Freshman Retention Study in Mechanical Engineering at the University of Arkansas

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abstract

Retention of freshman students has become a focal point for many engineering colleges throughout the country. With many literary sources written on the retention of students in engineering programs, there are many references that address why some students leave without completing a degree and why other students stay to ultimately complete a degree. It is important for institutions to understand the factors that affect the choice to leave or stay, or at a minimum become aware of them, in order to increase their retention of freshman.

The College of Engineering at the University of Arkansas has tracked freshman retention since 1985, but only since 1998 has this been done for each engineering department. This information provides the Department of Mechanical Engineering with valuable information to which it can quantitatively compare with the College and the University in an effort to ultimately improve the six-year graduation rate. The first step to improving the six-year graduation rate is to address the department's freshman attrition problem by determining the factors that influence freshmen in their decision of whether or not to continue in the program. In order to determine these factors, a 32-question survey of the Mechanical Engineering freshman students in Fall 2004 was administered which included surveys completed by some students who had already changed to another major.

Students of the freshman cohort were separated into two groups. One group was deemed at high-risk for changing majors and the other was at low-risk for changing majors away from Mechanical Engineering. Primary results from the study indicated that there are three areas where these two groups differed significantly. Those are the students' preparation for college while in high school, their study techniques, and their expectations about the curriculum in which they are beginning. In addition, the paper includes historical mechanical engineering retention data from 1998-2003, a discussion of freshman performance in math and science classes, a thorough description of the survey, analysis of the survey results, and a discussion of future efforts to improve the department's freshman retention.

introduction

In recent years, many engineering programs have focused on improving freshman

retention and identifying the factors that influence it. Since many College of Engineering (COE) programs have similar departmental freshman curricula, retention related activities are often evaluated at this level. The University of Arkansas (U of A) is no different and has an ongoing effort to increase its six-year graduation rate through improved retention. In addition, the U of A Department of Mechanical Engineering (ME) is trying to better understand its six-year graduation rate by first focusing on the retention of students during their freshman year.

For the sake of comparing retention data internally and externally, some common definitions need to be established to foster uniformity. A freshman is universally defined as a person who is going to college for the first time in their academic career and who is considered a full-time student with regard to the institution. Freshman retention is commonly defined as the return of a freshman student in his/her second consecutive fall semester to the same program in which he/she started. The University of Arkansas uses these definitions as criteria for its retention data generation. For the COE and the ME, freshman retention is defined the same as that of the U of A, but stipulates that the student enroll in the same college and department, respectively.

The recent growth of freshman class-sizes in ME came after a period when the department experienced a gradual decrease in total enrollment. The total enrollment of ME for 1998 was 290 and by the year 2002 had declined to 224 students. This phenomenon likely resulted from a 34% reduction of incoming freshmen to the U of A from 1998 to 1999 coupled with consistently low numbers of incoming freshmen through 2002. ME began to reevaluate its approach to the recruitment of freshman students and implemented some changes to that process that resulted in an 81% increase in freshman from 2002 to 2003. This surge of incoming freshmen caused the department to shift its focus from recruitment to the improvement of the retention rate for ME freshmen.

In part of this paper, retention rate data for the cohorts of ME have been compared to the data from the U of A and the COE to form a basis for retention rate comparison. The data for the cohorts of the U of A, the COE, and ME have different origin dates with ME having the shortest record starting in 1998. Thus, data beginning in 1998 will be used for comparison between ME, the COE, and the U of A. After comparing the data of ME to that of the COE and the U of A, the ME retention rate was found to be the lowest and indicates there is significant room for improvement. In addition, the grades of the 2004 Fall ME freshmen were evaluated for their Science, Mathematics, and Engineering (SME) courses in an effort to ascertain any areas of academic problems and their potential impact on overall freshman retention. Finally, this paper describes an effort to assist freshmen in their transition to college through a freshman mentorship program implemented in the Fall semester of 2004. The program personnel included one graduate assistant (GA) and two faculty members. This program was designed to have the GA be the primary out-of-class contact for the freshmen students and assist them in any academic or social challenges that faced them. The faculty members helped the freshmen with academic and advising issues and served as advisors to the GA. One of the major goals of this mentorship program was to gather data regarding the major obstacles students faced during their freshman year. During their second semester, freshman were asked to complete a survey that would provide information regarding their perspective of the ME program at the University of Arkansas.

background

The national average for the number of students that graduate from engineering is about half of those that start [1]. Freshmen expect engineering to be demanding but often get overwhelmed by the volume of the material and find it difficult to successfully manage their time and use of resources (course drills, tutoring, faculty office hours, etc.) [2]. This may be a major reason why academically capable students select a different career after a short time in engineering without any real exposure to engineering courses [2].

Engineering programs have experienced high attrition rates for many years and as a result have caused the perception that this is the norm [2]. Studies have shown those freshmen that are academically capable of completing a technical college program have often chosen other majors where they were successful in the completion thereof [3]. While this statement may speak of college students in general, what this may also indicate is that there is a need for the students who have left engineering to be more actively engaged during their freshman year. It is a widely known fact that the first two years of college are the most crucial in regard to the retention of college students [2]. In an effort to aid students in meeting their educational goals and to influence their retention, an institution must determine what solutions it has for the educational problems faced by its students [3].

Several strategies for improving freshman retention have been applied by other COE that, for the most part, have proven beneficial in attaining that goal. These strategies include a complete overhaul of COE programs [4,8], changes to COE curricula [1,2,9,10,11,12], and new academic assistance programs for freshman [1,2,13,14-17]. In some cases, the addition of a freshman hands-on course was implemented that directly exposed the freshmen to topics within engineering before they experience these topics in the classroom [10,12,18]. Marked increases in freshman retention have been seen in programs with the sole addition of a hands-on course [1,18]. A strategy that has been applied at numerous COE programs, including the U of A, is the establishment of a freshman mentorship program [1,2,10,14,17,19]. These strategies are discussed later. The implementation of these retention strategies require additional funding to help an institution bear the financial load of more faculty, facilities, or resources and thus has been investigated more by larger COE programs or by those with outside funding.

The programs that are choosing to initiate a completely overhauled curriculum are focused primarily on the COE as a whole. The approach most of these institutions take is to generalize the first two years of the curriculum by having the freshman take the same SME courses that are required for all engineering degrees. This places these engineering students in a theoretical academic community within the COE program that can, in itself, improve freshman retention [18]. These new curricula offer engineering courses that do not focus specifically on any one engineering discipline. Instead, faculty from all engineering programs instruct the freshmen for a part, or all, of the semester in their respective disciplines [10]. This gives the freshmen a broad foundation of academic and practical information on which they base their decision about what specific profession to pursue. This is a valuable concept in regard to freshman retention in that it allows the freshmen to make an informed decision about which career fits them the best.

There are a large number of engineering programs that have made specific changes to their curricula in an effort to boost freshman retention. These changes range from modifying an existing course [1,12,18] to the addition of new courses [9,10,11]. This approach is more widely seen because it is easier and less expensive to implement than a complete overhaul of a curriculum. It is easier because it creates fewer disturbances within a program due to the specificity with which course changes are made.

Another strategy that has produced positive results in retention rates is the addition of an academic assistance program (AAP). The two most commonly observed reasons that cause freshmen to encounter academic difficulty or to leave engineering is insufficient academic preparation and unrealistic expectations [2]. The AAP's aimed at students that may have received insufficient academic preparation provide academic support in some of the more troubling areas for freshmen such as Calculus, Chemistry, and Physics [1,2,14,15]. Some of these programs are setup to help freshmen with their acclimation to college by teaching fundamental skills such as studying, time management, and communication [14,15]. Most of these programs are short courses (under six weeks) and can be executed in the summer just before classes begin.

The offering of a hands-on course has become more of a norm for curricula since the early 1990's. This increase of hands-on courses is the result of COE programs trying to appeal to students and has proven to be a positive contributor in improving freshman retention. These courses have taken the COE curricula back to the fundamentals of engineering where students learn by testing and experiencing the laws of physics with their own hands. These experiences are aimed to show students some of the problems facing engineers in industry and offer reasons for the abundance of mathematics and science with which they are faced [18]. These courses introduce the students to the concept of working in a team environment and promote the students' feeling that they are part of the College [9,10].

The utilization of student or faculty to serve as mentors for freshmen has also become more numerous in recent years. Whether the mentors are students or faculty, they are generally thought of to have more academic knowledge and experience than the students being mentored. This can be helpful to freshmen when they are confronted with challenges beyond their own comfort levels. These mentoring programs are setup to facilitate meaningful interactions between freshmen, faculty and staff [2]. Student mentors have been employed to aid the faculty during the instruction of various courses, labs and summer academic assistance programs [1,10]. According to one freshman from Syracuse University, having the upperclassman to talk to was invaluable and generated a confidence such that "(the freshman) could see himself in (the upperclassman's) shoes in a few years and that was very reassuring" [1]. Some colleges, such as the New Jersey Institute of Technology, have created mentorship programs that utilize senior students in a way that makes them the primary source of help and information for freshmen [17]. At the U of A, the mentorship program consists of two faculty members and one graduate student, who is there for all freshmen to call on when they need assistance that does not require that of the faculty. The main purpose for any freshman mentor is to help freshmen make a smooth transition from high school to college.

Finally, literature states that retention rates were influenced significantly by the emotional connection that a student has with his/her institution [3]. Researchers from the University of

Buffalo developed a prioritized list of needs that are required by students to feel satisfied enough to persist in a program [2]. The needs found for their students were:

- Processing of academic experience
- Development of college-level thinking skills
- Connection with a peer group
- Developmentally-keyed pedagogy
- Informed vision of engineering
- Sense of belonging to the School of Engineering and Applied Sciences

historical data of retention rates at the U of A

The COE at the U of A has been tracking retention for its programs since 1998. Due to the date on which this paper was written, data from 1998 to 2003 were used for comparisons because official retention data were not yet available for 2004. The freshman class of 94 students that began in the Fall of 2004 serves as the cohort for comparison to the data in Table 1. This is the first class of ME freshman that had a formal mentorship program in place. The cohort will provide feedback regarding the success of the mentorship program in the form of a retention rate metric. Table 1 shows the retention rates of ME, the COE and U of A from 1998 to 2003. It indicates that ME has the lowest retention rate of the three on an annual basis by being 3-15% lower than the COE and 22-37% lower than the U of A.

Table 1. Retention rates since 1998 for freshmen entering their second year at U of A.

Year	ME	COE	U of A
1998	55.0%	66.1%	77.2%
1999	52.8%	64.7%	81.8%
2000	57.4%	60.7%	81.8%
2001	45.5%	57.5%	82.3%
2002	52.8%	57.2%	82.6%
2003	52.1%	66.8%	83.7%

As noted in the Introduction, ME experienced a sharp increase in the number of new freshmen starting in 2003 as shown in Table 2. Even though the number of new ME freshmen increased in 2003, Table 1 shows that the retention rate for that cohort did not increase. The authors proceeded to investigate the expected freshman retention rate for the upcoming Fall 2005 semester as a means of comparison to past data. This was done by adding together the numbers of students who had left ME during their freshman year or who did not register for any classes at the U of A in the Spring semester of 2005. The investigation revealed that 27 of the original 94 students had left the ME program during this time. If these numbers hold through the beginning of the Fall 2005 semester, then the retention rate for the 2004 freshman class would officially be 71%, which is a 20% increase from past years. One could deduce from this that the mentorship program helped reduce freshman attrition since it was the only change made from the previous

years, but no hypothesis can be substantiated until the official data become available in the 2005 Fall semester. The retention data for the COE and the U of A are not yet available for the 2004 academic year.

Table 2. Number of entering freshmen and total students in the Department of Mechanical Engineering at the U of A.

Year	Number of Freshmen	% Change from Previous Year	Number of Returning Students	Total Students in ME
1998	80	~	210	290
1999	53	-33.8%	206	259
2000	54	1.9%	198	252
2001	55	1.9%	181	236
2002	53	-3.6%	171	224
2003	96	81.1%	186	282

mathematics and science course data and analysis

The academic performance during the first semester is an excellent predictor for the future success of an engineering student [15]. Two of the most challenging courses for freshman engineering students are mathematics and science, and either one, or both, can have a large impact on retention. Mathematics and science courses are both considered by some to be "weed out" courses for engineering students [2]. These courses proved to be an overwhelming challenge for some of the Fall 2004 freshmen at the U of A as well. There were 92 of the 94 freshmen taking some course in mathematics (from Plain Trigonometry to Honors Calculus III) and 41 will need to retake the course due to unsatisfactory grades, which are either a 'W', 'D', or an 'F'. This number translates to 44.6% of all ME freshmen that attempted a mathematics course and 43.6% of the entire freshman class. Table 3 shows the numbers of students in the more frequented SME courses along with corresponding percentages. Table 3 does not show all upper-level mathematics courses or beginning mathematics courses, where there were an additional three students that did not pass. Statistics such as these can certainly have a significant negative impact on the ME retention rate.

Table 3. Numbers and percentages of mechanical engineering students listed by SME course at the U of A that received unsatisfactory grades during their freshman semester of Fall 2004.

Grade Received	Course Name							
	Introduction to ME	Graphics	Chemistry I	Pre-Calculus	Calculus I	Honors Calculus I	Calculus II	Honors Calculus II
W's	3	5	8	0	7	3	4	0
D's	4	5	8	3	4	3	0	0
F's	3	6	14	4	6	1	3	0
TOTAL	**10**	**16**	**30**	**7**	**17**	**7**	**7**	**0**
# Attempts	94	66	81	13	36	13	19	2
% of Attempts	**10.6 %**	**24.2 %**	**37.0 %**	**53.8 %**	**47.2 %**	**53.8 %**	**36.8 %**	**0.0 %**
% Overall	**10.6 %**	**17.0 %**	**31.9 %**	**7.4 %**	**18.1 %**	**7.4 %**	**7.4 %**	**0.0 %**

When observing the Fall 2004 academic results of those 27 students that had already changed majors, 15 (55.6%) of them did not pass their mathematics course and 13 (48.1%) did not pass their Chemistry I course. There were nine, or 33.3%, of those 27 students that passed neither Chemistry I nor their mathematics course. In addition, there were 12 of the 27 students that did not pass two or more SME courses. The remaining 67 of the 94 students in the ME program consisted of 26 (38.8%) students that did not pass their mathematics course and 17 (25.4%) that did not pass Chemistry I. There were 12 (19.9%) of these 67 students that did not pass two or more SME courses. These significant ratios are what drive the need for programs to assist students in areas of mathematics and sciences. These programs will help the students to not only understand the concepts of the material but also their relevance to engineering.

A study performed at Purdue University from 1981 to 1993 showed conclusive results of a correlation between student retention and their first semester mathematics grade [17]. In addition, the retention rate was also affected by the type of mathematics course the student was taking. For instance, retention for an A received in Purdue's MA151 mathematics course was equivalent to the retention of a student receiving a B in their MA161 mathematics course.

survey description

Beyond the difficulty of the mathematics and science courses are many other issues that influence a student's decision to continue in an engineering program. In order for an institution to improve freshman retention, it needs to have some understanding of the reasons why students decide to leave engineering and why they decide to stay. While literature offers many possibilities as to why students leave or remain in a program, the Department of ME at the U of A wanted this information from its own students and chose a survey to accomplish this objective.

A closed form questionnaire was utilized in order to obtain statistically reliable data that could be used for future comparisons [20]. It used a Likert scale system that consisted of five answers, which were 'Strongly Disagree', 'Disagree', 'Neutral', 'Agree', and 'Strongly Agree'. These answers provided the opportunity for the data collection to be repeated over time with future cohorts [20,21]. The questions had to be worded such that one answer would clearly provide the intent of the student. Development of the questions began with a literature search for reasons why students leave engineering and why they stay. A listing of reasons for leaving was made and organized according to their general topic which produced the first six categories of ideology. This list of reasons for leaving is as follows along with their respective topic headings.

<u>Why Students Leave:</u>

- Adjustment to College
  - *Educational Climate.* The reasons that 40-60% of freshman majors in SME leave these majors have much more to do with the educational climate and the workload required than their ability to complete an SME major [22].
  - *Transition to College.* Students' transition to college from high school is rough or uncomfortable [2.]

- Academic
  - *Understanding of Cognition.* "Faculty members do not understand how people learn" and thus use instruction methods not compatible to students [22].
  - *Pace of Class.* Science, math, and engineering faculty tend to cover too much material whether the students keep up or not [22].
  - *Applicative Lectures.* "Faculty members do not adequately employ applications, examples and discussion to lectures" [22].
  - *Importance of Fit.* "Coverage of material in reading, labs, and lectures does not overlap" [22].
  - *Grade Curving.* "Students do not take responsibility for learning; *grade just happens*" [22].
  - *Academic Difficulty.* Students have insufficient preparation for the college curriculum while in high school [3].
  - *Advising.* Inadequate advising or help from faculty [23].
  - *Lack of Challenge.* College life presents too little challenge and students get bored [3].

- Incongruence in College Atmosphere
  - *Lack of Commitment.* Students may possess little if any of the required commitment toward the goal of graduating with an engineering degree [3].
  - *Sense of Belonging.* Students may leave because they never develop a sense of belonging or a sense of community in an engineering program [2,3,24].
  - *Expectations.* Students develop unrealistic expectations of what engineering really is before their pursuit of it [2].
  - *Compatibility.* SME career not conducive to student's lifestyle [23].

- Feeling of Isolation
  - *Lack of Dialogue.* "Students do not feel like full partners in their learning" [22].
  - *Distancing Behavior.* "Professors do not communicate concern about students" [22].

- Outside Obligations
  - *Job Demands.* More students are working which places pressure on their academics [3,25]. The percentage of 16-24 year-old, full-time college students who were employed rose 33% from 1973 to 1996.
  - *Family Responsibilities.* Students who have to fulfill duties at their home.

- Finances
  - *Finances.* Students may find it difficult to 'stay afloat' financially while in college.

- Discipline
  - *Voluntary classes. Students take extra effort to attend voluntary classes to improve understanding.*
  - *Time management. Students prioritize and don't are willing to sacrifice recreational time to improve their classroom performance.*

Although not as plentiful in literature, reasons for students staying in engineering majors were found and are discussed as follows.

Why Students Stay:

- *Learning Outside of the Classroom.* Learning outside of the classroom can be the most important experience a student has. Learning in non-classroom settings such as residential or extracurricular locations is crucial [26].
- *Quick Feedback.* According to students, courses that are highly structured with many short assignments and quizzes improve learning significantly [26].
- *Working Cooperatively.* Student learning is increased when assignments are challenging enough to the extent that it requires the students to work in groups, i.e., study in groups, split up the workload of the assignment, etc. [26].

All of these reasons were considered during the development process of the questionnaire and most of them were employed in some form. The authors contributed additional questions based on personal experience or prior student feedback from which resulted a seventh category labeled "Discipline." This resulted in a 32-question survey. The goals for the structure of the questions were to make them succinct, easily understood, and fitting to the Likert scale. While the wording of the questions may seem rather benign, the answers to the questions make them powerful indicators for the thought processes of the students. The questionnaire also had a 'Comments' section that provided the students an opportunity to add any additional feedback.

survey results

The questionnaire was distributed via e-mail by the GA (first author) during the Spring semester to the 2004 cohort of 94 students. About eight of the questionnaires were transferred personally to the freshmen to be completed by hand with only four completed and returned. The reason for this personal transfer is that the GA was not getting responses from these freshmen through e-mail. All students were notified their responses would be confidential and that each of them would be assigned a number for classification purposes. Relying on the students to respond to e-mail gave rise to the possibility of fewer completed questionnaires than ones given in a classroom because its success depended on the motivation of the student to complete and return it. Nonetheless, there were 62 of the 94-student cohort (or 66%) that returned the surveys by the end of the 2005 Spring semester.

An analysis of the 2004 cohort data was performed in order to identify why some students left ME and why some stayed. The students that were already known to have changed majors were placed on a list called 'High Risk.' To this list were added the students that had not changed majors but did not perform well in one or more of their SME courses by receiving either a 'W', 'D', or 'F'. These two types of students were listed together because the two groups were seen as either having changed majors or being at risk to change majors based on academic performance. Students not on the 'High risk' list were placed on a list called 'Low Risk' because they were not seen as being at risk for changing majors based on academic performance. Of the 2004 cohort, there were 47 students (50%) in the high-risk category and 47 students (50%) in the low-risk category. Tables 4, 5 and 6 show specific questionnaire response data regarding the

high- and low-risk students. As the data in Table 5 indicates, it proved challenging to get those that had already changed out of ME to complete the questionnaire.

Table 4. Survey responses for low-risk ME students.

Number of Low-Risk Survey Responses				Percent Received
Low-Risk Students	38	out of	47	80.9%

Table 5. Survey responses for high-risk ME students.

Numbers of High-Risk Survey Responses				Percent Received
Poor Grades	13	out of	20	65.0%
Changed Major	11	out of	27	40.7%
Overall	24	out of	47	51.1%

Table 6. Overall percentages of high- and low-risk ME students.

Percentage of Overall High- & Low-Risk Students	
High-Risk (Grades)	21.3%
High-Risk (Majors)	28.7%
Low-Risk	50%

survey analysis

An example of the questionnaire can be found in the Appendix and is referenced during this analysis. In observing the responses to the questionnaires for both the high- and low-risk students, it was of interest to discover that 21 of the 32 questions showed essentially the same distribution of answers per student category (high-risk, low-risk) for each choice on the Likert scale. This means that for those 21 questions, there is no statistical difference in thought between the students that are at risk for changing majors and those that are not from the U of A 2004 cohort. Below is a list of topic headings from the survey with corresponding questions. The highlighted questions indicate a nontrivial difference in thinking between the two student categories. The results to the survey are represented graphically in the Appendix.

I. Adjustment to College
   1, 2, 3
II. Academic
   4, 5, 6, 7, 8, **9**, 10, 11, 12, **13**, **14**, **15**, **16**, **17**, 18
III. Incongruence in College Atmosphere
   19, 20, 21, **22**
IV. Feeling of Isolation
   23, **24**
V. Outside Obligations
   25, **26**
VI. Finances
   27, 28, 29
VII. Discipline
   30, 31, 32

The questions having significantly different responses between high- and low-risk students are as follows along with results and analyses.

Question 9: "My high school sufficiently prepared me for the college curriculum."
Result: 65% of low-risk students answered in the positive compared to 35% of the high-risk students.
Analysis: It may seem that students have difficulty with the requirement for them to 'teach themselves' the material along with the faster pace of the college courses. This supports the notion that a student's ability to succeed in difficult college programs begins with a strong academic high school experience [2].

Question 13: "I prefer to study in groups."
Result: 42.1% of the low-risk students answered with 'Disagree' while 45.5% of the high-risk students answered with 'Neutral'.
Analysis: Competition among peers may cause the low-risk students to work alone on their schoolwork while the high-risk students may prefer to collaborate with someone else in an information sharing process. This was the only question that had a significant difference in responses between the two risk categories of students.

Question 14: "I prefer to study alone." *(The antonym to Question 13.)*
Result: Most high-risk students answered with 'Neutral' while more low-risk students answered with 'Agree'.
Analysis: The same as question 13. Interestingly, the response distribution for the high-risk students was almost exactly the same for Questions 13 and 14.

Questions 15, 16, & 17 deal with the Physics, Chemistry, and Mathematics courses, respectively, in regard to faculty covering too much material (pace is too fast).
Result: In all three questions, the high-risk students answered more in the positive than did the low-risk students.
Analysis: This could be the result of the quality of academic preparation the students received in high school. Some research implicates the methods of pedagogy as contributing to problems experienced by students in SME courses [2].

Question 19: "I feel confident that I can succeed in my major."
Result: Approximately 20% more of the low-risk students answered in the positive than did the high-risk students. This was aided by a 27.3% response of 'Neutral' by the high-risk students.
Analysis: Because this survey was administered during the Spring semester, the perception of the students' success in ME could have already been affected if they have not performed well academically thus far.

Question 22: "The expectations I had about mechanical engineering have changed since I began college."
Result: A large majority of the high-risk students answered with 'Agree' where the majority of the low-risk students answered with 'Neutral'.

Analysis: Some mechanical engineering freshmen start school without fully understanding what to expect in their freshman year. This may result from inadequate counseling in high school or not visiting the school before committing to it.

Question 24: "It is easy to talk to my professors."
Result: 59.5% of low-risk students answered with 'Agree' while the high-risk students split their majority by 34.8% answering 'Neutral' and 34.8% answering 'Agree'.
Analysis: Fewer of the high-risk students feel comfortable talking to their professors which may allow the cycle of declining grades to continue. Professors that try to be more sociable with their students (learning students' names, speaking outside of class) will improve the climate and student response in the classroom [22].

Questions 25 & 26 refer to job demands and home responsibilities, respectively.
Result: In both questions, the high-risk students answered more in the positive than did the low-risk students.
Analysis: Students that have duties outside of school have less time for schoolwork and could experience more stress as a result. The number of students that left ME for "odd" reasons such as peer or family influence was not significant. For the freshman mechanical engineering student, taking a full-load of courses while fulfilling work or other duties can make it difficult to benefit from their college experience in a positive way.

Questions 28 and 29 ask the student to think ahead of what their lives will be like when they are working as mechanical engineers. Question 28 asks if ME will prove to be worth the work because of the things they will be able to do with the degree and Question 29 asks if their future salary will prove to be worth becoming a mechanical engineer. The responses showed that most students, in both student-categories, believe becoming a mechanical engineer will be worth the work because of what they can do with the degree rather than what they will earn in a salary. This may indicate that they desire to do something that seems enjoyable to them rather than just getting a paying job.

Another interesting result from the survey is in reference to Question 32, which states "I could do more to improve my grade in my courses." Each student-category responded with essentially the same distribution and percentages of answers. Exactly one-third of the high-risk students answered with 'Strongly Agree' while 47.6% answered with 'Agree' compared to the low-risk responses being 21.1% for 'Strongly Agree' and 52.6% for 'Agree'. This signifies that most responding students believed that they were not performing at their highest academic level.

survey discussion

The survey results for this freshman class by and large indicate that there is a smaller-than-expected amount of measurable differences (11 of 32) between the two student-categories (high- and low-risk for changing majors). This coincides with what was found through a student survey at Arizona State University in 1996 when they surveyed students that had left their engineering program and students that were still in it [24]. Within these eleven differences, however, might lay the key(s) to creating a major shift in retention rate trends at the U of A.

Problems with retention are often thought of as a set measurable and modifiable metrics that engineering programs can adjust in order to increase freshman retention. This is not always the case as indicated by the results from the U of A survey which showed only a few questions with marked differences in the answers between the students that were at high-risk for changing majors and those that were not. The most significant differences occurred in three subjects. The questions from those subjects involved (1) the student's high school preparation for college, (2) the students studying in groups, and (3) the student's expectations about ME.

The survey results regarding the students' belief about their high school preparation for college indicates there is a disconnect between what, or how, high schools teach and what is required to succeed in college as a freshman. Concerning the subject of group study, the high-risk students showed no preference to studying in groups or alone while the low-risk students indicated they preferred to study alone. With reference to the student's expectations about ME changing since their beginning college, the high-risk students experienced more of a change than did the low-risk students.

It would seem that a student's high school preparation for college and their expectations about ME might be related to one another in that both originate prior to the start of college. This could be because students who do well in high school mathematics and science classes feel they are already prepared to begin an engineering program because it is based on these same subjects. Even the more prepared freshmen students find it difficult to do as well in their college courses as they did in their high school classes [3]. When talking to some of the students that had already changed majors, some based their reason changing majors on the notion that they wanted to graduate with higher grade point averages than it appeared they would get in ME. In addition, students decide to start an engineering program because of what they 'think' they will get out of it. When those expectations, whether self-composed or otherwise indicated, are not met, the student begins to reevaluate their reason for choosing the program in the beginning. It is important for a program to provide comprehensive information during recruitment on which students can base their expectations and their decision to attend.

The low-risk students that prefer to study alone possibly have better study habits, more discipline, or more time to learn the material. The lack of study preference within the high-risk group might result from a smaller amount of study-time based on their indication of more job demands and home responsibilities. High-risk freshmen that are having academic difficulty might welcome the notion to study with someone else in order to pool their resources. On the survey, both groups alleged they could do more to improve their grades while in college.

"The presence of a strong commitment to students results in an identifiable ethos of caring which permeates the character of institutional life and sets it apart from institutions which place student welfare second to other goals" [3]. People generally perform better and try harder when they are excited about doing a new activity. Students begin college this way and would continue in a program, while doing well, if that level of excitement were maintained. Engineering programs would help students, and itself, by providing students with a realistic vision of what real engineering is about and letting the students 'experience' engineering for themselves [2]. While high schools could do more to inform and prepare students for a COE program, it is up to the student to determine what the career choice should be and why.

Likewise, the COE program would benefit by nurturing that decision with valid, educational information that broadens a student's awareness of the engineering discipline.

conclusion and future work

In conclusion, the work presented in this paper provides additional insight into understanding the complex issues of retention. A large freshman engineering class of students is diverse and each student must overcome obstacles to succeed and achieve their goal of obtaining an engineering degree. Primary results from the survey indicated that there are three areas (or obstacles) where the "at high-risk" group differed significantly from those in the "at low-risk" group. Those areas are the students': 1.) preparation for college while in high school, 2.) study techniques, and 3.) expectations about the curriculum in which they are starting. Focusing efforts to improve in these areas could lead to increased retention rates. The University of Arkansas Department of Mechanical Engineering plans to continue surveying its freshman classes in the effort to learn and monitor its progress in their regard. In addition, their mentorship program will attempt to assist incoming freshman through the development and encouragement of better study/time habits and preparing them to manage the workload requirements for an engineering degree.

references

1. Loftus, M., Retention Is A Big Issue in Engineering Education, and More Schools Are Developing Programs to Keep Students From Dropping Out, *ASEE Prism*, Vol. 14, No. 5, pp. 26-27, January 2005.

2. Wild, W.G. and Ryan, M.E., Retention and Success of Engineering Undergraduates: A Discussion of Retention-related Initiatives at the University of Buffalo, Session 1653, *Proceedings of the ASEE Annual Conference & Exposition*, Montreal, Canada, June 16-19, 2002.

3. Tinto, V., *Leaving College: Rethinking the Causes and Cures of Student Attrition*, The University of Chicago Press, Chicago, IL 1993.

4. Rojas-Oviedo, R., Deng, Z.T., Mobasher, A., and Jalloh, A., Synthesis of Engineering Best Practices and ABET AC2K into a New Mechanical Engineering Curriculum, Session 2266, *Proceedings of the ASEE Annual Conference & Exposition*, St. Louis, MO, June 18-21, 2000.

5. Karunamoorthy, S. and Ravindra, K., Integrated Curriculum Design in Mechanical Engineering – Opportunities and Challenges, Session 2566, *Proceedings of the ASEE Annual Conference & Exposition*, Seattle WA, June 28-July 1, 1998.

6. Wood, J.C., An Interdisciplinary Problem-Based Engineering Technology Freshman Curriculum, Session 2248, *Proceedings of the ASEE Annual Conference & Exposition*, Seattle WA, June 28-July 1, 1998.

7. Johnson, K.V. and Rajai, M., "Student in the University": A Format for Retaining Students in Engineering Technology, Session 93, *Proceedings of the ASEE Annual Conference & Exposition*, St. Louis, MO, June 18-21, 2000.

8. Etchison, J.R., Curriculum Restructuring for Freshman Retention in the 1990's and Beyond, Session 1547, *Proceedings of the ASEE Annual Conference & Exposition*, Seattle, WA, June 18 - July1, 1998.

9. Milano, G.B., Parker, R. and Pincus, G., A Freshman Design Experience: Retention and Motivation, Session 2553, *Proceedings of the ASEE Annual Conference & Exposition*, Washington, DC, June 23-26, 1996.

10. Demel, J.T., Gustafson, R.J., Fentiman, A.W., Freuler, R.J. and Merrill, J.A., Bringing About Marked Increases in Freshman Engineering Retention, Session 2043, *Proceedings of the ASEE Annual Conference & Exposition*, Montreal, Canada, June 16-19, 2002.

11. Hammoudeh, A.and Barrett, J., Tackling Engineering Retention: A Firsthand Experience, Conference Theme: Facing the Global Challenge, *International Conference on Engineering Education*, Manchester, U.K., August 18-21, 2002.

12. Bayles, T.M., Improving the Freshman Engineering Experience, Session 2253, *Proceedings of the ASEE Annual Conference & Exposition*, Salt Lake City, UT, June 20-23, 2004.

13. Borrelli, E.R., Quantitative Inquiry that Counts – Rethinking Why Students Leave Engineering, Session 1430, *Proceedings of the ASEE Annual Conference & Exposition*, Montreal, Canada, June 16-19, 2002.

14. Flores, B.C., Della-Piana, C.K., Brady, T., Swift, A., Knaust, H. and Martinez, J.R., An Institutional Model for Student and Faculty Support, Session 1430, *Proceedings of the ASEE Annual Conference & Exposition*, Montreal, Canada, June 16-19, 2002.

15. Waller, T.O. and Watford, B. A., *ASPIRE* – The Academic Summer Program Introducing Resources for Engineers, Session 2253, *Proceedings of the ASEE Annual Conference & Exposition*, Salt Lake City, UT, June 20-23, 2004.

16. Diefes-Dux, H., Does a Successful Mathematics Bridge Program Make for Successful Students?, Session 1653, *Proceedings of the ASEE Annual Conference & Exposition*, Montreal, Canada, June 16-19, 2002.

17. Briller, V., Carpinelli, J.D., Deess, E.P., Calluori, R. and Gonzalez-Lenahan, C., The Effectiveness of Education Learning Assistants Program for Student Retention, Session 1430, *Proceedings of the ASEE Annual Conference & Exposition*, Nashville, TN, June 22-25, 2003.

18. Roth, R., Improving Freshman Retention Through an Introduction to Engineering Design Course, Session 2553, *Proceedings of the ASEE Annual Conference & Exposition*, Albuquerque, NM, June 24-27, 2001.

19. Bishop, S.L. and Besterfield-Sacre, M., Freshman Engineering Leadership Team: Student Mentors for Recruitment and Retention, Session 3553, *Proceedings of the ASEE Annual Conference & Exposition*, Washington, DC, June 23 – 26, 1996.

20. Besterfield-Sacre, M., Atman, C.J., and Shuman, L.J., Engineering Student Attitudes Assessment, *Journal of Engineering Education*, Vol. 87, No. 2, pp. 113-141, April 1998.

21. Besterfield-Sacre, M., Atman, C.J., and Shuman, L.J., Characteristics of Freshman Engineering Students: Models for Determining Student Attrition in Engineering, *Journal of Engineering Education*, Vol. 82 ,No. 2, pp. 139-149, April 1997.

22. Hornbuckle, K., The National Science Foundation's Scholars Workshop: Strategies for the New Professor, Paper 132, *International Conference on Engineering Education*, Chicago, IL, August 13-15, 1997.

23. Seymour, E., *Revisiting 'The Problem Iceberg': Science, Mathematics, Engineering Students Still Chilled Out*, Journal of College Science Teaching, Vol. 29, No. 6, pp. 392-400, May 1995.

24. Anderson-Rowland, M., Understanding Freshman Engineering Student Retention Through a Survey, Session 3553, *Proceedings of the ASEE Conference and Exposition*, Milwaukee, WI, June 15-18, 1997.

25. Hansen, E., *Essential Demographics of Today's College Students*, American Association for Higher Education Bulletin, Vol. 51, No. 3, pp. 3-5, November 1998.

26. Light, R., *Making the Most of College: Students Speak Their Minds*, Harvard University Press, Cambridge, MA, 2001.

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The freshman survey used at the U of A during the Spring 2005 semester:

Mechanical Engineering Department Freshman Class Survey

Steps for completing the survey:

1. Save the file to your desktop.
2. Open it and place an 'X' where you would have colored in the circle.
3. Resave it to your desktop.
4. Attach it to an e-mail message back to me.
5. Delete it from the desktop when finished. ***

Answer Scoring Key:
SD - Strongly Disagree
D - Disagree
N - Neutral
A - Agree
SA - Strongly Agree

	Question	SD	D	N	A	SA
Adjustment to College						
1	The workload in college is more difficult than was my high school workload.	O	O	O	O	O
2	College life presents too little challenge.	O	O	O	O	O
3	My courses are interesting and stimulating.	O	O	O	O	O
Academic						
4	My professors understand the material they are teaching.	O	O	O	O	O
5	My professors know 'how' to teach the material in the course.	O	O	O	O	O
6	The lectures adequately employ applications, examples and discussion pertinent to the course.	O	O	O	O	O
7	Coverage of material in reading, labs, and lectures overlap.	O	O	O	O	O
8	In most cases, curve grading helps my grade.	O	O	O	O	O
9	My high school sufficiently prepared me for the college curriculum.	O	O	O	O	O
10	Faculty advising has been helpful to me.	O	O	O	O	O
11	I enjoy Science, Mathematics, and Engineering courses.	O	O	O	O	O
12	Mechanical Engineering compares positively to other fields of study.	O	O	O	O	O
13	I prefer to study in groups. (of two or more)	O	O	O	O	O
14	I prefer to study alone.	O	O	O	O	O
15	The Physics faculty covers too much material (pace is too fast).	O	O	O	O	O
16	The Chemistry faculty covers too much material (pace is too fast).	O	O	O	O	O
17	The Mathematics faculty covers too much material (pace is too fast).	O	O	O	O	O
18	The Engineering faculty covers too much material (pace is too fast).	O	O	O	O	O
Incongruence in college Atmosphere						
19	I feel confident that I can succeed in my major.	O	O	O	O	O
20	I am committed to finishing my degree at the U of A.	O	O	O	O	O
21	I feel a sense of community within the Department of M.E.	O	O	O	O	O
22	The expectations I had about Mechanical Engineering have changed since I began college.	O	O	O	O	O
Feeling of Isolation						
23	Meeting new people in my classes is difficult for me.	O	O	O	O	O
24	It is easy to talk to my professors.	O	O	O	O	O
Outside Obligations						
25	My job places heavy demands on me.	O	O	O	O	O
26	I have many responsibilities at my home.	O	O	O	O	O
Finances						
27	School places a heavy financial burden on my family and me.	O	O	O	O	O
28	Mechanical Engineering will prove to be worth the work because of what I can do with the degree.	O	O	O	O	O
29	Mechanical Engineering will prove to be worth the work because of the salary I will make when I begin working.	O	O	O	O	O
Discipline						
30	I attend all of my classes, labs, and drills (if applicable).	O	O	O	O	O
31	I make less time for recreation than I do for school.	O	O	O	O	O
32	I could do more to improve my grades in my courses.	O	O	O	O	O
Comments:						
	{The actual survey had six lines for comments.}					