Investigation of Retention and Perceptions among Freshman Engineering Students

M. Cavalli, L. Stanlake, S. Tolbert

Department of Mechanical Engineering, University of North Dakota, Grand Forks, ND, 58202-8359

Background

Retention of engineering students is an issue of ongoing concern across the country. A number of studies have been conducted to determine the causes for student attrition. Research indicates that the majority of students who leave engineering do so in the first two years of entering an engineering program (Della-Piana et al., 2003, Spring & Schonberg, 2001). Authors have reported that students leave the engineering field for a variety of reasons, including lack of interest in the coursework (Seymour & Hewitt, 1997), lack of mathematical preparation (Klingbeil, Mercer, Rattan, Raymer & Reynolds, 2004), desire to graduate in four years (Borrelli, 2002), student perception of the workload (Spring and Schonberg, 2001) and lack of integration of social and academic aspects of university life (Della-Piana et al., 2003). Data has also been reported linking performance in science courses to retention in engineering (Zhang, Thorndyke, Ohland & Anderson, 2004) as well as the effect of math preparation on retention (Alting & Alser, 2006). While general conclusions about student retention can be drawn, it is also clear that each institution faces unique challenges in retaining engineering students.

The purpose of the current work is to report on a two-year study of first-year engineering students (primarily freshmen) at the University of North Dakota (UND). The goals of the study were to identify any connections between math/science preparation and retention and perceptions in beginning engineering students. Students were asked to complete a short survey at the beginning and at the end of an introductory engineering course. Survey questions probed their preparation for engineering (math and science courses), social influences on their choice of engineering as a major and their perceptions of the engineering field. Data from academic records was used to supplement the survey responses. Students who transferred out of engineering during the first semester were asked to explain their motivations for doing so. Results of the study provide a snapshot of the background of typical engineering students at UND and suggest some possible areas of improvement both in preparatory classwork and the engineering curriculum.

Methods

A 20-question survey was administered during the second week of class in the Fall 2005 and Fall 2006 semester. Data was collected in three courses, ME101 (mechanical engineers), EE101 (electrical engineers), and ENGR101 (a mix of engineering majors with a small number of students from majors outside of engineering). Fall enrollment in these courses represents the

majority of engineering students at UND. The fact that participation was voluntary, but appreciated, was stressed by Dr. Cavalli as he explained the survey to the students. As additional motivation, the authors announced that four students would be randomly selected for $25 awards from the pool of students completing both the introductory and concluding surveys. Students were also asked to sign a release of academic records that allowed the Dr. Cavalli to view their transcripts and verify their current mathematic enrollment. Completion of the survey required about 10 minutes of classtime. The follow-up survey was administered during the last week of class.

Four areas of information were covered by the initial survey. First, students were asked to report their class standing, whether or not they were a transfer student, their gender, and their highest academic degree. Next, they were asked four questions regarding lab science, general science, technology and mathematics courses they had previously completed. Questions 5-8 inquired about social influences on their choice of engineering as a major. Finally, 12 questions related to their perceptions of the requirements of the engineering major as well as the role of engineering in society were asked. The final (semester-end) survey contained the identical 12 perception questions only. Students who left engineering during the course of the semester were emailed a list of about six questions regarding their decision during the first part of the following semester.

Results

During the course of the project, 237 students filled out both the initial and follow-up surveys (128 during the Fall 2005 semester and 109 during the Fall 2006 semester). Of these, 87.3% were classified as engineering majors of some description (primarily mechanical – 45.1%, electrical – 23.6%, and civil – 17.7%), 6.3% were undecided and 6.3% had a non-engineering major. Very few Chemical Engineering majors participated in the study because they enroll in a separate 'Intro to Chemical Engineering' course that is taught during the spring semester and which was not surveyed.

The majority of engineering students surveyed were freshman (highest academic degree of high school or equivalent). Slightly more than 4% of respondents indicated they possessed an associate's degree and 2.4% indicated they already had a bachelor's degree in another field.

Math and Science Preparation

Students were asked to indicate the level of math they had completed in high school. Response options were Pre-algebra (1), Algebra (2), Pre-Calculus (3), Calculus (4) and Other (5). Of the engineering majors participating in the study, 46.9% listed pre-calculus or lower as their most advanced math course in high school (a response of 1, 2, or 3). Approximately 90% of the students were enrolled in a math class at the time of the study. Thirty-nine percent of these students were enrolled at the same math level their maximum high school course. This compares with 29.9% of those in math classes who had progressed at least one level from high school to college and 12.8% who had regressed at least one level. A change in math level could not be determined for students who indicated a high school math level of 'Other'.

Respondents indicated they had taken an average of 5.4 science and technology course during the course of their high school curricula. On average, 2.7 of these courses were classified as lab science courses. This compares with an average of 2.2 technology courses per student. The remaining courses were non-lab science courses.

Social Influences

Question 5 asked students to indicate the number of immediate family members (defined as parents or siblings) who are engineers or scientists (possible responses were 0, 1, 2, 3, or 4 or more). Responses indicate about 1.3 engineers/scientists per student. Question 6 then asked how many members of the student's immediate family had encouraged him/her to pursue engineering as a major. On average, 2.7 immediate family members had done so. Similarly, an average of 3 immediate family members and 3.6 teachers encouraged the students to take math and science courses in high school (Questions 7 and 8, respectively). These questions do not gauge the intensity or frequency of the encouragement. Similarly, the reasons for the encouragement were not probed.

Perceptions

Statement	2005 Avg.	Change	2006 Avg.	Change
I believe my mathematical skills are sufficient for my current coursework.	4.0	-0.1	4.0	+0.1
I believe my scientific skills are sufficient for my current coursework.	4.0	-0.1	4.0	-0.1
I understand the level of math required to complete my degree.	3.8	+0.2	3.9	+0.1
I understand the level of science required to complete my degree.	3.8	+0.2	3.8	+0.2
I have a good understanding of the engineering profession.	3.5	+0.2	3.5	+0.1
I have a good understanding of the role of engineers in society.	3.8	+0.1	3.8	+0.1
I am confident I will obtain my Bachelor's degree in engineering.	4.0	-0.4	4.1	-0.3
My classmates are better prepared mathematically than I am.	2.6	+0.1	2.7	0.0
My classmates are better prepared scientifically than I am.	2.6	+0.1	2.6	+0.1
Engineering is the most difficult major on campus.	3.0	+0.4	3.0	+0.2
Math is an important part of engineering.	4.5	-0.1	4.6	-0.2
Engineers are scientists.	3.7	+0.2	3.9	-0.1

Table 1: Summary of starting perception responses by year along with change from initial to follow-up survey.

Table 1 shows the perception statements listed at the end of survey. Students were asked to respond to each statement on a scale of 1-5, with 1 being 'Strongly Disagree' and 5 being 'Strongly Agree'.

Responses to most of the statements tend to be above 3, which seems to indicate that most of the students think they have a good concept of what it means to be an engineer and perceive their own abilities to be sufficient to become engineers. They also seem to be confident in their skills as compared to those of their peers, but this does decrease slightly over the course of the semester.

Only two statements indicate changes of greater than 0.2 from the initial to the final survey. One is, 'Engineering is the most difficult major on campus.' Initially, the responses in both years are neutral (a response of 3). However, both years indicate an increase of students' perceptions of the difficulty of engineering by the end of the first semester. The second statement with a high value of change is, 'I am confident I will obtain my Bachelor's degree in engineering.' Both years show a marked decrease, though whether this is due to some students beginning to realize engineering is not for them, students wishing to remain in engineering but uncertain of their ability to do so, or some other reason is not clear.

A final interesting observation from Table 1 is related to the statement, 'Math is an important part of engineering.' Responses fall between 'Agree' and 'Strongly Agree' for both the starting and ending surveys. The level of agreement declines over the course of the first semester for both years of data, however. The change, while small, may indicate that students are not able to make connections between material being taught in their mathematics classes and its application to engineering problems.

Data did not indicate a clear trend between the highest math course taken in high school and current college math enrollment. As a result, perception data was not analyzed on the basis of high school math preparation. However, data from Table 1 is seen in a somewhat different light when responses are first sorted according to the student's current math enrollment. Table 2 summarizes the resulting data (averaged for both years).

Note that the level of math enrollment for incoming students at UND is determined by a combination of ACT scores and the results of a math placement exam. Students tend to enroll in the highest math for which they qualify, but some will choose to enroll at a lower level if they feel unprepared. No account was made for such choices in these results.

As might be expected, students' perceptions of the sufficiency of their mathematical skills increase with their current level of math enrollment. The lower a student's current math course, the lower the perception of the adequacy of his or her math skills for the current coursework. As expected, this also translates into a lower perception of the student's skills relative to his or he peers. The effect of current math enrollment on perception does not appear to transfer to science skills. Nor does current math enrollment appear to affect a student's overall perception that he or she will be able to successfully complete a Bachelor's degree in engineering.

Statement	< Pre-Calculus	Pre-Calculus	≥ Calculus
I believe my mathematical skills are sufficient for my current coursework.	3.6	3.9	4.1
I believe my scientific skills are sufficient for my current coursework.	4.0	3.9	4.0
I understand the level of math required to complete my degree.	4.2	3.6	4.0
I understand the level of science required to complete my degree.	4.2	3.7	3.8
I have a good understanding of the engineering profession.	3.9	3.5	3.4
I have a good understanding of the role of engineers in society.	4.2	3.9	3.6
I am confident I will obtain my Bachelor's degree in engineering.	3.9	4.0	4.1
My classmates are better prepared mathematically than I am.	3.7	2.8	2.4
My classmates are better prepared scientifically than I am.	2.9	2.7	2.5
Engineering is the most difficult major on campus.	3.0	3.1	3.0
Math is an important part of engineering.	4.5	4.6	4.5
Engineers are scientists.	4.2	3.9	3.7

Table 2: Perception responses sorted according to current math enrollment of survey participants.

Another interesting trend from Table 2 is that enrollment in a higher math course tends to lower a student's perceived understanding of the engineering profession and the role of engineers in society. This trend is also apparent in the 'Engineers are scientists' statement. It should be noted, however, that the average response for all groups remains above 3.

Assessment of the perception data in terms of social influences did not indicate any measurable effects of the number of immediate family members that encouraged a student to pursue science or engineering as a major. Similarly, no effects could be discerned from the number of immediate family members or teachers that encouraged students to enroll in math and science courses in high school.

Reasons for Leaving Engineering

During the semesters when data was collected, 31 students left the engineering program at UND. Most of these students remained at UND but switched to other majors. About 15% of these students left UND completely. Each of the students was contacted via email with a set of four questions and two statements related to their reasons for leaving engineering and their satisfaction with their new choice of major. Of the 31 students contacted, 10 students responded (five each year).

On a scale of 1-5 with 1 being 'No Influence' and 5 being 'Strong Influence', the average response to a statement that math was a primary reason for switching majors was 3. Within the respondents, however, two main groups were apparent. One comprised those students who described themselves as capable in math but simply not interested in engineering. They responded '1' or '2'. The other group highlighted math as the main reason for switching majors, either due to lack of time or lack of preparation. No student attributed much influence of science courses to switching majors (average response of 1.3). Regardless of the reason for switching majors, all students indicated an increase in their understanding of the engineering profession. About half of the students felt they had found the right major for them.

Conclusions

No connection was found in this study between mathematical preparation (as represented by highest high school math enrollment) and perceptions in beginning engineering students. Some trends became apparent when the data was analyzed in terms of current math enrollment. The lower the current math course, the lower a student's perceptions of his or her mathematical abilities. Interestingly, this did not translate into a lower level of confidence in being able to complete an engineering degree, even though all students perceived math as being very important in engineering.

Of the limited responses from students who left engineering during their first semester, two main trends were apparent. One was students who were interested in engineering but who were unable to keep up in math, either due to lack of preparation or lack of time. The second group described themselves as capable of completing the required work but simply not being interested in engineering. The data available from students leaving engineering majors is limited but seems to be in keeping with results from previous studies on retention (Seymour & Hewitt, 1997, Alting & Alser, 2006, Klingbeil et al. 2004).

Acknowledgements

Financial support of the project through a mini-grant from the NSF-sponsored Rigorous Research in Engineering Education project is gratefully acknowledged. Thanks are also due to Ms. Benedicte Slee for initial analysis of the survey data.

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MATTHEW CAVALLI is an Assistant Professor of Mechanical Engineering at the University of North Dakota. His primary teaching responsibilities are sophomore level mechanics courses and upper level/graduate materials courses.

LOWELL STANLAKE is an Assistant Professor of Mechanical Engineering at the University of North Dakota. His primary teaching responsibilities are freshman/sophomore design and computing courses.

SCOTT TOLBERT is formerly an Assistant Professor of Mechanical Engineering at the University of North Dakota. He is currently a Research Manager at the UND Energy and Environmental Research Center in Grand Forks.