Identifying Student Differences in a First-Year Engineering Course: A Comparison of Mid-Year Survey Reponses

Leo H. McWilliams, Catherine Pieronek, Stephen E. Silliman, Carrie Graf, Mark Gunty

University of Notre Dame

Abstract

As of May, 2004, the College of Engineering at the University of Notre Dame completed the fourth year of a two-semester, first-year engineering course sequence. During the 2003/4 academic year, a mid-year survey was administered during the final week of the first semester. This survey targeted differences among student experiences for three groups of students: (i) those who left engineering after the first semester (group 1), (ii) those who completed both semesters of the first-year course but pursued a major other than engineering (group 2) and (iii) those who remained in engineering into the sophomore year (group 3).

A number of observations were derived from the survey results. First, the greatest difference in student response was observed in comparing students in group 1 with students in either group 2 or group 3. Second, students in group 1 reported a higher rate of negative experience in the first-semester course as expressed by higher rates of occurrence of feeling "overwhelmed by the intelligence of fellow students" and "intimidated by the environment" in the course. These same students reported a lower rate of developing "relationships with new people" during the course experience. Third, in comparison to group 1 students, students in group 3 were more likely, within group activities associated with the first-year course sequence, to lead discussions, enter computer programs or calculations into a computer, operate equipment, and feel confident in expressing ideas. In comparison to group 1 students, students in group 2 were more likely to enter programs or calculations into a computer, but did not show significant differences with respect to leading discussions, operating equipment or expressing ideas. In comparing group 2 with group 3, the only statistically significant difference in response to the survey was the observation that the students in group 2 reported a higher rate of feeling "overwhelmed by the intelligence of fellow students."

Introduction

The end of the spring 2004 semester marked the completion of the fourth year of the Introduction to Engineering Systems course sequence in the College of Engineering at the University of Notre Dame (the sequence is designated EG 111/112). This sequence is a two-semester, six credit hour course sequence required of all first-year students planning to enter the College of Engineering at the end of their first year. The details of the motivation and development of the EG 111/112 have been discussed by Brockman et al [1].

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Monitoring of retention statistics, student surveys and exit interviews has provided valuable insight into the effectiveness of the course as well as demographic data on retention and student satisfaction with the course. For example, Pieronek et al. [2] report that early modifications to the course involving increased expectations with respect to computing in the first semester had an apparent negative impact on retention. In response to this negative impact, McWilliams et al. [3] and Silliman et al. [4] describe modifications to the course that had substantial positive impacts on retention. Similarly, Pieronek et al. [2, 5] have provided evidence of differential retention rates based on gender as well as initial indication of major upon application to Notre Dame.

During the first three years of the course, students completing the second semester were asked to complete a survey. This survey was an essential tool used in assessing the strengths and weaknesses of the educational experience received by the students in the course. In reviewing the appropriateness of the assessment tools applied to this course, it became apparent that use of this end of the year survey as the primary assessment tool for students who had experience in the two-semester sequence had several limitations. Primary among these were:

1. The students had to evaluate the first semester course nearly 5 months after it was completed;
2. No information was gained from students that left engineering prior to the end of the second semester.

Of these, the second limitation was considered to be the most significant as there was no formal survey given to the students that left engineering prior to the completion of the course. It was argued that assessment of the course impact on the students would be considered complete only if the students who left the course were provided with at least one opportunity to evaluate the course experience with the same assessment tool as used by those students who completed both semesters of the course.

The College responded by developing and administering a formal survey in the final weeks of the first semester course (termed the mid-year survey below). This survey can be found at http://www.nd.edu/~engintro/publications/EGFYA2_base1.pdf. During the most recent academic year, ~98% of all students entering the first semester course were still enrolled and active in the course at the time of administration of this survey. Hence, this tool is considered to have excellent coverage of the students involved in the first semester of this course. When combined with the survey administered at the end of the second semester (termed the year-end survey below), this survey also provides for longitudinal comparison of student responses (for those students completing the second semester). Within both surveys (mid-year and year-end), students are asked to rate various aspects of the course, their experiences during the most recent semester, the average number of hours per week performing various activities, and their attitudes on various topics. This paper focuses on assessment of differential responses to the mid-year survey from three distinct groups of students demonstrating distinct differences in student self

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evaluation, student experience, and student assessment of the course after the first semester. Longitudinal results for students continuing in engineering will be discussed elsewhere.

Approach to Analyses

The surveys were administered under controlled (classroom) conditions. There were 69 response items on the survey and each item provided 4-5 possible responses. Responses were recorded on bubble sheets which were later read electronically. In comparing the responses for the different groups of students, responses for each item were given integer values (1-4 for items with 4 possible responses and 1-5 for the other items), thus allowing numerical analysis of the responses using standard statistical methods. In all tables below, mean values for group responses are rounded to one decimal place. However, statistical comparisons were performed prior to this rounding.

The following analysis is based on standard hypothesis testing among pairs of data sets with three distinct groups of students identified for testing: (i) students who enrolled in EG 111 in the fall semester of 2003 but did not enroll in EG 112 in the spring of 2004 (group 1), (ii) students who enrolled in both EG 111 / 112 in the 2003/4 academic year but did not continue in engineering in the sophomore year (group 2), and (iii) students who enrolled in both EG 111 / 112 in the 2003/4 academic year and continued in engineering in the sophomore year (group 3). Specifically, three sets of hypothesis tests were run. Results from groups 1 and 2 were compared, separately, against results from group 3. The results from group 1 were then compared against group 2. The null hypothesis in each case was that the mean response of the comparison data set was the same as the mean response of the reference data set. The number of possible responses and the actual number of responses received for each of these groups are summarized in Table 1.

	Class of 2007	**Maximum Number of Students Responding**	**% Responding**
First Year Students Starting EG 111	366	319	87%
Group 1	82	70	85%
Group 2	38	23	61%
Group 3	246	226	92%

Table 1 Group Size and Survey Response Rate for Mid-year Survey During 2003/4 Academic Year.

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Comparisons for the 2003/4 Academic Year

Table 2 summarizes the number of survey items (out of 69 total items) for which the difference in the student responses (between two groups) was found to be statistically significant at the 1% and 5% levels of significance. For example, when group 1 was compared with group 3, the null hypothesis was rejected for 19 of the survey items at $\alpha = 0.05$.

Significance level of test	Group 1 vs. Group 3	Group 2 vs. Group 3	Group 1 vs. Group 2
$\alpha = 0.01$	13	0	1
$\alpha = 0.05$	19	2	4

Table 2 For Each Pair of Student Groups, Number of Survey Items for which the Null Hypothesis (i.e., the two groups provided the same response) Could Be Rejected at the 1% and 5% Levels of Significance (out of 69 total items).

The results in Table 2 indicate that the students in group 1 have a significant number of differences as compared to students either in group 2 or in group 3. In contrast, the students in groups 2 responded in a statistically different manner than students in group 3 for only a small number of items (0 at the 1% level of significance and 2 at the 5% level). Hence, there appears to be a relatively large difference among students who leave engineering after only one semester of the introductory course as compared to students who enroll in the second semester, whether or not they continue into engineering in the second year. Further analysis of these data provides some insight into this difference.

For example, students were asked to indicate on a scale from 1 (not at all) to 5 (very well) how well they felt that their high school experience prepared them for EG 111. The mean of the response from group 1 was 2.7 while the mean for groups 2 and 3 were 3.2 and 3.5, respectively. While it is noted that this difference is statistically significant at $\alpha = 0.05$ only in comparison with group 3, it is apparent that the students who continued into the second semester felt that their high school experiences left them better prepared for this first-year experience. In contrast, no statistically significant difference in means at $\alpha = 0.05$ was observed in the comparison of the responses for groups 2 and 3.

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Another section of the survey asked students to indicate how important each of the following factors was to them in choosing a major.

- My perception as to the amount of effort required for the major;
- My contact with faculty in the College of Engineering;
- My experiences in EG 111;
- My Experiences in Math;
- My experiences in Chemistry;
- My experiences in other first year courses;
- Advice from upper class Engineering students;
- Advice from First Year of Studies.

While students do not make a final decision on major until the second semester, students opting not to enroll in the second semester of the course have made a decision not to major in any of the engineering disciplines. Hence, response to this question was considered to be of interest in comparing the three student groups. Responses to this section of the survey included:

1 = A very important positive factor;
2 = A somewhat important positive factor;
3 = I considered this but it did not matter;
4 = A drawback outweighed by other considerations;
9 = Does not apply.

All responses indicating "does not apply" were eliminated from the data set prior to comparison. Statistically significant differences in the responses of group 1 versus group 3 at $\alpha = 0.05$ for the three areas were observed for three of these items. The mean responses for these three items are presented in Table 3, ranked from most important to least important as identified by students in group 1. These results are consistent with a conclusion that student experience in math and in the first-semester engineering course encouraged some students to remain in engineering.

Factor in choosing a major	Mean of Group 1	Mean of Group 3	Level of Significance
Experiences in other first year courses	2.1	2.5	<0.001
Experiences in Math	2.4	1.8	<0.001
Experiences in EG 111	2.5	2.1	0.013

Table 3: Mean Response and Level of Significance for Items Showing a Significant Difference in Comparison of Group 1 versus Group 3.

In reviewing the responses from the group 2 students, it was noted that these students placed more value in advice from upper class engineering students than did students either in group 1 or

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in group 3. Specifically, the group 2 students provided a mean response of 1.75 as compared to the mean response of 2.1 for group 3 and 2.4 for group 1. The group 2 results with respect to this question were statistically different from the responses of either of the other two groups. Although this result is the focus of further study, it suggests that advice from upper class engineering students may have played a role in the decision of students in group 2 to remain in engineering for the second semester.

Differences were also noted in student evaluation of the quality of the learning environment in the first-year course. EG 111/112 meets in a variety of formats and provides many different learning experiences to the students. A section of the survey asks students to rate the quality of the learning experience in six aspects of the course: (i) learning center sessions with hands-on activity, (ii) learning center sessions with direction from faculty, (iii) working independently or in groups in the learning center, (iv) lectures, (v) use of an audience response system during lectures, and (vi) using programs to solve homework problems. The following scale is used in the interpretation of the results:

1 = Very Poor;
2 = Poor;
3 = Fair;
4 = Good;
5 = Very Good.

A comparison of the responses from group 1 with those of group 3 yielded a statistically significant difference for three of the aspects (at $\alpha = 0.05$). These results are summarized in Table 4.

Quality of the Learning Experience	**Mean for Group 1**	**Mean for Group 3**	**Level of Significance**
Learning Center sessions with hands-on activity	4.1	4.3	0.028
Working independently or in groups in the Learning Center	3.9	4.2	0.001
Using MATLAB or NQC programs that were provided to solve the homework problems	3.5	3.7	0.036

Table 4: Comparison of Student Response to Questions on Quality of Learning Experience for which there was a Statistical Difference at 5%.

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These responses indicate that, where there is a difference, students in group 1 have a lower overall opinion of the first-semester engineering course. There was no statistical difference between group 2 and group 3 responses (at 5%) with respect to the evaluation of quality of learning in the six aspects of the course.

Two other areas where differences were observed between group 1 and the other two groups of students related to student evaluation of the two projects completed in the first semester and student experience with respect to interacting with other students in the course. With respect to the projects, the students are asked to rate the amount of learning, amount of effort, and interest level experienced in each of the projects using the following scale:

1 = Very high;
2 = High;
3 = Medium;
4 = Low;
5 = Very low.

A statistically significant difference was observed in the second project with respect both to amount of learning and interest (see Table 5). It is noted that the difference between group 1 and group 3 students appeared in the second project, the project completed in the second half of the semester. While this result may indicate that redesign of this project may make it more attractive to group 1 students, it must be noted that a second interpretation of this result is that many students in group 1 may have already decided to leave engineering and therefore may not have the enthusiasm to embrace or expend the effort on the second project, regardless of topic or workload.

Project Ratings	**Mean of Group 1**	**Mean of Group 2**	**Level of Significance**
The "rover" project (interest level)	2.6	1.8	<0.001
The "rover project" (amount of effort)	2.4	2.1	0.036

Table 5: Group 1 versus Group 3 Responses for Project Items Showing Statistically Significant Difference.

A final significant difference among the student groups is observed in the student evaluation of their interpersonal experiences (with other students) within the first-semester course. A series of possible student interactions were outlined for the students (see Table 6) and the students were

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asked to rate the frequency of their personal experience with each of these interactions using the following scale:

1 = Never;
2 = Rarely;
3 = Occasionally;
4 = Frequently.

Statistically significant differences were found in the responses of group 1 students versus group 3 students in 8 of 11 possible interactions. These 8 are listed in Table 6. Significantly, the responses to "felt your ideas or suggestions were not taken seriously by other group members" were not statistically different for the three student groups.

Experience	Mean of Group 1	Mean of Group 3	Level of Significance
Operated the equipment	3.4	3.6	0.014
Lead the discussion to determine how to proceed with the project	2.9	3.2	0.003
Typed programs or calculations into the computer	3.1	3.5	<0.001
Felt confident about expressing your ideas	3.3	3.6	0.001
Pushed yourself to produce your best effort (in the course overall)	3.2	3.4	0.008
Developed relationships with new people (in the course overall)	3.5	3.7	0.016
Felt intimidated by the environment (in the course overall)	2.5	2.0	0.001
Felt overwhelmed by the intelligence of others (in the course overall)	2.7	2.3	<0.001

Table 6: Difference in Student Response, Group 1 versus Group 3, for Possible Student Interactions During the Course.

Review of the student responses shows that the students in group 1 responded that they had fewer positive experiences (the first 6 entries in Table 8) than their group 3 counterparts as well

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as more negative experiences (the last 2 entries). Significantly, group 2 students also indicated a higher frequency of being overwhelmed by the intelligence of others than did students from group 1.

Primary Findings

Study of the mid-year survey responses indicates significant differences between those students who left engineering after the first semester and students who continued in engineering into the sophomore year. Smaller differences were noted between those students completing the second semester of the engineering without continuing in engineering and those students continuing in engineering in the sophomore year.

The areas where students leaving engineering after the first semester showed the greatest differences as compared to students enrolling in engineering in the sophomore year were:

- Students leaving engineering indicated lower evaluation of their high-school preparation for the freshman course
- Continuing students indicated higher satisfaction with the first-year math and engineering courses as guides to choosing a major
- Continuing students indicated higher satisfaction with both the quality of the freshman learning environment and the second course project.
- Students leaving engineering indicated a lower frequency of positive student interactions and a higher frequency of negative student interactions.

These survey results provide substantial insight into the differences among the three student groups identified. As such, these results provide for the opportunity to identify changes in the course structure or content that might improve the learning environment for individual student groups, or the student population as a whole. As noted in McWilliams et al. [4], such analyses can lead to changes in course structure which dramatically impact both student learning and retention.

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LEO H. McWILLIAMS
Dr. Leo H. McWilliams has served as course coordinator for the First-Year Engineering Program at the University of Notre Dame since 2001. Prior to joining Notre Dame in this capacity, he worked as a principal engineer at Honeywell International. Dr. McWilliams received his B.A. in economics, B.S.E.E., M.S.E.E. and Ph.D. from the University of Notre Dame.

STEPHEN E. SILLIMAN
Dr. Stephen E. Silliman is a professor of civil engineering and geological sciences and an associate dean for undergraduate programs in the College of Engineering at the University of Notre Dame. He joined the faculty in 1986, and his primary area of research is in groundwater hydrology with recent focus on water resources in developing countries.

CATHERINE PIERONEK
Catherine Pieronek, J.D., has directed the Women's Engineering Program at the University of Notre Dame since 2002. She has worked as a senior systems engineer on NASA spacecraft projects at TRW Space & Defense Sector, and as director of external relations for the Notre Dame Law School. She earned her B.S.A.E. from the University of Notre Dame, her M.S.A.E. from UCLA, and her J.D. from the Notre Dame Law School.

CARRIE GRAF
Carrie Graf is an undergraduate researcher for Institutional Research at the University of Notre Dame. She will graduate in May 2005 with bachelor degrees in sociology and psychology

MARK GUNTY
Dr. Mark Gunty has been Assistant Director of Institutional Research at the University of Notre Dame since 1996. He coordinates student outcomes assessment research at Notre Dame and teaches research methodology in the Department of Sociology. His work with the College of Engineering began with a Scholarship of Teaching and Learning project and has evolved with the college's on-going assessment of its first-year program and its tracking of long-term outcomes among graduates.

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