Programmatic Support to Facilitate Student Success

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Abstract

The West Virginia University College of Engineering and Mineral Resources has implemented a multi-dimensional approach to the freshman year experience in an effort to support and facilitate student success in attaining the College’s high academic standards and to improve retention of students from the freshman to sophomore year. This paper describes several program characteristics, such as: separate tracks for the calculus-ready and the more mathematically-challenged students; an orientation course focusing on academic transition and success skills; frequent parental communication; mandatory engineering exploration activities; and strict minimum grade attainment requirements. These elements supplement the traditional first year curricular emphasis on problem-solving, computer, and communication skills. Early interventions for struggling students are another key part of this multi-dimensional program. Special classes in foundational math and science material are provided along with mandatory help sessions and/or tutoring. These programs are partially supported by a four-year NFS Grant. An analysis of five years of student performance data, indicating improved academic success and retention, is provided, as well as recommendations for potential future program enhancements.

1.0 Introduction

Attracting and retaining qualified students is essential to surviving and thriving in current enrollment-driven environments. Concern about student retention in engineering has been well-documented during the last few years. Many colleges of engineering have developed programs to increase retention on their campus. A brief review of peer institutions and those institutions with engineering education programs reveals a variety of programs and efforts to help students successfully transition to college life, to succeed in freshman math, science and engineering courses, and to continue in engineering past their freshman year. For example, Purdue University, known for its expertise and leadership in engineering and engineering education, provides a common first year experience and organizes students into learning communities. Supplemental instruction in core math, science and engineering courses, as well as workshops on motivation, avoiding procrastination, and other topics relevant to college students are also
offered on campus. Virgina Tech provides a common first year experience as well as a focus on hands-on design projects in the freshman engineering courses to create an exciting learning environment.

The WVU College of Engineering and Mineral Resources (CEMR) has implemented similar programs, as well as a few novel approaches to the freshman year experience in an effort to support students in their attempt to attain the College’s high academic standards and to improve retention of students from the freshman to the sophomore year.

2.0 Benchmarking/Baseline Data

In the academic year 2000/01, freshman retention, defined as the percentage of freshmen who transferred to a discipline major or to sophomore status at the end of the second semester, was 66.7%; the average GPA of freshmen engineering students was 2.48; and 48 freshmen (10.7%) ended the year with a GPA of 3.5 or better. Since performance in fundamental math and science courses is also a measure of success in an engineering program, student data was compiled and evaluated in three fundamental math and science courses required of all engineering majors: Calculus 1 (MATH 155), Fundamentals of Chemistry (CHEM 115), and General Physics (PHYS 111). In the academic year 2000/01, the engineering GPA in Fundamentals CHEM115 was 1.82, with 55.1% of the students earning a grade of C or better; the engineering GPA in MATH 155 was 1.52, with 38.3% earning a grade of C or better; and the engineering GPA in PHYS 111 was 2.28, with 63.6% earning a grade of C or better.

3.0 Programmatic Support Changes

To improve the academic success of freshman engineering students, several student support structures were implemented over a three year period (academic years 2003/04 through 2005/06). Changes made to the freshman program include:

- Implementation of two engineering tracks: Engineering, a traditional track for those students ready to take MATH 155 (or a higher math course) in the first semester of their freshman year; and General Engineering, a track designed for those students needing to take algebra and trigonometry, or pre-calculus mathematics during the first semester.
- Development of a one-credit hour engineering-specific orientation course for all engineering freshmen which provides early exposure to the value of an engineering degree; tracks student progress throughout the first semester; and involves parents through weekly emailed newsletters.
- Requirement of participation in weekly, two-hour study lab sessions.
- Requirement of participation in supplementary, engineering activities.
- Implementation of the freshman engineering curriculum that focuses on problem-solving, and an increased management of the multiple sections of the first year engineering courses to ensure a more uniform experience for all students.
- Implementation of a five-day MATH 155 sections comprised of three lectures and two recitations per week.
- Creation of a mid-semester pre-calculus class to support students who drop Calculus 1.
- Enforcement of minimum grade requirements.
• Continual tracking of student academic success and provision of academic advising and mentoring throughout the freshmen year.

3.1 Engineering Tracks

The WVU College of Engineering and Mineral Resources admits students under two distinct programs: Engineering, a traditional two-semester track for those students ready to take MATH 155 (or a higher math course) in the first semester of their freshman year; and General Engineering, a three-semester program designed for those students needing to take algebra and trigonometry, or pre-calculus mathematics during the first semester. The objective of the two path approach is to match each student with a first year curriculum that prepares him or her for study in any of the discipline majors and also is tailored to maximize the learning success of that student. To qualify for the Engineering program, students must have an ACT-Math score of at least 26 with a composite score of at least 19, or an SAT-Math score of at least 600 with a composite SAT score of at least 910. To qualify for the General Engineering program, students must have an ACT-Math score of at least 20 with a composite ACT score of at least 19, or have an SAT-Math score of at least 480, with a total SAT score of at least 910. Students who do not meet these minimal requirements are enrolled in General Studies (Engineering). While these students are not admitted to the College of Engineering and Mineral Resources, they are permitted to take the engineering orientation course. These General Studies (Engineering) students are then accepted into the Engineering track when they have passed all the prerequisite classes to enter into MATH 155.

3.2 Engineering Orientation

A mandatory, one-credit hour engineering orientation course, ENGR 199, was created which meets the WVU requirement for an orientation course. All incoming engineering students take the engineering orientation course instead of the general university orientation course. In this course, students are taught college and career “success skills” such as study skills, prioritization, and time management; are given early exposure to the value of an engineering degree; are introduced to all the engineering discipline majors; are taught how to write a resume; participate in a career fair; are exposed to internship opportunities; and are required to give periodic progress reports on their grades in all their other courses. To facilitate some of these goals, weekly assignments are given which are intended to provoke consideration of their future career options. Also, attendance in class and mandatory study labs is a high priority and is worth one-third of their grade.

This engineering orientation course is also designed to help ease the transition from high school to college through various interactions between the instructor, students, and parents. The instructor of the orientation course takes an active role in supporting student achievement, and meets with each student reporting poor grades to help the student refocus his or her priorities on academic success and create a recovery plan to improve his or her grades. In addition, weekly emails, which are both informational and inspirational, are sent to the parents describing what is going on in their student’s life. These communications include when tests and midterms are administered; activities that are being held in on campus; dates of football and basketball games; and stories of past student success in overcoming adversity.

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3.3 Study Labs

Students enrolled in the first two engineering courses as well as the engineering orientation course are required to attend course specific engineering study labs for at least two hours each week. During the evenings Sunday through Thursday, two hour study labs are offered for algebra, trigonometry, pre-calculus, and calculus; chemistry; physics; and programming. Attendance in at least one of these study labs is mandatory. To ensure attendance, a percentage of the students’ grade is dependant upon continued participation in these labs. Attendance is tracked through one office, and then distributed to each section of the various engineering courses.

Each study lab has at least two tutors who work with students to help them understand and do their homework. The tutors occasionally hold review sessions to help students understand key concepts in each subject and to prepare students for tests. In general, tutors circulate throughout room to make sure that everyone gets the help he or she needs.

To guarantee the quality and usefulness of study labs, upperclassmen and graduate engineering students are hired as tutors based on the grades they earned in the subject they wish to tutor. At the end of every semester, student feedback is used to determine which tutors should be rehired. Only tutors with high grades and positive student feedback are allowed to continue in this program.

3.4 Out of Class Experience

All students enrolled in any of the freshman engineering courses are required to attend various extracurricular, engineering events. This requirement is designed to increase awareness and excitement of what the students will do as engineers after they graduate. As with study labs, these out of class experiences are incorporated as part of the students’ grades. To fulfill this requirement, students are encouraged to visit engineering facilities; to participate in tours of research facilities at WVU; to attend lectures given by engineering professionals; or to become actively involved in student chapters of professional engineering organizations. These student activities are self-reported to the freshman engineering office, where their participation is tracked and reported to their engineering course instructors at midterm and at the end of the semester.

3.5 Engineering Courses

To better prepare students to enter into their specific engineering discipline, the first two engineering courses at WVU have been redesigned to focus on problem solving, team work, real world math applications, and the development of professional skills. Changes to these classes include increasing the focus on computers and programming as problem-solving tools; increasing the emphasis on both written and verbal communication skills; improving coordination of the various sections of the engineering classes to ensure a more common first year experience; and recruiting faculty from engineering departments who are enthused and excited about teaching freshman engineering students.
3.6 Engineering Mathematics

Based on data collected from previous years, the College has focused its efforts on working with the university’s Department of Mathematics to improve engineering students’ math success rate. The math department has created 5-day engineering sections of MATH 155 which meets for lecture three days per week and for recitation two days per week. The lectures are taught by senior mathematics professors, and the recitations are staffed by one math graduate teaching assistant and two engineering undergraduate assistants. The recitation sections are designed to provide additional problem-solving experience for the students. Enrollment in these classes is limited to engineering students.

A mid-semester math course has also been created for those students with a D or F at midterm who choose to withdraw from MATH 155. This one credit hour course focuses on the review of pre-calculus and early calculus skills to help prepare students to be successful in MATH 155 in their next attempt.

3.7 Minimum Grade Requirements

A set of minimum grade requirements have been set up to make certain that students are prepared to take and pass advanced courses required of an engineering degree. These requirements help to ensure that students have sufficiently learned the prerequisite content to enable them to be successful in the course. These requirements include: a grade of C or better in Calculus 1 before taking Calculus 2, General Physics, and the second freshman engineering course. Freshman engineering advisors also enforce new minimum grade requirements that have been set in the engineering discipline majors. These requirements include a grade of C or better in both Calculus 1 and General Physics before taking Statics; and a grade of C or better in Calculus 2 before taking Dynamics.

4.0 Results

Two indicators are used to assess the success of the changes made to the freshman engineering program (all measures were computed using data from freshmen engineering students in the Engineering and General Engineering tracks):

- Freshman retention, defined as the percentage of freshmen who transferred to a discipline major or to sophomore status at the end of the second semester.
- Average GPA of freshman engineering students in three specific foundational classes: Calculus 1, Fundamentals of Chemistry, and General Physics.

4.1 Retention

Freshman retention has been defined as the “percentage of freshman transferred to a discipline major or to sophomore status.” Figure 1 plots retention by academic year for the last six years. The retention rate for the three years before the multi-dimensional approach was taken (academic years 2000/01 through 2002/03) averaged 65.7%, and averaged 67.0% for the three years after
this approach was implemented (2003/04 through 2005/06). The difference in the averages indicates a 1.3% increase in the overall retention rate.

![Figure 1. Retention rate of freshman to a discipline major or the sophomore year.](image)

During the three-year period in which the Engineering and General Engineering tracks have been implemented, the retention rate for Engineering students averaged 73% compared to the average retention rate of 60% for General Engineering students.

### 4.2 Academic Performance

Freshman engineering and general engineering student performance over the last six academic years has been evaluated by grade achievement, measured by course GPA, and percentage of C or better grades in the three foundational math and science courses: Calculus 1 (MATH 155); Fundamentals of Chemistry (CHEM 115); and General Physics (PHYS 111). These data show some improvement over the last five years, with more substantial improvement in PHYS 111. The data are illustrated in Figures 4 through 6.

#### 4.2.1 MATH 155

Performance in MATH 155 by academic year is presented in Figure 4. The MATH 155 GPA of all freshman engineering and general engineering students in the three years before this new multi-dimensional approach was taken (academic years 2000/01 through 2002/03) averaged 1.63, and averaged 1.93 for the three years after this approach was implemented (2003/04 through 2005/06). The difference in the averages indicates a 0.3 point increase in the MATH 155 GPA.
Figure 2. Stacked Bar Graph of MATH 155 Grades Including AY-GPA and % of Grades C or Better

The percent of C or better grades in MATH 155 in the three years before the multi-dimensional approach was taken (academic years 2000/01 through 2002/03) averaged 44.4%, and averaged 56.1% for the three years after this approach was implemented (2003/04 through 2005/06). The difference in the averages indicates an 11.7% increase in the percent of C or better grades in MATH 155.

4.2.2 CHEM 115

Performance in CHEM 115 by academic year is presented in Figure 5. The GPA performance of all freshman engineering and general engineering students in the three years before this new multi-dimensional approach was taken (academic years 2000/01 through 2002/03) averaged 1.82, and averaged 2.0 for the three years after this approach was implemented (2003/04 through 2005/06). The difference in the means indicates a 0.18 point increase in the CHEM 115 GPA.
Figure 3. Stacked Bar Graph of CHEM 115 Grades Including AY-GPA and % of Grades C or Better

The percent of C or better grades in CHEM 115 in the three years before the multi-dimensional approach was taken (academic years 2000/01 through 2002/03) averaged 55.2%, and averaged 60% for the three years after this approach was implemented (2003/04 through 2005/06). The difference in the means indicates a 4.8% increase in the percent of C or better grades in CHEM 115.

4.2.3 PHYS 111

Performance in PHYS 111 by academic year is presented in Figure 6. The GPA performance of all freshman engineering and general engineering students in the three years before this new multi-dimensional approach was taken (academic years 2000/01 through 2002/03) averaged 2.02, and averaged of 2.70 for the three years after this approach was implemented (2003/04 through 2005/06). The difference in the means indicates a 0.68 point increase in the PHYS 111 GPA.
The percent of C or better grades in PHYS 111 in the three years before the multi-dimensional approach was taken (academic years 2000/01 through 2002/03) averaged 55.8%, and averaged 71.8% for the three years after this approach was implemented (2003/04 through 2005/06). The difference in the means indicates a 16% increase in the percent of C or better grades in PHYS 111.

4.2.4 Results

In general, these data suggest that the initiatives implemented by the College to improve retention have had a positive impact on the freshman academic performance in key freshman courses.

5.0 Conclusions

The retention and student achievement data suggest that the implementation of the elements of an evolving retention plan has resulted in the maintenance and possible improvement of a relatively high freshman retention rate and the improvement in the academic performance of first year students in key foundational courses. The key ingredients contributing to this success appear to be the implementation of two engineering tracks to facilitate an appropriate and achievable program of study for each student based on the student’s mathematics preparation; development of a one-credit hour engineering-specific freshman orientation course with mandatory weekly study labs; enforcement of pre-requisite grade standards for key courses; and well-managed freshman engineering courses focused on problem-solving.
The data cannot be dissected to indicate which programmatic change had the greatest or any effect on student retention or academic success in the first year of engineering education. While there may be confounding factors influencing the trends observed in the data, the combination of all efforts made to increase freshman success in engineering and to improve retention appears to have been effective.

6.0 Recommendations for Further Study

Since the improvement in retention and student success is a continual process, data collection and analysis must also continue to determine which modifications are beneficial and which are not. As new ideas to improve student retention and academic success are tried, continued analysis of retention and student success data will assist the College in determining which changes lead to significant and sustained improvement. Additional data related to student academic performance can be collected and analyzed to make recommendations to influence recruiting and advising of students. Increased understanding of student achievement patterns will assist the College in establishing appropriate acceptance and enrollment criteria and in determining more accurate course placement criteria. These future recommendations will have significant impacts, not only on programming and course development, but on student recruiting and academic advising as well.

In addition, through the process of implementing the various elements of the College’s evolving retention plan, a continuing dialogue was initiated with the University’s Mathematics Department to explore ways of improving the performance of engineering freshman in Calculus 1. That dialogue is continuing and has expanded to include ways to help students succeed in other required math courses. Similar discussions are being initiated with the Chemistry and Physics Departments as well. Intra-university cooperation will benefit all entities involved by gradually improving all students’ opportunities for academic success. Continual assessment of each initiative must drive these efforts.

Bibliography

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