

## **AC 2007-2161: COMPARISON OF THREE UNIQUE STUDENT POPULATIONS IN AN ENGINEERING TECHNOLOGY STRENGTH OF MATERIALS COURSE**

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# Comparison of Three Unique Student Populations in an Engineering Technology Strength of Materials Course

## Abstract

The Engineering Technology (ET) department at The University of North Carolina at Charlotte has historically been a *plus two* program, offering only the junior and senior years of the BSET curriculum. In the fall of 2004, the department began offering all four years of its programs, accepting freshman students for the first time. That first freshman class has now matriculated to the junior year, joining a new class of transfer students entering at the same point in the curriculum.

Four-year ET programs also opened the door to transfer students from the engineering science programs on campus, with most arriving from mechanical engineering. Though some students expressed a greater interest in the technology programs, many sought transfer due to academic struggles, particularly in calculus and calculus based physics classes.

Mechanical engineering technology students take a traditional strength of materials course in the fall of the junior year. In fall 2006, this course enrolled 51 students, the majority of which fell into one of three categories: entered ET as freshmen; entered ET as junior transfers; transferred into ET from mechanical engineering. This paper details the experiences of teaching these three unique student populations in a junior level ET strength of materials course.

## Background

The Engineering Technology department at The University of North Carolina at Charlotte began operations in 1970 as a *plus two* program, offering only the junior and senior years of the BSET curriculum. All students entered in the junior year with an associate's degree, predominately AAS degrees from two-year community college programs. Though outside the national norm, the department continued to operate exclusively as a plus two program through the 2003/2004 academic year.

In order to facilitate growth and to bring its structure inline with current trends, the department began offering all four years of its degree programs in the fall semester 2004, accepting freshman students for the first time. In addition to freshman, the department also accepted numerous transfer students from the engineering science (ES) programs on campus<sup>1</sup>, with a significant number transferring from mechanical engineering into mechanical engineering technology.

Some of the transferring students expressed a greater interest in the technology programs, reporting that the more practical application of engineering concepts and additional hands-on activities better suited their learning styles<sup>2</sup>. Many others, however, sought transfer into the technology programs due to academic struggles, particularly in calculus and calculus based physics classes<sup>3</sup>.

Two separate circumstances led to this large, one-time cohort of transfer students from engineering to engineering technology. First is that word of the four-year ET programs had spread among the ES students well in advance of fall 2004. Many students who were considering transfer out of their ES program waited an extra year or two so they could enter the ET programs, creating a one-time pent-up demand.

The second circumstance was fueled by the fact that ET was late receiving approval to offer the four-year programs, and was only able to announce them in October of the previous year. The department had a lot invested in the four-year programs, and was anxious for them to succeed. The late date created concern about a potentially small freshman class, and the department was eager to fill the initial lower division offerings. For that reason, the department was not especially selective in its screening of potential transfer students from the ES programs, and accepted approximately fifty into the program in the first year. The flow of transfer students into ET has since diminished significantly, as the one-time pent-up demand has been satisfied and department has established minimum requirements for transfer into engineering technology.

By the fall semester 2006, the ET department's first freshman class had matriculated to the junior year, joining a new class of transfer students entering at the same point in the curriculum. In addition, a significant portion of the ES transfer students had also moved along to the same upper division classes. This convergence has resulted in junior level classes with significant numbers of students from three distinctly different populations, providing a one-time opportunity to study their differentiating characteristics.

### **Junior Level Strength of Materials**

Mechanical engineering technology students take a traditional strength of materials course in the fall of the junior year. This course has a prerequisite of statics (sometimes called applied mechanics) and a corequisite of integral and differential calculus. The course is taught in lecture format on a chalk board in a traditional classroom setting.

The course begins with a brief review of statics, then moves through basic concepts of stress and strain, shear and bending stress, and design of members subject to shear and bending stresses. Additional topics include bearing stress, stress concentrations, axial strain, thermal effects, torsion, shear and moment diagrams, centroids, area moment of inertia, beam design, and combined stresses.

Although students in their junior year also take core courses such as fluid mechanics, dynamics, and thermodynamics, strength was chosen for this study due its many prerequisite competencies. Anecdotal data over the years suggests that preparation in statics varies widely among students in the class. Another common observation is a lack of basic algebra skills among some students, as well as difficulties in unit conversions. Finally, although calculus is not used or even presented extensively, its appearance does lead to problems for some students in certain application areas.

It is expected that the multiple competencies relied upon during the teaching of this course will help uncover differences between the diverse groups of students. Each group will have had

different preparation in statics, calculus, physics, and perhaps even algebra, which has been shown to create challenges when teaching this subject<sup>4</sup>.

### The Students

In the fall 2006 semester, two sections of strength of materials had a total enrollment of 51 students. 42 students returned end-of-semester surveys, the first question of which dealt with their origin point into the course. Of the 42, 12 students entered with an AAS degree from a two-year school, and are heretofore referred as AAS. 7 students began as freshmen in engineering technology, which we'll call FET. 19 students began university study as freshmen in an engineering science program then transferred into technology. Those students will be referred to as FES. An additional 4 students fell in the "other" category, which are not considered in this study. This leaves 38 students distributed as shown in Figure 1.

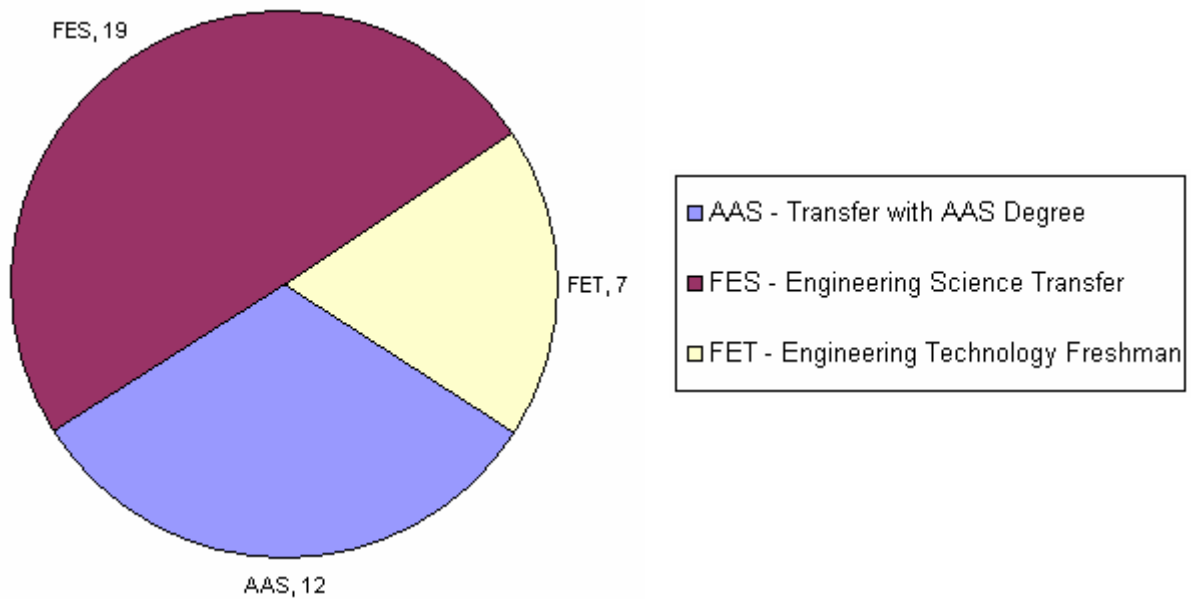


Figure 1 – Breakdown of Student Entry

### The Grades

A logical first approach to compare these distinct student groups is by the grades they earned in the class. But as is shown in Figure 2, while the FET students reported a slightly higher final average for all coursework, there was no significant difference among the three groups. Further analysis of homework averages, test averages, and scores on the final exam produced similar results with no differentiating characteristics.

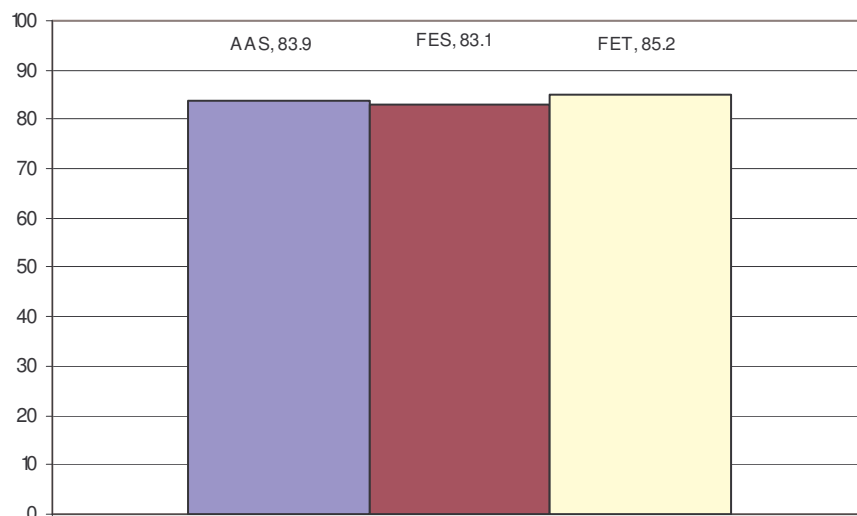


Figure 2 – Final Average (out of 100 points)

## The Survey

In order to learn more about the differences in the student's preparation levels and overall perceptions of the course, an end-of-semester survey was executed. Students were first asked to estimate the weekly time they spent doing work and otherwise preparing for the course. They were then asked about their perceived level of preparedness in statics, algebra, and calculus. They were asked about any specific problem areas, such as equilibrium, free body diagrams, normal vs. shear stress, etc. Finally, they were asked about the helpfulness of various learning strategies, such as in-class lectures, homework, or working in groups. The significant survey results were compiled and are presented in the following sections.

## Time Spent on the Class

Students were asked "On Average, I spend \_\_\_\_\_ hours per week on strength of materials homework, preparing for tests, etc." The responses broken down by student entry are shown in Figure 3. As can be seen in the graph, the students that transferred with associate degrees spent the least amount of time, while the students that entered the program as freshmen majoring in engineering technology spent the most. The transfer students from engineering science fell in the middle of the other two groups.

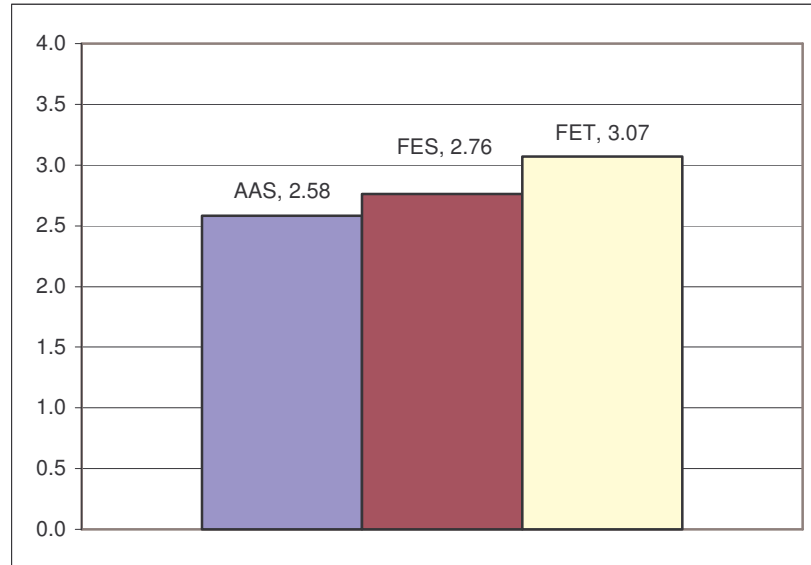


Figure 3 – Average Hours per Week Preparation Time

### Preparation in Statics

Students were asked if their preparation in statics, prior to entering the course, could be considered fully adequate, somewhat adequate, somewhat lacking, or severely lacking. The percentage of students from each origin that responded "fully adequate" is shown in Figure 4. As detailed in the graph, the students that entered as freshmen in engineering technology considered themselves the least prepared.

This is an unexpected result, as all of these students took statics within the department, whereas the AAS transfer took statics at their two-year school, while the former engineering science students may have taken statics in their department or in technology, depending on when they transferred. Based on written comments within the survey, a potential cause may be that statics is taken in the fall of the sophomore year, with a semester break between statics and strengths. Some students reported the time lag as a contributing cause to their lack of preparedness.

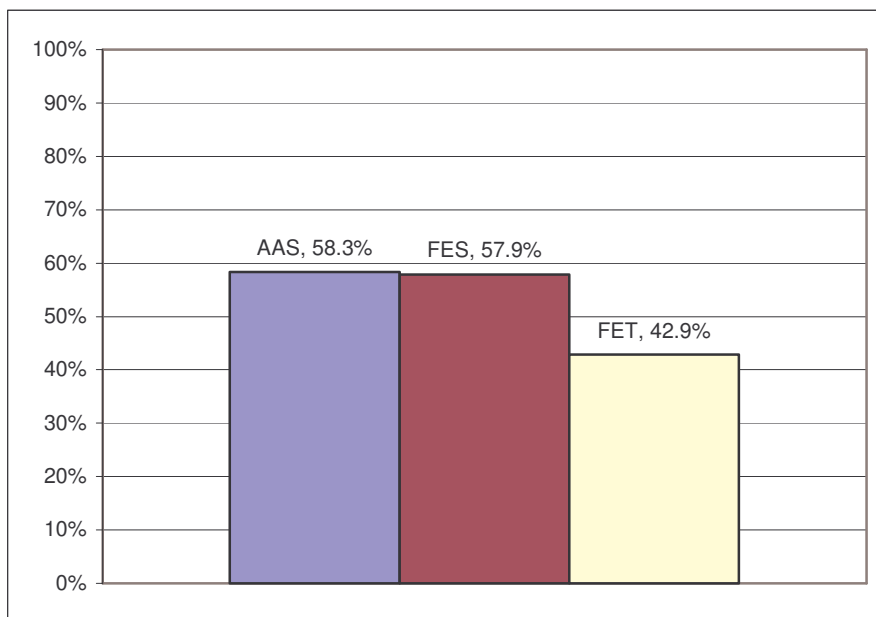


Figure 4 – Percent Reporting Fully Adequate Preparation in Statics

### Preparation in Algebra and Calculus

Students were asked if their preparation in algebra, prior to entering the course, could be considered fully adequate, somewhat adequate, somewhat lacking, or severely lacking. The percentage of students from each origin that responded "fully adequate" is shown in Figure 5. Based on the results, there appears to be no significant difference among the student populations. It's worth noting that preparedness in algebra did not seem to be a significant problem for any of the student groups, as at least 83% of students in each group reported that they were fully prepared

Students were asked a similar question about their preparation in calculus. The percentage of students from each origin that responded "fully adequate" is shown in Figure 6. Based on the results, there also appears to be no significant difference among the student populations in calculus preparation. This result is somewhat surprising, given that each group likely had significantly different quantities and levels of calculus leading into this course. Another interesting result is the overall low percentages. The fact that no more than 43% of any group reported being full prepared in calculus suggests further study in this area is needed.

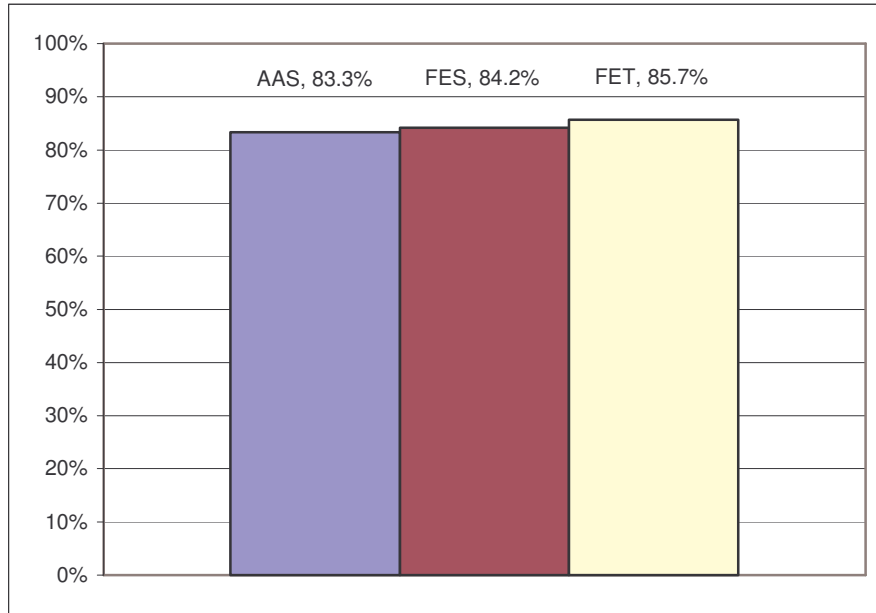


Figure 5 – Percent Reporting Fully Adequate Preparation in Algebra

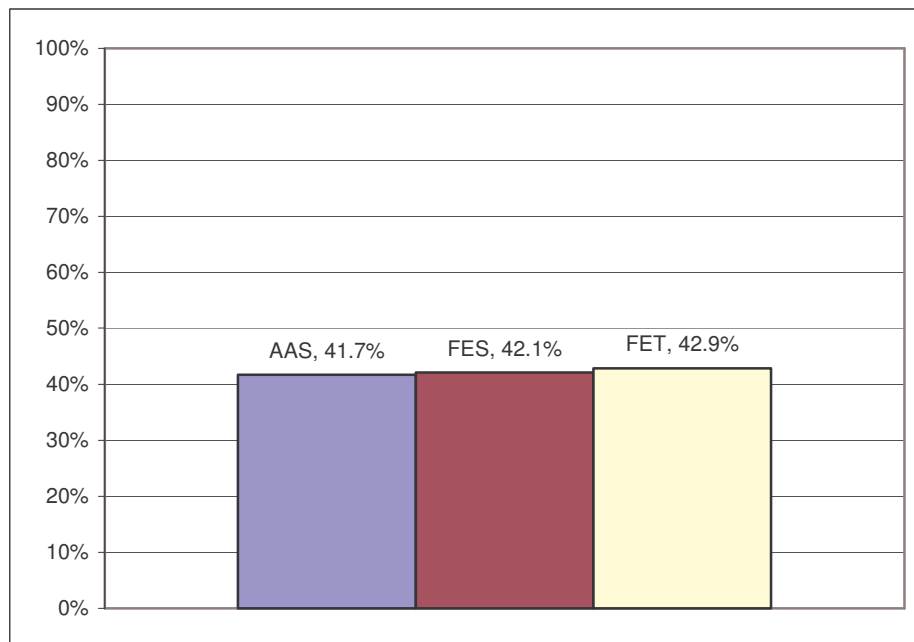


Figure 6 – Percent Reporting Fully Adequate Preparation in Calculus

### Problem Areas

Students were asked if they had some level of difficulty with any of the following concepts: equilibrium, resolving forces into components, forces and moments, canceling units, stress vs. strain, shear and moment diagrams, free body diagrams, and normal vs. shear stress. Study of

the individual problem areas did not produce any differentiating results between the student groups. But examining the percentage of students that reported problems in *any* of the areas did produce some interesting outcomes.

The percentage of students from each group that listed at least one problem area is shown in Figure 7. The results here show that the AAS students experienced the least amount of difficulties, while the students that entered as ET freshmen all reported problems in one area or another. These results for the AAS students are difficult to interpret. They seem to indicate a better understanding of the course material, but that was not borne out in any of the grade averages. This data does provide an odd contrast to Figure 3, however, which reports average hours per week spent on the course. The AAS students spent the least amount of time per week, and had the fewest problems, while the FET students spent the most amount of time and reported the highest percentage of problems. In both cases, the FES student fell in the middle.

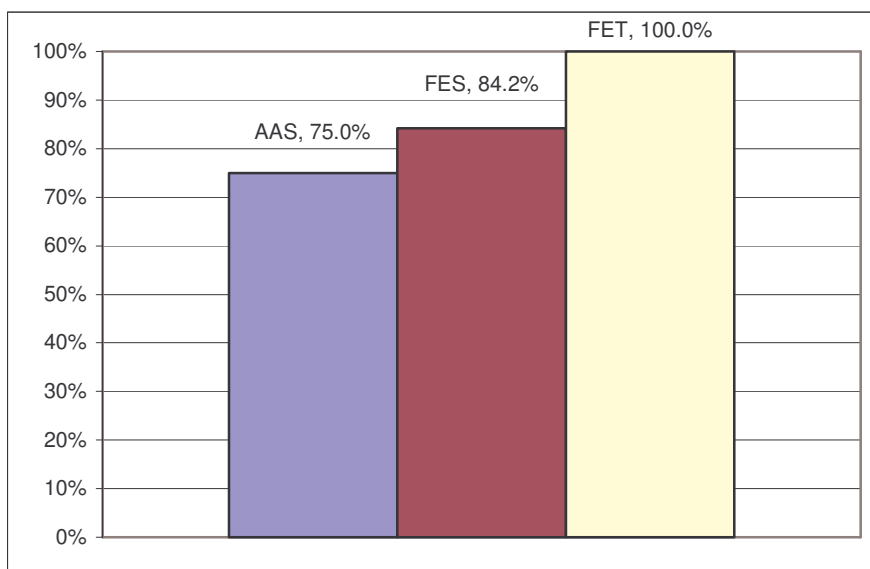


Figure 7 – Percent Listing *Any* Problem Area

### Working in Groups

An attempt was made in the survey to examine if the different student groups exhibited significantly different learning styles. Students were asked to rate various elements as to whether they were very helpful, somewhat helpful, not helpful, or not utilized. An interesting result from the data is the student's response to the helpfulness of working in groups. Figure 8 shows the percentage of students reporting that working in groups was very helpful. As can be seen in the graph, the FET students appear to take the largest advantage of working in groups, followed closely by the FES students. The AAS students report a much smaller benefit.

A logical reason for this result is that many AAS students hold jobs outside of school, and many do not go to school full time. They frequently are older than their peers that entered as freshmen, and many already have families. It's logical that their opportunity to work in groups is not as great as the other two cohorts of students. It's worth recognizing that these students may

potentially benefit from alternate methods of homework assignments, as they clearly work more independently than their counterparts.

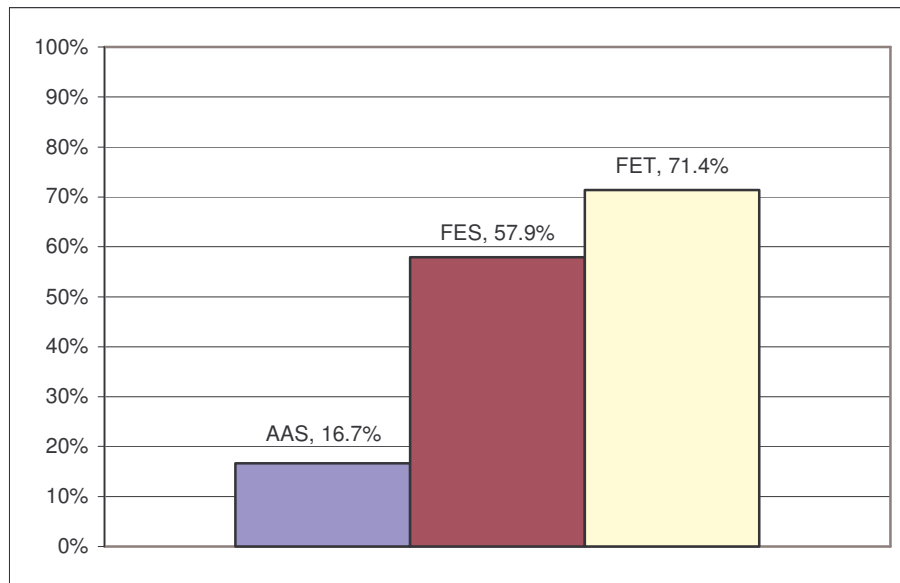


Figure 8 – Percent Reporting Working in Groups as *Very Helpful*

### The Data in Whole

Rather than examining each result on its own, it is interesting to consider the results of Figures 3, 7, and 8 together. In all plots, the AAS students are at one extreme, the FETs are at the other, and the FES students are somewhere in the middle. In summary, the AAS students spent fewer hours per week, reported fewer problem areas, and did not find working in groups helpful. In contrast, the FET students spend more hours per week, reported the most problem areas, and found working in groups most helpful.

A possible conclusion is that the AAS students had an overall better understanding of the material than the other groups, without it being reflected in the grades. Perhaps not working in groups led to errors on homeworks or tests that were not necessarily representative of their understanding of the material. By contrast, perhaps working in groups enabled the FET students to perform better on tests and homework relative to their basic understanding of the material. These suggested conclusions are only conjecture, of course, as no alternative independent assessment tool was used to gage the student's understanding level of course concepts.\*

### Conclusion

Due to a convergence of events, a one-time opportunity existed to study three distinct student populations in an engineering technology strength of materials course. The first cohort was

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\* Further information regarding group based learning in engineering can be found in reference 5.

made up of students that had transferred with an AAS degree into a plus two program. The second cohort consisted of students that had entered as freshmen intending to study engineering, rather than engineering technology, but had transferred into the technology program. The third cohort was students that entered as freshmen, decided on engineering technology from the beginning.

Two basic metrics were employed to examine differences between the groups: earned grades and an end-of-semester survey. Grades, including homework averages, test scores, and final averages, failed to produce any distinguishing characteristics. The end-of-semester survey did produce differences in some areas, but also failed to find differences in others. Taken in whole, the results illustrated sometimes significant differences between the AAS students and their four-year peers, but little to no discernable difference between four-year students that started in engineering and those that began study in engineering technology.

Recommendations resulting from this work include: changing the curriculum for four-year students so that statics immediately precedes strength of materials; examining why all three groups reported a lack of preparedness in calculus; studying out-of-class work assignments, recognizing that AAS transfer students are much less likely to work in groups than their peers.

## **Bibliography**

1. Brower Tim, *Can Engineering and Engineering Technology Programs Reside within the same Department?*, Proceedings of the 2006 American Society for Engineering Education Conference, 2006
2. Rutz Eugene, Westheider Virginia, *Learning Styles Of Engineering & Engineering Technology Students – Similarities, Differences and Implications For Effective Pedagogy*, Proceedings of the 2006 American Society for Engineering Education Conference, 2006
3. Koch Darryl, Herrin Gary, *Intervention Strategy for Improving Success Rates in Calculus*, Proceedings of the 2006 American Society for Engineering Education Conference, 2006
4. Passmore, Lucas and Kuzmar, Aiman, *Comparison Between The Engineering Mechanics-Strength Of Materials Course In The Engineering, And Engineering Technology Programs At Penn State*, Proceedings of the 2006 American Society for Engineering Education Conference, 2006
5. Springer, Leonard, Stanne, Mary Elizabeth, Donavon, Samuel, *Effects of Small-Group Learning on Undergraduates in Science, Mathematics, Engineering, and Technology: A Meta-Analysis*, Review of Educational Research, Spring 1999, Vol 69, No 1, pp. 21-51