Student Chosen Professional Contributions in the Freshman Experience

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Abstract
A novel approach to the freshman experience was used in the Introduction to Industrial and Manufacturing Engineering course at North Dakota State University (NDSU) towards maximizing retention using professional contributions. The students were required to become members of either the Society of Manufacturing Engineers (SME) or Institute of Industrial Engineers (IIE) and make a contribution to the respective student organization for fifty percent of their course grade. This encouraged student chosen engagements with industry, professors, upper classmen, and each other. The resultant activities accommodated individual learning styles, interests, and career paths. Based on the Individual Development and Educational Assessment (IDEA) Center nationally normalized long-form survey of the student reactions to this instruction and course, three aspects of the teaching methods and style were rated significantly higher than for other classes of similar size and level of student motivation. These highly rated aspects were relevant to the essential and important objectives of the course and involved fostering student collaboration, establishing rapport, and encouraging student involvement. This paper introduces the course, explains its pedagogy, summarizes the student chosen professional contributions, and demonstrates its value through the IDEA student survey results, National Survey of Student Engagement results, and NDSU Student Rating of instruction results.

Introduction

The one credit course titled "Introduction to Industrial and Manufacturing Engineering" is the first Industrial and Manufacturing Engineering (IME) Department course taken by students considering a career in Industrial Engineering and Management (IE) or Manufacturing Engineering (ME) at North Dakota State University (NDSU). As such, it was especially desirable to maximize the student ratings of the course, which was considered important for student retention.

There were four primary objectives for each student to reach during the course. (1) Understand what industrial and manufacturing engineers do. (2) Experience how industrial or manufacturing engineers learn. (3) Appreciate why industrial and manufacturing engineers lean systems. (4) Practice self-directed learning. These objectives were conceived to lead each student into the knowledge and engage each student in the activity of either the industrial engineering curriculum or the manufacturing engineering curriculum, as the two options available in the Department.

Course methods and style

Twenty-five on-campus students were enrolled in the course and accessed online course delivery software[1] for faculty posted textual information, audio comments, lean manufacturing audio-visual presentation, short quizzes over each aspect of the course, course announcements, email, threaded discussions in each aspect of the course, website reviews, and document submission.

Only six one-hour lecture style meetings occurred with four presentations by industry guests and two by the Department faculty. These lectures detailed IE, ME, hospital IE, aircraft ME, ME industry experiences, value stream mapping, and electronics ME. One tour of a local electronics assembly plant, was also arranged by the faculty during the third week of the semester. The textbook used for this course was chosen to complement the lean manufacturing component of the course and for its compelling plot[2].

Student grades were calculated using: 25 % for on-line automated quizzes covering the on-line and lecture content, 25% for attendance at the four-hour lean hands-on factory simulation experience, 25 % for Society of Manufacturing Engineers (SME) or Institute of Industrial Engineers (IIE) Membership, and 25 % for making a professional contribution to either the SME or IIE student chapter at NDSU. The quizzes were intended to provide some accountability for the desired learning via the on-line and lecture content, as usual. The lean event was designed to culminate and integrate the course learning. The professional society membership requirement connected students with the professional learning channels, including publications and networking opportunities, that complement their curriculum choices. The professional contribution requirement was initiated to motivate and empower the students to collaborate with upperclassmen, faculty, industry personnel, and each other toward accomplishing SME or IIE Chapter goals, aligning with their own interests.

The course contained students with interests ranging from aircraft process science to hospital management. For this reason, after the lecture portion of the course was complete (during the fifth week of the semester), each student was asked to indicate his curriculum interest by placing his name in a table, with columns as shown in Table 1, where his interests were most closely aligned. This was done after the lecture portion of the course was complete, such that the options had been clearly presented. At the same time students placed their name in a table, with columns as shown in Table 2, under the professional contribution area in which they were most interested. Proposals for professional contributions other than those shown in the Table 2 were also welcome. Once filled with student names, these two tables were posted in the eCollege software for each student to learn who in the class had similar interests. One student in each group was then asked to initiate the group communications and meetings to accomplish the respective contribution, with faculty and Chapter guidance.

Table 1. Student Discipline Focus Group Table

Student Interest in Discipline Focus Groups	
Manufacturing Engineering Options at NDSU	Industrial Eng. & Management Areas at NDSU

General Manufacturing Engineering	Aircraft Manufacturing Engineering	Electronics Manufacturing Engineering	General Industrial Engineering	Manufacturing Industrial Engineering	Hospital Industrial Engineering

Table 2. Student Professional Contribution Interest Planning Group Table

IIE or SME Contribution Planning Groups							
Nail Defect Sorting Automation Equipment Conception and Proposal	Rapid Prototyping of Fractal Using Laminated Object Manufacturing	High School Presenta-tions of IE or ME	Industry Tours or Other Field Trips	Invitation of Guest Speakers	Wright Flyer Metal Part Production for EAA and Fargo and Minot Aircraft Museums	Arrangement of Industry Shadow Experiences	No Clue

Novel Pedagogy

For 50% of the course grade, each student was required to become a member of either SME or IIE and make a professional contribution to the respective NDSU student organization. During the first five weeks of the semester, the faculty arranged four industry presentations and one field trip to prepare the students for their subsequent self-directed activities. During the remainder of the semester, the students (individuals and teams) focused on making their contribution to the SME or IIE student organization, with student Chapter President and faculty supervision.

Student Chosen Professional Contributions

The following paragraphs present an overview of the student professional contributions. There were three major projects, seven field trips, and three other miscellaneous contributions that were all administered or acknowledge via the IIE or SME Chapter President, as the respective student professional contribution.

Wright Flyer Part Production

For a contribution to the NDSU SME Chapter, five students chose to make 150 spring steel rib caps for the two 1903 Wright Flyer aircraft being built for the aircraft museums in Fargo and Minot, North Dakota. These students were introduced to the project by members of the local Experimental Aircraft Association (EAA) and recruited two upper division students to show them how to accomplish the required production drawings, process plans, routing sheets, and operations sheets. The project ran through the NDSU SME chapter to provide common long-term project management and a focal project for the students choosing the Aircraft Manufacturing Option in the Manufacturing Engineering program. One upper division student volunteered to manage the NDSU Wright Flyer Production during subsequent semesters and was given three technical elective credits. The design drawings were provided by the National Air and Space Museum of the Smithsonian Institution, as illustrated in Figure 1. The freshman students served as volunteer production workers during their second semester, to make the rib caps using a heat treat oven to anneal the spring steel, sheet metal shears to cut the blanks, press break to bend attachment ends, belt sander to produce wood forming molds, arbor press to form the rib caps, and measuring templates to qualify the final dimensions of the molds and parts. Management concepts taught through the project included simplified activity based cost accounting and lean manufacturing elements.

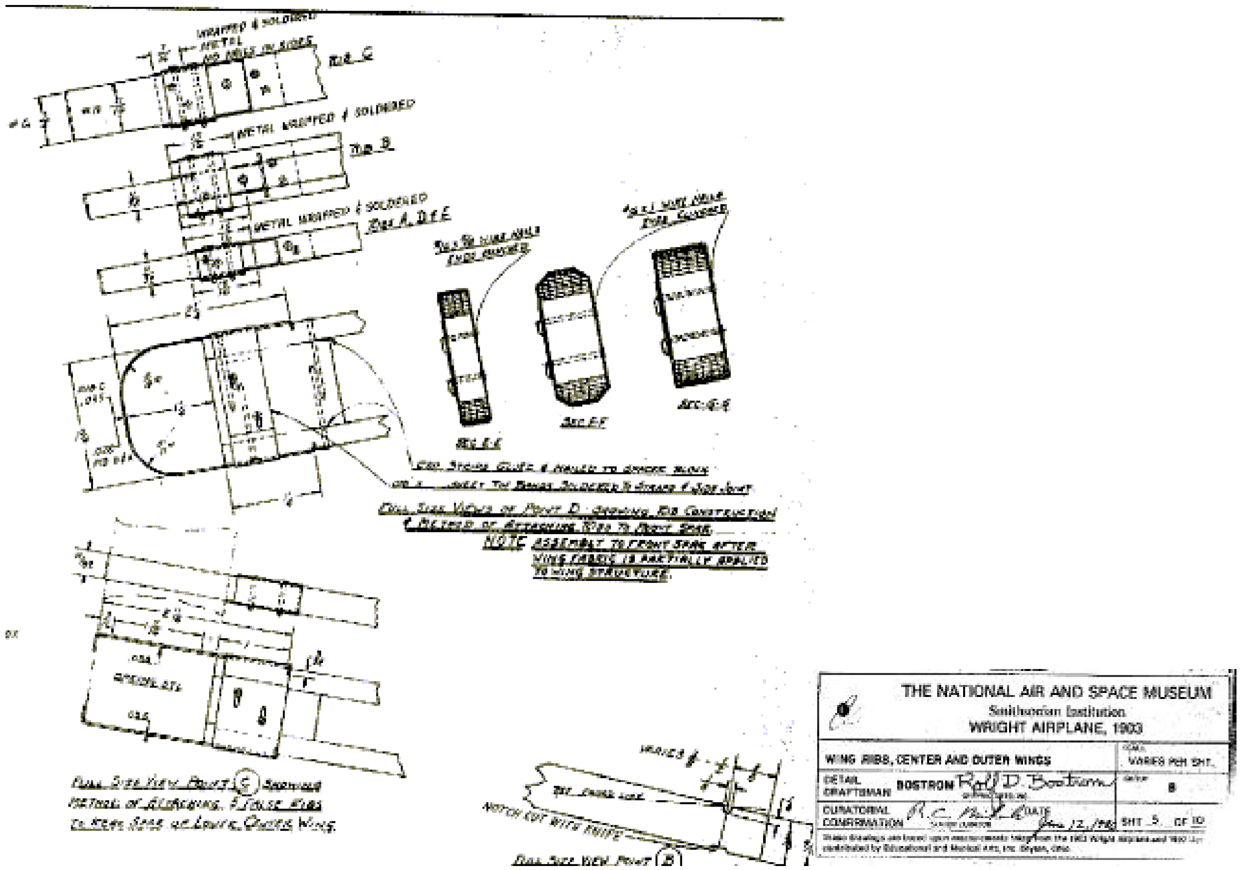

Figure 1. 1903 Wright Flyer Aircraft Rib Cap Drawings

Automated Nail Sorting Machine Design

A regional company and US Customs agent partner, involved in the production of plastic strap staples for house electrical wiring, requested that the students and faculty propose the design of a machine to sort out spade end nail defects that interfered with the automated assembly of plastic staples. Figure 2 shows the spade end nail defect to be sorted with the design drawing for the nail.

Four students worked with the faculty to conceptualize the design and estimate the cost of a mechanical-pneumatic prototype. The result was a $3,582 proposal, processed through NDSU research administration, to the company for the mechanical-pneumatic prototype with option to use a commercial automated laser detection system in conjunction with the pneumatic sorting systems conceptualized. The students met weekly with the faculty, kept and posted meeting minutes, carried out the conceptualization, drawing, research, reporting, and revising needed to accomplish the prototype proposal. The proposal encompassed the design, fabrication and testing of the mechanical-pneumatic prototype machine.

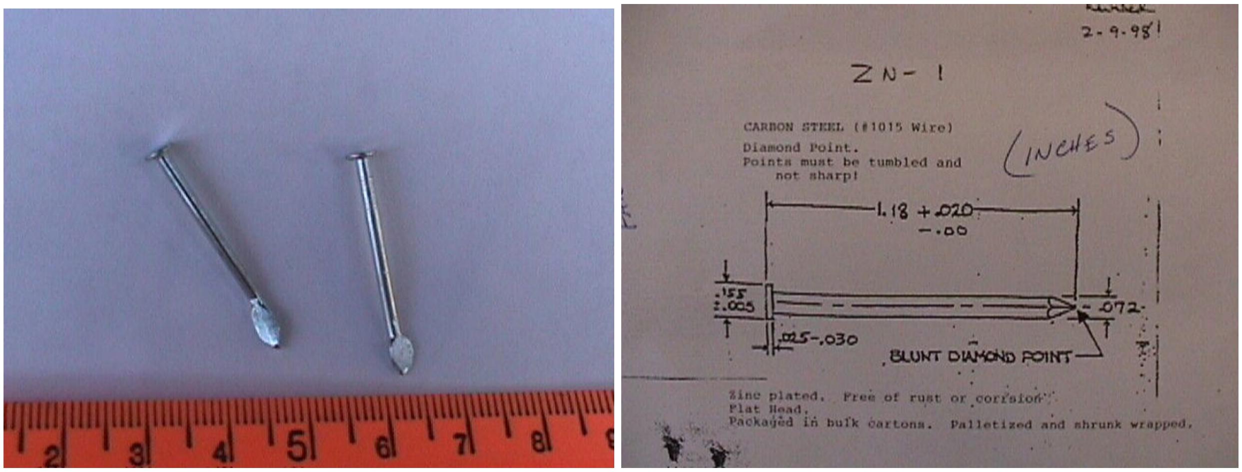

Figure 2. Spade End Nail Defect to be Sorted with Nail Drawing.

Laminated Object Manufacturing of a Fractal

NDSU received a large NSF grant to promote the learning of science and math through involving graduate students and senior undergraduate students in the K-12 classroom[3]. Through this activity, the faculty learned that a high school math teacher had students spend one week building a fractal, with sheet paper and tape, as a hands-on complement to fractal theory. To bring advanced technology into the fractal building experience, three NDSU freshman students chose to study and propose the use of Laminated Object Manufacturing[4] to accomplish this assembly of the fractal in one hour. The fractal chosen for this proposal was the three-dimensional Menger Sponge[5]. Figure 4 presents a black and white drawing of the Menger Sponge. The students of this team learned basic fractal mathematics, laminated object manufacturing rapid prototyping concepts, cost estimating, and proposal writing. As with the other projects, this team posted their work in the eCollege software for the entire class to read.

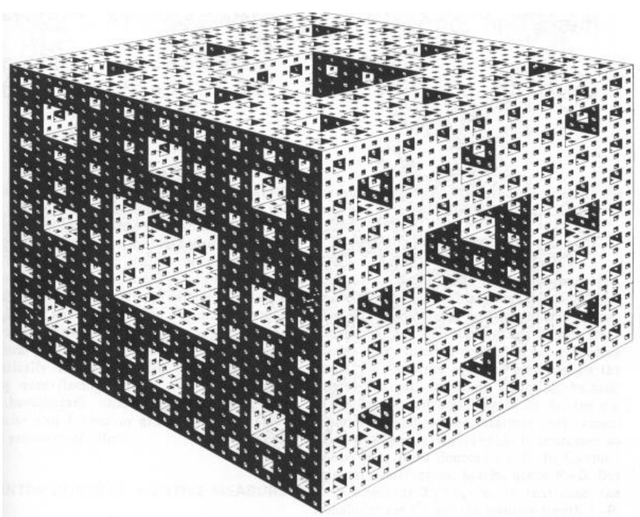

Figure 4. Menger Sponge Fractal[5].

Plant Tours

As expected[6], the author could not keep pace with all the exciting student activities that resulted from encouraging self-directed learning. This was most evident in the area of plant tours. The author arranged only one plant tour and then taught the class how to arrange subsequent tours. Seven additional plant tours were arranged by the students which included: Phoenix International for electronics manufacturing, Meritcare for health care IE, Winnipeg mint for money manufacturing, Dakota Growers for pasta manufacturing, Douglas Machine for metal fabrication, Case New-Holland for farm tractor manufacturing, Turtle Mountain Manufacturing for metal fabrication, and Innovis Hospital for hospital IE. The students found these field trips very helpful toward understanding what IEs and MEs do and how they learn. Another unique aspect of these tours was that the freshmen arranged the tours and invited upper division students. Each tour was coordinated as an IIE or SME contribution through the channel of the IIE or SME Chapter President, respectively. A one page review of each tour was presented by the responsible student and posted in the eCollege course discussion area where follow-on discussion occurred. This informed and engaged the students in the topic, even when a student could not attend a given tour, due to scheduling conflicts.

Miscellaneous Contributions

Other miscellaneous student contributions to the IIE Chapter or SME Chapter at NDSU through this freshman course included a presentation about manufacturing engineering to the seventh grade technical education class at Agassiz Middle School (Fargo, ND), a day of shadowing an industrial engineer at Phoenix International in electronics manufacturing, and helping to develop a logo for the IME Department at NDSU. Each of these contributions invited additional student participation through the SME or IIE student meetings and listservs.

Student Survey Results

Three surveys were used to evaluate the effectiveness of this freshman experience. The first was the Individual Development and Educational Assessment (IDEA) Online Survey Form - Student Reactions to Instruction and Courses[7], the second was the Faculty Institute for Excellence in Learning (FIEL) National Survey of Student Engagement[8], and the third was the NDSU Student Survey of Instruction[9].

The three surveys administered to each of the 25 freshman students showed that the course objectives were met. Based on the IDEA Center nationally normalized long-form survey of the student reactions to this instruction and course, three aspects of the teaching methods and style were rated significantly higher than for other classes of similar size and level of student motivation. These highly rated aspects were relevant to the essential and important objectives of the course and involved fostering student collaboration, establishing rapport, and encouraging student involvement.

Regarding the fostering of student collaboration, the IDEA survey showed that the item “Formed teams or discussion groups to facilitate learning” was rated at 13% more frequent than the national average. On establishing rapport, the item “Encouraged student-faculty interaction outside of class (office visits, phone calls, email, etc.)” was rated 12.5% higher than the national average. Thirdly, on encouraging student involvement the item “Involved students in hands-on projects such as research, case studies, or real-life activities" was rated at 10 % higher than the national average.

Table 3 shows the key IDEA survey results for the highly rated items and faculty written questions related to the course objectives. Other survey questions not specifically addressed here were all in the average range as compared to the IDEA T-Score Comparison with Classes of Similar Size and Level of Student Motivation in IDEA National Normative Database. It can be inferred, therefore, that the highly rated teaching methods contributed to making the course better than average, in the minds of the students. The high ratings (over 4.0 out of 5.0 possible) for the three course objective survey questions demonstrated that the course objectives were met.

Table 3. IDEA Teaching Methods and Faculty Written Survey Question Results[10].

Teaching Method or Faculty Written Survey Question	Specific Highly Rated Activity	Raw Rating out of 5.0, where 1.0 was minimum response (standard deviation)	T-Score Comparison with Classes of Similar Size and Level of Student Motivation in IDEA National Normative Database
1. Fostering Student Collaboration	Formed "teams" or "discussion groups" to facilitate learning.	4.2 (0.9)	This class rated this item 0.55 points higher than the national average, indicating 0.55 / 4 levels = 13 % more frequent fostering of student collaboration.
2. Establishing Rapport	Encouraged student-faculty interaction outside of class (office visits, phone calls, e-mail, etc.)	4.5 (0.8)	This class rated this item 0.50 points higher that the national average, indicating 0.50 / 4 levels = 12.5% more frequent establishing of rapport.
3. Encouraging Student Involvement	Involved Students in "hands on" projects such as research, case studies, or "real life" activities.	4.4 (0.8)	This class rated this item 0.40 points higher than the national average, indicating, 0.40 / 4 levels = 10% more frequent encouraging of student involvement.
4. Faculty Written Question about course objective (1): Understand what industrial and manufacturing engineers do.	I now understand basically what industrial and manufacturing engineers do and think about.	4.2 (1.1)	NA
5. Faculty Written Question about course objective (2): Experience how industrial or manufacturing engineers learn.	I now know about the professional organization through which I can learn and participate toward becoming a professional manufacturing or industrial engineer.	4.4 (0.8)	NA

6. Faculty Question on objective (3): Appreciate why industrial and mfg engineers lean systems.	I see the value of reducing wastes, toward improving productivity and profit, in ind & mfg org through lean conc.	4.3 (0.8)	NA

Figure 5 shows the IDEA Teaching Methods and Faculty Written Survey Question Results data of Table 3 data, in bar chart form. The horizontal axis numbers correspond to the numbered rows in Table 3.

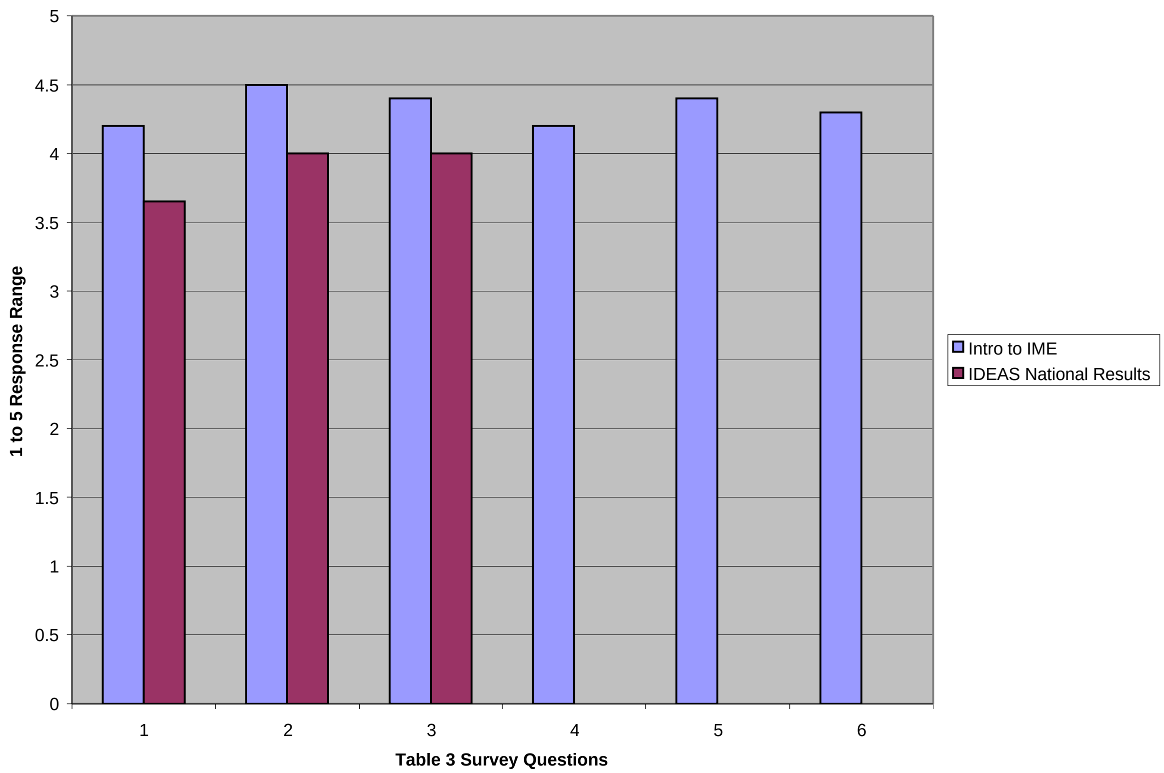

Figure 5. IDEA Teaching Methods and Faculty Written Survey Question Results.

The results from the National Survey of Student Engagement (NSSE) coordinated at NDSU through the Faculty Institute for Excellence in Learning (FIEL), demonstrated that in this class, six of the 14 engagement activities operated above both the NDSU and the national average. Comparing the survey average totals (last row in Table 4) demonstrates that this class was engaged 6.5 percent more than the average of all classes at NDSU and 2.6 percent more than the freshman class nationally. Table 4 presents the relevant data from the NSSE that compares this course to both NDSU results and the NSSE national database.

Table 4. Introduction to Industrial and Manufacturing Engineering Course, National Survey of Student Engagement (NSSE) results compared to NDSU results and the NSSE database[11].

Survey Group / Survey Question	Introduction to Industrial and Manufacturing Engineering Class - Fall 2001, 4.0 possible (standard deviation)	NDSU Surveys - Fall 2001, 4.0 possible (standard deviation)	National Survey Database for First-Year Courses (Spring 2000, 4.0 possible)
1. Memorizing facts, ideas, or methods from your course and readings so you can repeat them almost in the same form.	3.056 (.873)	2.508 (0.910)	2.19
2. Evaluating the value of information, arguments, or methods such as examining how others gathered and interpreted data and assessing the accuracy of their conclusions.	2.611 (0.698)	2.499 (0.883)	2.54
3. Acquiring job or career related knowledge and skills.	3.471 (0.800)	2.550 (0.952)	2.47
4. Thinking critically and or analytically.	2.947 (0.911)	2.787 (0.849)	2.95
5. Learning effectively on your own, so you can identify, research, and complete a given task.	3.000 (0.791)	2.776 (0.821)	2.95
6. Working effectively with other individuals.	3.294 (0.849)	2.786 (0.925)	2.82
Survey Average Totals (14 questions, 56.0 possible)	37.42 (4.757)	35.15 (6.625)	36.47

Figure 6 shows the Introduction to Industrial and Manufacturing Engineering Course, National Survey of Student Engagement (NSSE) results compared to NDSU results and the NSSE database of Table 4, in bar chart form. The horizontal axis numbers correspond to the numbered rows in Table 4.

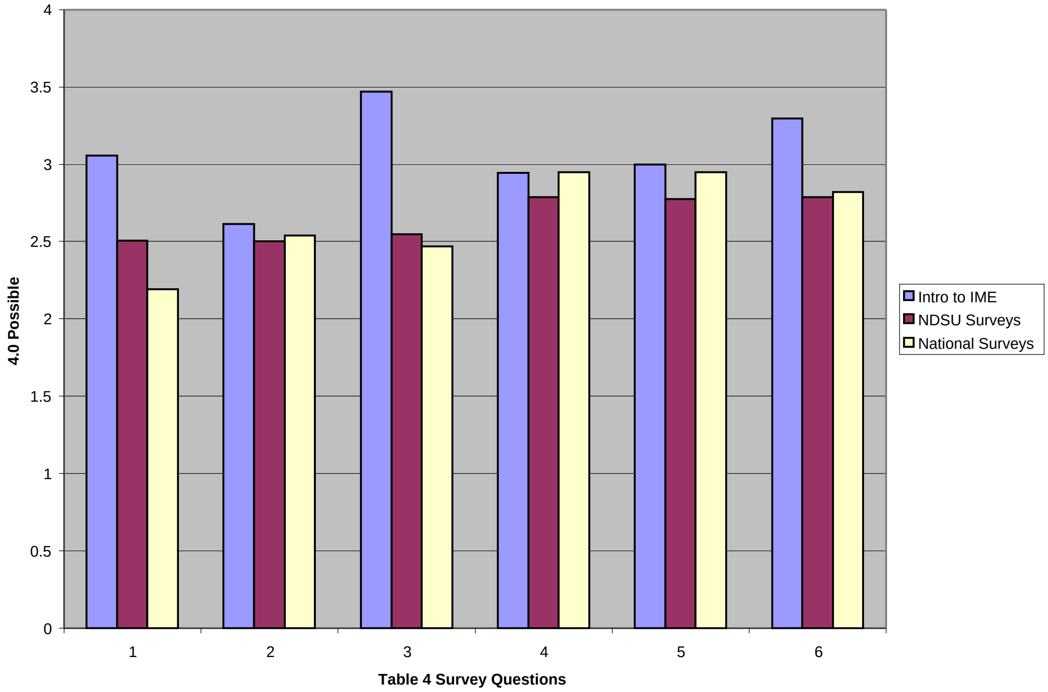

Figure 6. Introduction to Industrial and Manufacturing Engineering Course, National Survey of Student Engagement (NSSE) results compared to NDSU results and the NSSE database.

The NDSU Student Survey of Instruction[7] results were higher in all categories as compared to the Department average, College Average, and the University average as shown in Table 5. In light of the "forced" student membership, it was interesting to note the positive responses to the three questions about grading, indicating that the students did not object to this membership requirement.

Table 5. NDSU Student Rating of Instruction Results[12].

Survey Question	Class Results -5.0 possible (standard deviation)	Department Results -5.0 possible (standard deviation)	College Results -5.0 possible (standard deviation)	University Results - 5.0 possible (standard deviation)
1. Your satisfaction with the instruction in this course.	4.167 (0.857)	3.081 (1.257)	3.835 (1.007)	3.979 (0.930)
2. The instructor as a teacher.	4.235 (1.033)	3.143 (1.299)	3.921 (1.014)	4.054 (0.948)
3. The ability of the instructor to communicate effectively.	4.167 (0.786)	3.004 (1.291)	3.860 (1.039)	3.986 (0.976)
4. The quality of this course.	3.889 (0.832)	3.173 (1.109)	3.743 (0.961)	3.876 (0.889)

5. The fairness of procedures for grading this course.	4.278 (1.018)	3.435 (1.084)	3.897 (0.960)	4.048 (0.897)
6. Your understanding of the content.	4.111 (0.832)	3.404 (1.048)	3.890 (0.849)	3.935 (0.841)
Department Questions	Class Results -5.0 possible (standard deviation)	Department Results -5.0 possible (standard deviation)		
7. The instructor was well prepared.	4.667 (0.617)	3.455 (1.271)		
8. The instructor's treatment of students was courteous.	4.824 (0.393)	3.695 (1.208)		
9. The criteria for grading were clear in advance.	4.200 (1.014)	3.106 (1.391)		
10. The concepts emphasized on exams were relevant.	4.294 (0.686)	3.252 (1.225)		
11. The instructor graded fairly.	4.313 (1.014)	3.467 (1.195)		
12. I learned a great deal from this course.	4.125 (1.025)	3.095 (1.325)		

Figure 7 shows the NDSU Student Rating of Instruction results of Table 5, in bar chart form. The horizontal axis numbers correspond to the numbered rows in Table 5.

<u>Discussion</u>

The positive results of the three student surveys indicated that the course objectives were met and that the teaching methods were effective. Requiring each student to join a professional society encouraged the early discerning of the difference between industrial engineering and manufacturing engineering. This membership requirement was embraced by most of the students as an important and positive move toward their career objectives. The self-directed student chosen professional contributions led to student teamwork, communications and networking with upper class students, faculty, industry personnel, and each other. These early active engagements of the freshmen interests were undertaken as important contributors to student retention and to improve learning.

The requiring and empowering of students to accomplish self-chosen professional contributions expanded the number and variety of the learning opportunities that occurred, as compared to faculty inspired and led opportunities. The students conceived and led other students to be involved in the smorgasbord of three projects, seven plant tours, and three miscellaneous activities. Their reach went beyond the class and involved upper division students through the venue of the local SME or IIE Chapter.

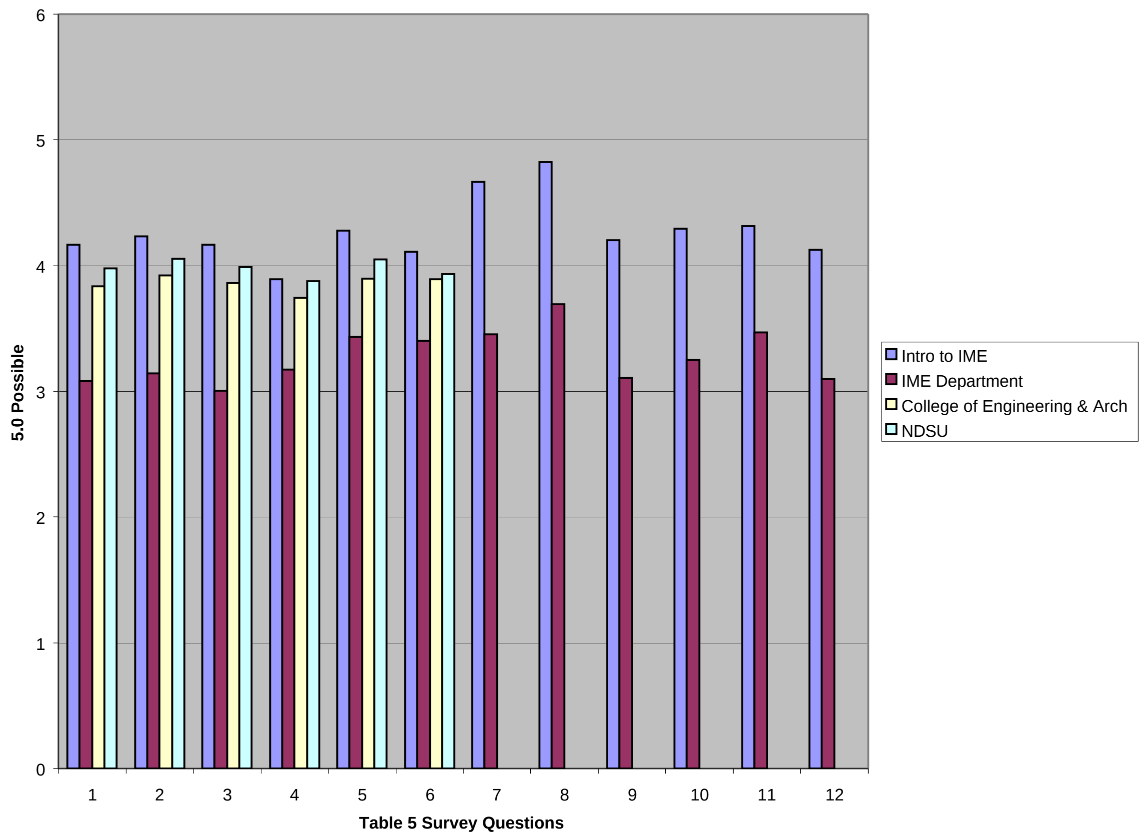

Figure 7. NDSU Student Rating of Instruction Results.

The development of interpersonal relationships and clear communication was encouraged and necessary for each student to arrange and lead their respective activity. The placing of more responsibility on each student, through the contribution requirement, both acknowledged their abilities and empowered them to use their abilities, as in the parable of the talents[13]. The benefits of having the student activities directed partly by the IIE or SME student leaders was to involve the freshman early in the student Chapter activities, provide the student Chapters manpower to accomplish additional goals, and lead the freshmen toward continuous Chapter involvement throughout their college education as a complement to their academic studies.

Forced Student Membership and Contribution Dialog

The NDSU faculty advisor for IIE had reservations about the appropriateness of requiring the professional membership and student contribution. Likewise, eight of eight IIE upper division IIE students opposed the student membership and contribution requirements on the basis that: (1) IIE is a voluntary student organization. (2) Student organizations should attract members through their inherit value. (3) Participation in a student organization shows initiative and drive for the profession, where forced membership would devalue this employer screening tool.

At the beginning of the course, in response to this opposition, the author explained that: (1) Professors regularly "force" students to do less productive activities than paying a small fee to become aware of their chosen profession and begin professional networking. (2) These requirements were a stab at retaining freshmen through empowering and engaging their interests. (3) The students would receive professional literature throughout the year, which would be helpful and interesting supplements to other class materials and activities. (4) This would also begin to close the Department communication gap resultant from the students only having one or two courses in the IME Department during their freshman year, considered a contributor to attrition. (5) These requirements were only for this one semester course, towards encouraging an early taste of the value of both the professional literature and the value of being an active contributor versus a passive observer.

Throughout the semester, both the SME and IIE student Chapter Presidents cordially and appropriately coordinated the interactions of the freshmen students with, and as, student Chapter activities. The time required of these student Presidents was minimal, essentially providing communication opportunities during the semester then reviewing and signing the student reports at the end of the semester.

Conclusions

1. The students were required to become members of either the Society of Manufacturing Engineers (SME) or Institute of Industrial Engineers (IIE) and make a contribution to the respective student organization for fifty percent of their course grade. This fostered student collaboration, established rapport with the faculty, encouraged early student reading of professional publications, provided professional society networking opportunities, and accommodated individual learning styles. It also served to inspire the variety of student interests and desired career paths.

2. The three student surveys conducted (IDEA, NEES, and NDSU) demonstrated that the course objectives were met and that the teaching methods were effective. In the NDSU survey, the grading clarity and fairness was also highly ranked, indicating student acceptance of the professional membership requirement.

3. Discussion on the appropriateness of professional membership as an academic requirement would be helpful at the national level. Based on the results of this experiment, the professional membership requirement appeared beneficial.

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