to production and where industrial engineers are needed throughout the entire process. The instructor typically gives a tour of all department laboratories to half of the class while the other half of the class machines their name plates with the laboratory technicians, Figure 2. The course instructor also discusses the industrial engineering student group related to this area of industrial engineering. The student group is the Penn State University Park student chapter of the Society of Manufacturing Engineers (SME).

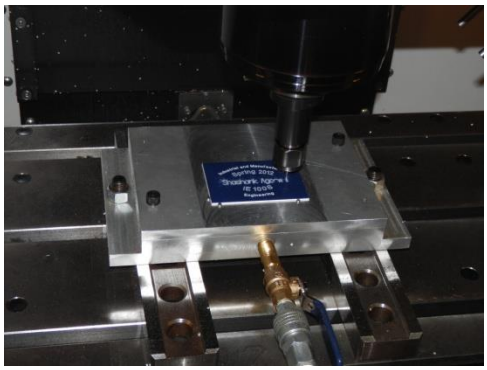

FIGURE 2
STUDENT MACHINES A NAMEPLATE DURING THE MACHINING LAB.

Class #4: Factory Tour and Material Handling:

In the fourth class period, the students tour the Penn State Housing and Food Services warehouse and bakery on the University Park campus, Figure 3.. During the tour, the manager discusses production planning, production scheduling, order quantities, cost reduction strategies, material handling, and warehousing operations. The instructor uses this tour to talk about operations research and material handling. The instructor introduces the students to the Material Handling Industry of America (MHIA).

FIGURE 3
FIRST YEAR STUDENT TOUR OF CAMPUS BAKERY AND FOOD WAREHOUSE.

Class #5: Simulation and Lean Manufacturing

In the fifth class period, the students are actively engaged in a simulation game activity to teach them the difference between manufacturing in a "PUSH" system or a "Make to Stock" system and a "PULL" system or a "Make to Order" system. After a 20 minute powerpoint presentation on lean manufacturing and Push vs. Pull systems, the students carry out a Manufacturing Simulation game activity, Figure 4. The instructor uses this activity to talk about operations research and simulation while also discussing lean manufacturing, assembly line balancing, and inventory control.

FIGURE 4
STUDENTS ACTIVELY ENGAGED IN PUSH/ PULL SIMULATION ACTIVITY.

Class #6: Human Factors: Hand Tool Design

In the sixth class period, the students carry out a human factors hand tool design lab. A professor specializing in human factors engineering leads the class through an activity to design an optimal hand tool. The students generate grip span and grip force data and use the data in the class to produce an optimal design for a crimping tool, Figure 5. The instructor uses this class period to introduce the students to human factors engineering and also to introduce the Human Factors and Ergonomics Society (HFES) student group within industrial engineering.

FIGURE 5
STUDENTS COLLECT GRIP FORCE DATA DURING A HUMAN FACTORS HAND TOOL DESIGN ACTIVITY.

Class #7: Internships, Co-Ops, and Study Abroad
In the seventh class of the semester, typically held during career fair week at Penn State, the students get to hear 10 to 15 minute presentations from current industrial engineering students that have been out working in industry on internships and/or co-ops. The industrial engineering students discuss how they got the internship/ co-op, what they did in the internship/ co-op, and how they applied their industrial engineering skills in the experience. The industrial engineering students encourage the first year students to take part in the upcoming career fairs.

In addition to the internship/ co-op presentations, the industrial engineering undergraduate coordinator also gives the students information about study abroad opportunities and gives examples of recent study abroad experiences for current industrial engineering students.

Class #8: Industrial Engineering Alumni Presentations
In the eighth class of the semester, typically held the day of the University wide career fair, the students get to hear 10 to 15 minute presentations from recent industrial engineering alumni talk about their current position and how they were able to get this position. The presenters are typically on campus recruiting at the industrial engineering and University wide career event. The class gives the students an opportunity to ask questions regarding how to secure an internship or co-op and to help break the ice approaching recruiters at the career event.

In addition to the alumni presentations, a student member of the Engineering Career envoy group will visit the class to inform the students of the resources available in the Penn State College of Engineering to help the students with perfecting resumes and networking with potential employers.

Class #9: Operations Research: Monte Carlo Simulation
In the ninth class of the semester, the students are actively engaged in a monte carlo simulation activity where random numbers are generated and students are broken down into teams in an effort to locate a municipal fire station in an effort to minimize cost associated with property damage and injuries. A professor specializing in operations research leads the class through this activity. The instructor uses this class to again introduce the students to operations research and also to introduce the Institute for Operations Research and the Management Sciences (INFORMS) student group within industrial engineering.

Class #10: Quality Engineering
In the tenth class of the semester, the students are actively engaged in a "house of quality" activity. A professor specializing in engineering economy and quality engineering leads the students through a presentation and activity on designing experiments to provide an optimal design for a paper helicopter using quality principles.

In addition to the quality demonstration, members of the student group of the American Society for Quality (ASQ) and the National Organization for Business and Engineering (NOBE) give short presentations about their student groups to the first year students. The instructor also distributes information about the popular Six Sigma Quality Control minor to the first year students.

Class #11: Tips for Success in Engineering
In the final class of the semester, a college of engineering academic adviser will give a presentation covering tips for success in engineering. The presentation is an interactive presentation covering study habits, an overview of all engineering majors in the college of engineering, relationships between different engineering disciplines. The adviser also spends time teaching the students how to navigate the entrance to major process while stressing the importance of working with an academic adviser.

II. Course Homework and Extra Credit Assignments

As noted above, 50% of the class grade is homework assignments. The homework assignments shown in Table I below were designed to complete the college of engineering first year "Passport to Success." The Passport to Success was designed by the college of engineering at Penn State to achieve the first year seminar (FYS) objectives. These five objectives include: introducing students to university study; introduce students to Penn State as an academic community; acquaint students with the learning tools and resources available at Penn State; provide an opportunity for students to develop relationships with full-time faculty and other students with similar interests; introduce students to their responsibilities as part of the University community [14]. After helping students make changes to their resumes, the course instructor attended the industrial engineering career event with the students to help students break the ice talking to company recruiters for the first time.

TABLE 1
HOMEWORK ASSIGNMENTS AND TOPICS.

Homework	Assignment	Due
HW #1	Student Resume	Class Period #3
HW #2	Meet with Academic Adviser	Class Period #6
HW #3	Attend Career Fair	Class Period #8
HW #4	Attend Student Org. Mtg.	Class Period #10
HW #5	Attend World in Conversation Discussion	Class Period #11

If a student had to miss a class period or for some reason missed a homework assignment, five total points of extra credit were made available to all students, Table II. .

TABLE 1I
EXTRA CREDIT ASSIGNMENTS AND TOPICS.

Extra Credit	Assignment	Due
EC #1	Material Handling (MHIA)	Class Period #5
EC #2	Lean Manufacturing (Push vs. Pull Systems)	Class Period #6
EC #3	Human Factors (HFES)	Class Period #7
EC #4	Get Connected (Career Services Event)	Class Period #10
EC #5	Tips for Success in Engineering	Class Period #11

RESULTS AND DISCUSSION

The following quantitative results shown in Table III and Table IV were collected over a course of 4 years or 8 semesters for the IE 100S class for first year students at Penn State University Park. Qualitative results were also collected but could not be included in this paper due to page limitations. On average, 85% of the students taking the IE 100S would go on to major in an engineering major. Overall, 53.2% (about 1 in every 2 students) of the students taking the IE 100S course became industrial engineering majors. Of the 85% of students majoring in an engineering major, 62.3% of those students were actually industrial engineering majors.

TABLE III
ENGINEERING AND INDUSTRIAL ENGINEERING RETENTION DATA.

Semester	Enrollment	ENGR Major	%ENGR	IE Major	%IE (Total)	%IE (ENGR)
FALL 2011	23	19	82.6%	12	52.2%	63.2%
SPRING 2012	25	20	80.0%	15	60.0%	75.0%
FALL 2012	26	22	84.6%	9	34.6%	40.9%
SPRING 2013	24	22	91.7%	14	58.3%	63.6%
FALL 2013	23	18	78.3%	6	26.1%	33.3%
SPRING 2014	26	25	96.2%	22	84.6%	88.0%
FALL 2014	24	19	79.2%	12	50.0%	63.2%
SPRING 2015	25	21	84.0%	15	60.0%	71.4%
Totals (Avg.)	196	166	(84.6%)	105	(53.2%)	(62.3%)

One item that should be taken into account when looking at this data is the number of students taking the IE 100S class that could not major in industrial engineering due to scholarship requirements from their home country. A number of students noted to the instructor that as a result of their scholarship requirements provided by some of the Middle Eastern countries, they could not major in industrial engineering. Those students are included in the percentages reported as not being industrial engineering majors.

As discussed in the introduction, the authors of this paper set out to put their best foot on the delivery of the class while putting special emphasis on developing open relationships between course instructor and students. As shown in Table IV below, the student rating of the teaching effectiveness of this FYS course was overwhelmingly positive. At the end of the semester, the students are 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 is 6.78 while the overall average rating for the quality of the instructor of the course is 6.85. The college of engineering was unable to release FYS data for comparison. However, this was likely one of the highest rated FYS classes in the college of engineering.

TABLE IV
STUDENT RATING OF TEACHING EFFECTIVENESS DATA FOR IE 100S.

Semester	Enrollment	Response Rate	Quality of course	Quality of Instructor
FALL 2011	23	82.60%	6.79	6.95
SPRING 2012	25	84.00%	6.8	6.76
FALL 2012	26	80.80%	6.57	6.81
SPRING 2013	24	83.33%	6.65	6.6
FALL 2013	23	69.60%	6.88	7
SPRING 2014	26	73.10%	6.83	6.94
FALL 2014	24	54.20%	6.83	7
SPRING 2015	25	64.00%	6.88	6.75
Totals (Avg.)	196	73.95%	6.78	6.85

In addition to the quantitative data collected, students also gave feedback to the course instructor regarding freshman and sophomore internship opportunities they were offered as a result of the IE 100S class. In addition, a number of students taking the IE 100S class become involved as freshman and sophomores in industrial engineering students societies and eventually become officers of those organizations. Multiple students from the IE 100S class also became research and teaching assistants for industrial engineering courses taught by the IE 100S course instructor as a result of the relationships fostered in the IE 100S class.

As a result of the work carried out in the IE 100S class, the course instructor was presented with a certificate and special recognition by Penn State University for Outstanding Service to First Year Students at Penn State University in 2012.

CONCLUSIONS

This work shows clearly that by designing course content and delivering the course content to students in a manner that connects with their learning styles and their current and past experiences, students can be actively engaged and motivated to participate in their first year seminar course. By actively engaging students in the material and showing the relationship to future job opportunities and connections to the larger picture, the first year seminar course can become a favorite among the students. By actively working with the students and attending a career event with the students, the false notion of "freshman and sophomores cannot get internships" can be discredited and the instructor can help students get past nervousness when talking with recruiters for the first time. By introducing students to industrial engineering student groups, students can get involved as early as freshman and become student group leaders as they progress through their academic programs. This active, engaging pedagogical approach taken for first year seminar course delivery was also effective in retaining students in engineering. In fact, 85% of the first year students taking this class went on to major in engineering while 62.3% of this 85% actually majored in industrial engineering over a four year period. It is the hope of the authors that other industrial engineering programs can implement the content and changes to improve their first year industrial engineering experience.

ACKNOWLEDGMENTS

The authors of this paper would like to thank Dr. Deborah Medeiros for providing materials and information from previously taught semesters of IE 100S. The authors would also like to thank Ms. Jennifer Mines and Ms. Cindy Bober for their work on student satisfaction and motivation that contributed to the success of the first year seminar course.

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