2006-1926: AN EVALUATION OF THE IMPACT OF A SERVICE LEARNING PROJECT IN A REQUIRED FIRST-YEAR ENGINEERING COURSE

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Abstract

In Fall 2004, a service-learning curriculum was introduced in one section of Engineering 100: Introduction to Engineering, at the University of Michigan. Engineering 100 is a required course for all first year students and comprises a team project coupled with an introduction to technical communication. The course also includes threads of environmental sustainability, ethics and the role of the engineer in society. As a required course, Engineering 100 has suffered from low teaching evaluations, despite the efforts of many faculty to actively engage students in the learning process. Thus, one of the goals of this project was to explore the impact that service-learning might have on students' learning, including their level of engagement and motivation, in a required first year course.

One method for assessing student learning is an anonymous instructor evaluation questionnaire; at the University of Michigan, such a questionnaire is required for all courses at the end of the semester The Likert-scale questions are divided into two categories. The first four questions address students' perceptions of the quality of the course and instructor, the extent to which they "learned" in the course, and their desire to enroll in the course. The second set of questions is directed at the specific teaching outcomes for the course. These reflect outcomes centered on technical communication, engineering problem solving, teamwork, global/societal impacts and ethics. These questions also address the students' level of engagement with the material and their motivation. Students' responses to both sets of questions provides an insight into their learning.

To determine if the integration of a service-learning curriculum into Engineering 100 affected the student's learning in the course, a detailed statistical analysis of the teaching evaluation responses was performed. These analyses included a Stepwise Regression analysis, Multiple Regression analysis, Correlation analysis, and a Multifactor ANOVA test performed on the teaching evaluations for four successive semesters of ENG 100 taught by the same instructor; the first three without and the last with a service-learning curriculum.

This paper presents a summary of the general course objectives, the service-learning curriculum components introduced in 2004 and a detailed discussion of the study results outlining the statistical results and broader implications for first year engineering curricula.

Background

Since the mid-1900's, traditional undergraduate engineering education has been focused on the development of specialized technical knowledge in students for the purpose of solving challenging problems. As a result, the last half-century of engineers have been highly technically trained, but generally lack the skills often associated with other successful professionals, such as the capacity to function in a team environment, communication skills and the broad education necessary to understand their impact in a global and societal context. With the dawning of the

21st century, and the movement toward a global social consciousness, the engineer can no longer operate in a vacuum, but must embrace the professional skills which were previously lacking in traditional education and move beyond the cold stereotype to solve problems of global and societal importance [1]. It is the responsibility of our educational institutions at the highest levels to engage students in an educational program that redefines engineering in this context, by increasing the relevance of undergraduate education to modern engineering practice.

One highly successful method for instituting a change toward societal awareness is the implementation of a service-learning component within the engineering curriculum [2]. Such a program facilitates the development of professional skills in engineering students as they work with community partners through the design process. Students are exposed not only to the engineering skills involved in problem solving, but must also enter into the initial design stages of needs assessment and problem identification which are commonly missing from traditional engineering design courses. A service-learning approach also exposes students to the implementation stage of design, as well as the challenges associated with the very real constraints of clients and the need for a sustainable solution in a social and environmental context. In addition, the opportunity to apply their skills in a social setting reveals a very human aspect of engineering, a crucial element of the profession thought lacking in the previous curriculum.

While few would question the value of experiential hands-on learning in engineering education, the role of service-learning, coupling actual experience with reflection, although common in the social sciences, is still very limited in the engineering curriculum [3]. Yet it can be argued that engineering serves people and society as much as, if not more than any other profession. ABET's "Criteria for Accrediting Engineering Programs" [4] clearly identifies "professional skills" needed by future engineers that are important in this service capacity. These include "an ability to function on multidisciplinary teams," "an understanding of professional and ethical responsibility," "an ability to communicate effectively," "the broad education necessary to understand the impact of engineering solutions in a global and societal context," and "a knowledge of contemporary issues." Service-learning courses are an ideal mechanism to meet these critical program outcomes in the training of the next generation of engineers [1, 5-9].

Service-learning opportunities in the engineering curriculum have an additional potential bonus of increasing the diversity of the profession. Altruistic reasons for choosing a career in science or engineering are predominantly expressed by women or historically underrepresented minority students [10, 11]. In Seymour and Hewitt's work, they found that "women were more likely than men to rank materialistic goals below the desire to work at something they care about, whether as a matter of personal fulfillment, or in pursuit of a valued social cause." In addition they found that "making a long-term contribution to their families and communities" was very important for students of color. Traditional engineering curricula, with its emphasis on individualistic and competitive technical training, can mask the importance that this profession has to society and the role that the engineer can play. Service-learning, particularly if offered early and throughout the curriculum, can play a significant role in the recruitment and retention of underrepresented students. It was with these concepts in mind that the author introduced a service-learning curriculum into a required introductory engineering course at the University of Michigan.

Engineering 100 Course objectives

Introduction to Engineering, at the University of Michigan, is a required first-year course designed to introduce students to their career choice through practice in the overall work experience of professional engineers. The course topics, as written in the college bulletin are:

> "Focused team projects dealing with technical, economic, safety, environmental and social aspects of a real-world engineering problem. Written, oral, and visual communication required within the engineering profession; reporting on the team engineering projects. The role of the engineer in society; engineering ethics. Organization and skills for effective teams."

The course is offered in several sections, each based on a different engineering design project, ranging from very discipline-oriented to systems design concepts. First-year students select a section that interests them from a list of section descriptions with guidance from engineering advising. The design projects presently offered in this course vary widely in order to provide a broad range of choices for a diverse engineering student community.

Although each section of the course hosts a different technical design project, the course content is standardized between sections to address the ABET outcomes [4]:

a. An ability to apply knowledge of mathematics, science and engineering;
b. An ability to design and conduct experiments, as well as to analyze and interpret data;
c. An ability to design a system, component, or process to meet desired needs;
d. An ability to function on multi-disciplinary teams;
e. An ability to identify, formulate, and solve engineering problems;
f. An understanding of professional and ethical responsibility;
g. An ability to communicate effectively; and
h. The broad education necessary to understand the impact of engineering solutions in a global and societal context.

These outcomes are assessed through individual and team assignments, peer evaluations of team performance, exams, and course evaluations.

Outcomes (f) and (h) present the greatest challenge to the faculty, as they are professional outcomes associated with the development of a professional identity and an ethical framework, which are typically achieved with personal experience and reflection over a lifetime. The introduction of such opportunities into the classroom can be difficult and time consuming and is commonly accomplished through case studies. Although case studies can be used as an effective learning tool [12], many traditionally used engineering cases lack relevance to the students, their culture, and their level of professional development.

Thus, in an effort to implement a more relevant curriculum, in Fall 2004 a service-learning pedagogy was implemented by this author in one section of Engineering 100.

The Service Learning Curriculum

There are several strong justifications for the development of a service oriented design project into the engineering curriculum at the first year level. First, it has been shown that community learning is a powerful pedagogy [13]. The opportunity for community service brings active and reflective learning to students and has been shown to produce deeper understanding and better application of subject matter, increased complexity of problem and solution analysis, and greater use of subject matter knowledge in analyzing a problem [14, 15]. Second, research on the retention of women in the field of engineering shows that the enrollment of women is enhanced in courses with a community-based focus with both social and environmental facets [10]. Finally, this collaboration offers an opportunity, heretofore nonexistent, for students to make linkages between their first design course and upper-level design courses.

There are three required criteria for a service-learning course [16]:

1. Relevant and meaningful service with the community;
2. Enhanced academic learning; and
3. Purposeful civic learning.

To address these criteria, the course design project was based around the needs expressed by a local community partner, a not-for-profit organization serving an under-resourced community.

Students in the course participated in a team design project centered on the development of innovative, low cost greenhouses for several under-resourced public schools in the Ann Arbor/Ypsilanti area. Our community partner in this endeavor was Growing Hope of Ypsilanti, Michigan, a non-profit organization. Growing Hope works to help people improve their lives and communities through gardening. Their activities are designed to foster learning and improved nutrition, encourage self-reliance and promote positive community futures. As part of their ongoing programs in the Ann Arbor and Ypsilanti area, the greenhouses designed by the Engineering 100 students were designed to serve educational needs, provide year long growing potential to supplement standard food offerings in schools and community service facilities, and support early plantings for local community gardens.

This project provided relevant and meaningful service within the community by providing tangible resources for use in the local schools. Academic learning was enhanced in many ways. For example, the addition of the service-based design project provided a real-world experience in which the students were exposed to aspects of the engineering design process not present in a textbook design problem. Problem definition and the establishment of design criteria occurred through a student-led discovery process with an open-ended outcome, rather than a clearly defined need. Also, since the project led to an implementation phase, students were driven to consider risk, safety and associated ethical concepts with consequences that would impact their client, users and potentially the environment.

Purposeful civic learning is learning that contributes to the preparation for community or public involvement in a diverse democratic society, and is the key ingredient that sets service-learning pedagogy apart from the simple inclusion of community service in a course. In addition to academic learning addressing key issues such as the role of engineers in society, engineering ethics and appropriate technology, student were actively involved in applying their knowledge in a responsible manner for the betterment of society and developing interpersonal skills in both a team setting and a multi-cultural setting. For example, students applied the concept of asset-based community development to form a framework for design criteria by personal interaction with the client and users.

In addition, requirements for the course were expanded to include a weekly reflection journal assignment designed to enhance both academic and civic learning outcomes in an informal setting.

Course Evaluations

One method for assessment of the course objectives is through student evaluations of teaching. Every course offered at the University of Michigan is subject to a likert-scale questionnaire consisting for four common questions, and a series of additional questions designed to determine student perceptions of learning objectives of the course. Table 1 provides a listing of the questions asked for all sections of Engineering 100. This anonymous questionnaire is administered during one of the final class meetings. The distribution of results and median value of each question is then supplied to the faculty and departments early the following term for course documentation, faculty recognition, tenure and use in improvement of teaching methodology.

Typically, faculty and college administration view these evaluations in a gross sense by reviewing the median values of each response as calculated via the recommended method for calculating medians based on a frequency distribution [17] as follows:

$$Md = L + w\left(\frac{0.50N - F_{<c}}{F_c}\right) \quad (1)$$

Where *Md* is the median, *L* is the lower limit of the likert interval containing the middle score of the data set, *w* is the width of each likert interval, *N* is the number of responses, F_c is the frequency of the interval containing the middle score of the data set and $F_{<c}$ is the total frequency below the interval containing the middle score of the data set.

The primary effort is placed in reviewing and tracking the responses to Questions 1 and 2 (Q1 and Q2), with some attention to the remainder of the questions as they relate to accreditation and curriculum development issues. Unfortunately, this minimal review of this extensive data set can provide misleading results for curricular decision-making. Several instances can be shown in which external factors, for example class placement in the time schedule, can influence questionnaire results causing inconsistent medians for a faculty member teaching the same course, during the same semester at different times. Table 2 provides five such instances for a course taught at the University of Michigan. The range in medians is so large, that interpretation of one section of the course independent of another can lead to vastly different conclusions. Ranges in Q1 and Q2 under these circumstances averaged 0.34 and 0.35, respectively. It is common practice for the University to publish median quartiles for the full range of University

Table 1. Questions posed for student evaluations of teaching in Engineering 100 at the University of Michigan.

Question # (Q#)	Question
1	Overall, this was an excellent course
2	Overall, the instructor was an excellent teacher
3	I learned a great deal from this course
4	I had a strong desire to take this course
712	This course helped me understand the rewards and challenges of being an engineer
713	This course deepened my interest in a career in engineering
714	This course helped me understand the range of skills/disciplines needed in engineering
715	This course helped me understand social and economic considerations in engineering
716	This course helped me understand environmental implications of engineering decisions
717	I feel more a part of the North Campus engineering community as a result of this class
718	I enhanced my technical knowledge in at least one area of engineering in this class
719	I have a sense of pride and accomplishment as a result of completing my projects
720	I have become more aware of the responsibilities engineers have as professionals
721	I will think more carefully about engineering's impact on society because of this course
722	I gained an understanding of the fundamentals of technical writing
723	I gained an understanding of the fundamentals of oral and visual communication
724	I understand how to design and implement a technical report and oral presentation
725	I understand that technical communication has multiple audiences and purposes
726	Writing assignments helped me develop my skill as a writer
727	I believe that team skills are important for engineers
728	My team performed effectively
729	The team work was a positive experience
730	I found the guest lecturers valuable
731	The discussion sections were valuable
732	The amount of work required was appropriate for the four credit hours received
733	I developed some skill in using the University Library and its resources
734	I developed my skill in finding, evaluating, and citing information resources
735	Grades were assigned fairly and appropriately
736	I attended class regularly
737	I used all the learning opportunities provided in this class

Table 2. Five examples of median values reported for Q1 and Q2 for a faculty member teaching the same course during the same semester at two to three different times.

	Semester 1		Semester 2		Semester 3		Semester 4		Semester 5		Average Range	
Av	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2
Class 1	3.69	4.18	3.20	3.88	3.28	3.93	3.50	3.50	4.10	4.50		
Class 2	4.00	4.71	3.42	3.88	2.89	3.56	3.33	3.67	4.54	4.73		
Class 3							3.67	4.13	4.25	4.73		
Range	0.31	0.53	0.22	0.00	0.39	0.37	0.34	0.63	0.44	0.23	0.34	0.35

and College courses. For Q1, a median discrepancy of 0.34 can make the difference between placement in the top quartile and the third quartile. Therefore, a more effective method for the evaluation of this data may be an examination of the interrelationships that exist between responses, as well as the potential for statistical normalization of median results.

Statistical Analysis of Course Evaluations

The Likert scale course evaluation questionnaires consist of the 30 questions listed in Table 1. The questionnaires are scaled from 1 (strongly disagree) to 5 (strongly agree) with the option for selecting not applicable (0). In the event that a student indicated that the question was not applicable, this response was not included in the analysis due to its ambiguity and leverage.

When working with Likert scale data, it is important to note the limitations of data analysis and interpretation introduced by the ordinal characteristic of the Likert scale. This problem arises because Likert scales host a rank order, however the intervals between the values cannot be presumed to be equal. In addition, data obtained through the use of Likert-type scales often exhibit a skewed or polarized distribution. Therefore, the legitimacy of analyzing Likert scale data using parametric statistics becomes in important issue, since parametric statistics assume that the data is normally distributed. However, the argument can be made that because of the robustness of parametric statistical analysis methods, data exhibiting large departures from normal distribution often produce valid results [18]. This is especially true for larger data sets with a mound-shaped distribution pattern. To assess the validity of applying parametric statistical analysis to this data set, the Ryan-Joiner test for normality was applied to each set of student responses for each question and semester. The results of this analysis showed that approximately 75 % of the distributions satisfied the null hypothesis and reflected a normal distribution. Of the remaining 30 data sets, 7 were weakly, 16 were moderately, and 7 were strongly non-normally distributed. Most of the moderately and strongly non-normal distributions could be attributed to questions which were more likely subject to bimodal responses based on student experiences with teams. These questions were excluded from the analysis which follows.

The sample size of questionnaires from each semester is provided in Table 3, along with the median values for questions that the investigators felt were most closely linked to the learning outcomes associated with the service-learning pedagogy. It should be noted that the service-learning pedagogy was introduced in Fall 2004. Prior term projects were centered on applications of basic coastal engineering concepts to documented problems of reduced water quality at coastal sites within the United States. These earlier projects differed from the service-learning projects in that they had less freedom for student identification of design criteria, lacked engaged clients and users, and did not result in implementation. All four semesters of the course were taught by the same instructor.

The information in Table 3 clearly shows that the median values for student responses were much higher for the service-learning semester than for previous semesters, and in most cases exceed the ranges suggested in Table 2 for variability between sections in the same semester, presumably taught in a similar manner by the same faculty member. It is interesting to note that the largest differences between the service-learning semester and the previous semesters occurs in Q4. Often Q4, the question aimed at ascertaining the students' desire to enroll in the course, for a required course is quite low. This change indicates that students deliberately pre-selected this section of the course in Fall 2004 to meet their educational goals. This supports the concept that offering a service-learning section to engineering students provides an attractive option for students with altruistic goals, who are commonly under-represented students in the STEM disciplines. It is interesting to note that this section of Engineering 100 enrolled approximately 35 percent women and 15 percent underrepresented minorities, while the average for the incoming class was approximately 25 percent and 10 percent, respectively.

A multifactor ANOVA test was performed to determine whether there was a significant difference between the mean response values of each question between semesters. Tukey's Method was also used to individually and graphically compare the means of each question between each semester. The results of this analysis showed that the mean responses for Fall 2004, Q1 through Q4, as well as the questions related to service-learning curriculum noted in Table 3 were all significantly higher when compared to the three previous semesters. The P-values for all 10 of these questions, comparing Fall 2004 to the remaining semesters, was 0.000.

To survey any basic interrelationships between questions within each semester, a correlation analysis was performed. This was also used to resolve the effect that the structure of the survey may have had on the student's responses. In general, the Pearson correlation value rarely exceeded 0.80 for any of the data evaluated, showing limited correlations at best. The strongest correlations existed between Q1 and Q3 ($P = 0.67$ to 0.83), the students perception of the quality of the course and their desire to enroll, and Q712 and Q714 ($P = 0.63$ to 0.75), understanding both the rewards and challenges of being an engineer and the range of skills/disciplines necessary in engineering.

Participants engaged in Likert-scale questionnaires often settle into patterns and subsequently circle the same response for different questions if the survey instrument is lengthy such as the one utilized in this study. The Pearson correlation values calculated for these data show a weak tendency towards this behavior in the diagonality of the correlation matrix. However, there are clear departures from this tendency when questions are clearly unrelated. For instance, the correlations between Q716 and Q717, regarding understanding environmental impact and feeling a part of the engineering campus, are very small, despite their position in the middle of the survey instrument. This behavior indicates a deliberate act on the part of the respondents to answer all of the questions on the questionnaire as honestly as possible.

A Forward Selection Stepwise Regression analysis was performed on Q1 through Q4 for each semester. These questions were chosen to best describe the overall effectiveness of the course, as well as the prime motivator for enrollment. This helped determine, within each semester, which questions in the questionnaire could be used to best predict the outcome of the first four questions. Once these significant "predictor" questions were determined, a Forward Selection Stepwise Regression analysis was also performed for each of the predictor questions independently. This provided a determination of the degree of multi-collinearity between the questions on the questionnaire. In addition, a Multiple-Regression analysis was performed on each of the first four questions and their "predictor" questions to further determine the degree of multi-collinearity between the questions and to gauge the validity of the results.

Table 3. Summary of course evaluation data set showing median values for questions pertinent to service-learning curriculum by term and minimum difference between term with and without service-learning component.

Parameter	Question	Fall 2002	Fall 2003	Winter 2004	Fall 2004	Minimum Difference
N		70	75	94	114	
Q1	Overall, this was an excellent course	3.71	3.69	3.77	4.58	0.81
Q2	Overall, the instructor was an excellent teacher	4.12	3.86	3.98	4.73	0.61
Q3	I learned a great deal from this course	3.69	3.87	3.72	4.41	0.54
Q4	I had a strong desire to take this course	2.97	3.1	3.13	3.96	0.83
Q712	This course helped me understand the rewards and challenges of being an engineer	3.92	3.89	3.85	4.52	0.60
Q714	This course helped me understand the range of skills/disciplines needed in engineering	3.86	3.89	3.89	4.37	0.48
Q715	This course helped me understand social and economic considerations in engineering	4.06	3.96	3.94	4.42	0.36
Q719	I have a sense of pride and accomplishment as a result of completing my projects	3.91	3.89	3.87	4.6	0.69
Q720	I have become more aware of the responsibilities engineers have as professionals	3.99	4.06	3.96	4.56	0.50
Q721	I will think more carefully about engineering's impact on society because of this course	3.81	3.83	3.82	4.5	0.57

Table 4 lists, for questions Q1, Q2, Q3, and Q4 the corresponding questions that best predicted the student's response to each of these questions, as well as the R^2 percentage value for each model. It is clear to see that the variance attributable to a multiple regression model for each question is much higher than that attributable to any single variable. The table shows the consistent dependencies, and unique dependencies present in each semester. It is interesting to note that the model for Q2 is the only model in which there is a consistent dependency outside of Q1 through Q4. Q735 addresses the fair and appropriate assignment of grades, and is reasonably linked to student perceptions of an excellent teacher. It is also interesting to note that neither Q3, student perception of learning, nor Q4, student perception of desire to enroll, have a consistent dependency on Q2, the student perception of the excellence of the teacher.

Unique model dependencies during Fall 2004 are dominated by questions pertinent to the service-learning curriculum. In particular, student assertions that they will "think more carefully about engineering's impact on society," are reflected in their perceptions of the course and teacher excellence, as well as their achievement in learning. Also, student responses regarding their level of "pride and accomplishment as a result of completing [their] projects," serve as a

Table 4. Forward Selection Stepwise Regression results for Q1 through Q4, showing model dependencies for each semester and associated R^2 value. Unique dependencies are listed in order of importance to model. Bold Q-values indicate questions considered pertinent to a service-learning curriculum. Refer to Table 1 for question wording.

	Model for			
Semester	**Q1**	**Q2**	**Q3**	**Q4**
	excellent course	excellent teacher	learned a great deal	strong desire to take
Consistent Dependencies (present in 3 or more semesters)	Q2 Q3 Q4	Q1 Q735	Q1 Q4	Q1 Q3
Fall 2002		**Q719** Q737	**Q712**	Q737
Model R^2	61.1%	53.0%	56.7%	45.3%
Fall 2003	**Q721** Q730	**Q721**	Q718 **Q712**	Q736 **Q716** Q726 Q732
Model R^2	81.4%	74.5%	77.4%	52.8%
Winter 2004	**Q712** Q726 Q725 Q730	Q730 Q726 Q3	Q2 Q722	Q731 Q717
Model R^2	72.7%	71.2%	64.0%	59.5%
Fall 2004	**Q719** **Q721** **Q712**	**Q721** **Q714** **Q715**	**Q721**	Q737 4
Model R^2	65.2%	56.4%	59.1%	41.2%

significant part of the model for the rating of course excellence, Q1. The lack of clear model dependency on Q715, is most likely due to the compound nature of the question, which incorporates both social and economic considerations.

The results of these analyses show that the multiple regression tool is useful in determining the range of student perceptions which may contribute to the respondent's overall impression of the course. Despite the existence of some multi-collinearity within the data set, it is evident that during the service-learning term, Fall 2004, the student responses to the service-learning questions form a reasonable model for the overall perception of the course, which was not as prevalent during previous non-service-learning terms.

Qualitative Support

Several opportunities to collect qualitative data on student perceptions was also presented throughout the Engineering 100 course. First, students were asked to complete a one-minute paper on the first day of class indicating their reason for enrolling in this section of Engineering 100, as opposed to other sections. Second, students composed weekly journal entries, one of which asked for them to elaborate on "Why I chose engineering…" Finally, as part of the course evaluation procedure an open comment form was made available to the students.

The notion was commonly held within the first year engineering teaching community, that students were inclined to select their section of Engineering 100 based primarily on the availability of space within their schedule; setting their other courses first, and adding Engineering 100 last. For the Fall 2004 service-learning section, only 24% of the students indicated in their one-minute paper that they had selected the course purely due to it's place in the time schedule, while 70% indicated that they chosen the section based upon the description of an engineering project involving community service. These students typically noted that the design project sounded interesting or practical or that they were interested in the opportunity to work with a community. Although hard data does not exist for other sections of this course, or previous years, there is no argument among the teaching community that this represents a departure from the norm and may indicate a shift towards deliberate premeditated choice in student selection of their introductory engineering design project, one of the effects of which may be increased motivation of students towards the course goals.

As part of the service-learning curriculum, students were required to write journal entries in which they were asked to reflect on topics relevant to the course material, how the topic relates to their personal values and the social systems and issues surrounding them. As part of this exercise, students were asked during the first week of class to elaborate on their choice of engineering as a career path. It is interesting to note that about 70% of the journal entries reflected an interest in community and helping people, a recognition of responsibility for the safety and well-being of humans, or the ability to "make a difference" as an engineer. The comments are well summarized by a Latina student who notes, "The most important reason I chose to study engineering is because I have always had a long-term goal of being in a profession helping people."

At the close of the course, students were provided the opportunity for open-form feedback on their impressions of the course. These forms listed many brief comments regarding the interesting and relevant course design topic, the working environment which seemed to the students to imitate real engineering and an environment which led to a higher level of perceived learning. Students specifically noted that the course design project "enabled me to see the real-life applications of the class, which increased my interest in the subject" and that the "direct correlation between the education in the class and our project provided an incentive to learn." One student notes, "I learned just as much, if not more, about cultural interactions and interpersonal skills as I did engineering in Engineering 100. I made a difference."

The authors can personally attest to the difference in the classroom climate during the Fall 2004 term, where students were clearly more engaged in the course material and design project, actively seeking external support for their design projects and making extra effort outside of class to link with their community partners on their own time. However, although these instances of qualitative support affirm that the relevance of the course to student goals can be seen to lead to an increased perception of learning and student motivation, this is by no means a thorough evaluation in itself. Thus, a new project has been initiated to address the impact of student choices and climate during the first year on persistence in engineering in a quantitative sense.

Conclusions

In an effort to evaluate the impact that a service-learning curriculum had on student perceptions of learning when implemented in a first-year introductory design course, a thorough statistical evaluation of course evaluations questionnaires was completed. This analysis included a Multifactor ANOVA test, a Correlation analysis, and Stepwise Regression and Multiple Regression analyses, performed on the teaching evaluations for four successive semesters of the course taught by the same instructor; the first three without and the last with a service-learning curriculum.

The results of these analyses show that the overall response of students during the service-learning semester was significantly higher than previous semesters, indicating a higher sense of satisfaction with the course and instructor. Based on these statistics, students deliberately elected this section of the course based on the course description which clearly stated the service-learning nature of the curriculum. Thus, the course served a population with more altruistic goals, and hosted a larger population of women and under-represented minorities than the first year program population

An evaluation of correlations between questions in the data set were revealed most clearly through a multiple regression analysis. This analysis showed that during the service-learning semester, student perceptions of the quality of the class could be best predicted by a model which included responses to questions related to the service-learning curricular goals. In previous semesters, the models were often dominated by questions relating to the technical communication objectives of the course.

Qualitative information supports these findings, showing that students deliberately chose to enroll in this section based on their altruistic goals as engineers. Also, end of the term open evaluations showed that the interesting and relevant course design topic may have led to a higher level of perceived learning. A further study of the effects of student choices in the first year is underway to quantitatively understand the effects that service-learning may have on under-represented student retention in engineering.

Overall, the implementation of a service-learning curriculum in this course offered a unique opportunity for students to partake in a project relevant to their professional and educational goals. Providing these opportunities is an excellent method for increasing the relevance of engineering curriculum to under-represented students, thus improving the diversity of the field. In addition, students enrolled in the course had an increased perception of their understanding of social and economic considerations in engineering, a sense of pride and accomplishment as a result of completing the project, and a recognized commitment to thinking more carefully about engineering's impact on society; educational objectives consistent with ABET criteria which are difficult to teach using traditional design problems and case studies alone.

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