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Reform the Intro to Engineering course For Retaining Minority Engineering Freshmen

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Reforming the Introduction to Engineering Course to Retain Minority Engineering Freshmen

Abstract

It is always a challenge to retain engineering students, especially in Historically Black Colleges and Universities (HBCUs) like ours, Virginia State University (VSU). There are several fundamental issues, and we provide some solutions to these fundamental issues by reforming the Introduction to Engineering course.

The first fundamental issue is the open admission to the general population of students with different mathematical skills. The curriculum of the engineering programs is much more rigorous than the other majors at VSU. Specifically, all of the engineering programs at VSU are accredited by the Accreditation Board of Engineering and Technology (ABET). To maintain the accreditation, the engineering programs are required to follow a very vigorous curriculum. Therefore, the students with weak mathematical background have difficulty to satisfy the requirements and change their major if they did not improve their mathematical skills dramatically during the first year.

The second fundamental issue is that freshmen usually have vague or unrealistic prospects about engineering. For example, some students chose the Computer Engineering due to their interest in playing video games or to digital music. Therefore, when encountering the stringent challenges of required courses such as Calculus, Physics, and Chemistry, these students often get discouraged and decide to change their major. The students need to understand that a science, technology, engineering and mathematics (STEM) degree is worth the effort, that they have the ability to complete the degree, and that the degree is very useful for future professional career.

Like many other engineering programs in the U.S., we require incoming freshmen to declare their intended major. All the engineering students are required to take two semesters of Introduction to Engineering (ENGR 101 and ENGR 102). This paper discusses some of the methods we used in first semester of Introduction to Engineering to increase the retention rate, and provides the statistical results for the past two years.

Introduction

The demand for more diversified and qualified graduates in science, technology, engineering and mathematics (STEM) has increased dramatically in recent years, as many baby boomers approach the retirement age [1]. In response to the demand, the number of freshman engineering students has grown considerably over the last decade and this trend is expected to continue for the near future [2].

The Engineering Department at the Virginia State University (VSU), a small Historically Black Colleges and Universities (HBCU), was established in 2001. Similar to the national enrollment trend, the enrollment doubled during the past five years. In addition to mathematics, science, and humanity courses, all engineering freshmen are required to take Introduction to Engineering I (ENGR 101) and Introduction to Engineering II (ENGR 102).

We designed Introduction to Engineering I to address the two fundamental issues: enhance mathematical skills [3][4]during the first half of the semester, and then to provide realistic prospects about engineering by explore engineering concepts[5][6] in the second half of the semester.

Problems with the old Instruction to Engineering I (ENGR 101)

In the past, the Engineering Department offered 3 to 4 sections of ENGR 101 at various scheduled times in the fall semester. Freshmen registered into the section that they chose (primarily based on choosing a time that was convenient for them). Due to the open admission policy, the range of the mathematical background of the engineering freshmen is very wide. Inevitably there were students in the same section that had at least three widely different mathematical background levels. For example, one student reached College Algebra I, a second student reached Calculus I, and a third student reached Calculus II. This wide range of mathematical background made it impossible to simultaneously improve mathematical skills for all students.

Many students lost interest during this course either because it was too easy and they got bored, or it was too hard and they could not catch up. As a result, the department lost many students after the first semester because some students with advanced mathematical skills transferred to other universities, and some the students with low mathematical skills changed their majors.

Reforming Introduction to Engineering I (ENGR 101)

Stating in Fall 2011, we have addressed the aforementioned problems by creating customized sections of the Introduction to Engineering I course, with some sections being more advanced than others. To overcome the difficulty placing each student in an appropriate section after classes have already begun, we schedule all the sections of Introduction to Engineering course at the same, have the students to take the assessment test (pre-test) at the first week of the class, transfer the students during the second week to a section corresponding to their mathematical skill level (according to the assessment test), and document this transfer directly to the Registrar's office. The main reason for informing registrar is for grading and Blackboard communication.

The assessment test was designed by experienced engineering professors, is graded including partial credit. Full credit requires showing the steps. The assessment test consists of 10 basic algebra and Trigonometry problems with 50 points in total.

Here is one question that is usually failed by low level students, and usually passed by intermediate level students: Given $\sin x = \frac{3}{4}$, find $\tan x$.

Here is one question that is usually failed by intermediate level students, and usually passed by high level students: 250 m/s = _____mi /h. At first glance, this conversion looks easy, however, it involves simultaneous conversions both in length and in time, so it not automatically available in any calculator.

Notice that many important substantive decisions are made by engineering professors: scheduling a single time period for all of the sections, assessing students' mathematical skills, and assigning students to an appropriate section based upon the test results.

Small things are surprisingly important. For example, all of these sections start at 10:00 AM on Monday, Wednesday, and Friday because we have observed that this schedule historically has a high attendance rate. Another reason for having all the sections at the same time is the convenience to invite speakers or having workshops.

Even though all the sections have the same course outcomes, the emphasis of each section is different. The sections with high assessment test scores spend less time in mathematics review, and more time on engineering topics (such as Computer Aided Design, and using a 3D printer to "print" the 3D models). In this way, these advanced students are more challenged and more interested in the course.

On the other hand, the sections with low assessment test scores spend more time reviewing essential fundamental mathematical skills. These less advanced students are not "left behind" during class lectures, and this mathematical review strengthens their mathematics to help them in future science and engineering courses.

Additionally, several times during the semester the students in all sections have a large common class together (in an auditorium) for special topics such as invited speakers, career development, and resume writing. At the end of the semester, all of the students take the math skill assessment exam again.

Results

To assess the reformed Intro to Engineering I, we had the students take the same assessment test at the end of the semester. The combined results (all sections) of the assessment exams for the last two years (Fall 2011 and Fall 2012) are depicted in figures 1-4.

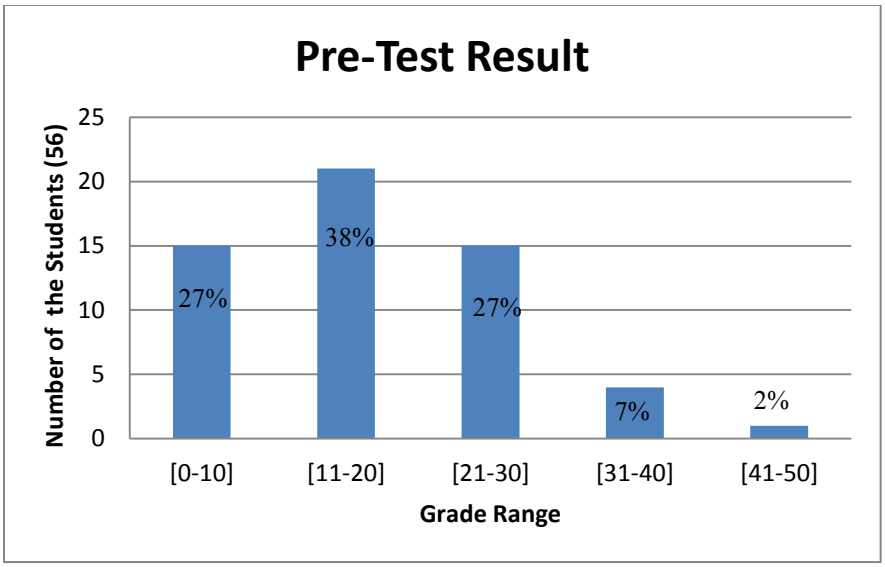

Figure 1: Assessment Test Results at the Beginning of Fall 2011 Semester

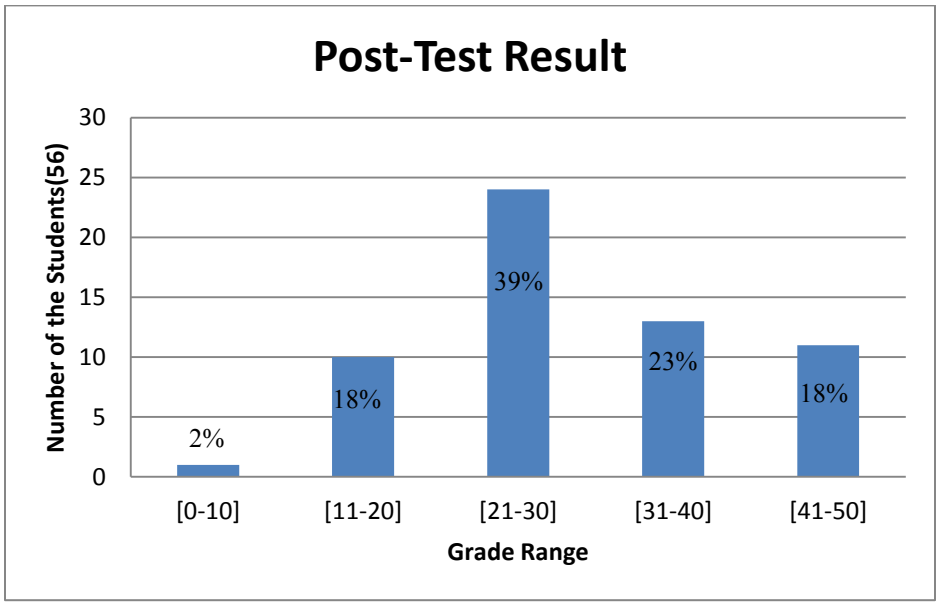

Figure 2: Assessment Test Results at the End of Fall 2011 Semester

According to Figures 1 and 2, in Fall 2011, 65% of the students obtained a score in the range of 20 or below in the pre-test while in the post-test, just 20% of the students' scores fell in that range. On the other hand, out of 27% of the students who earned a score between 0-10 in pre-test, just 2% of them earned a grade in that range again in post-test. Instead, students with score of 41-50 have increased from 2% to 18%.

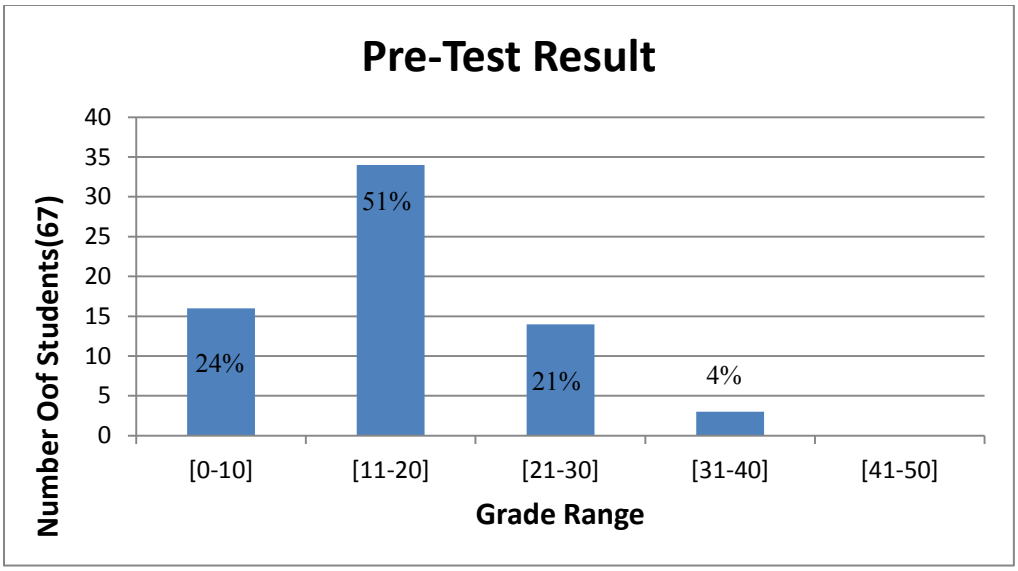

Figure 3: Assessment Test Results at the Beginning of Fall 2012 Semester

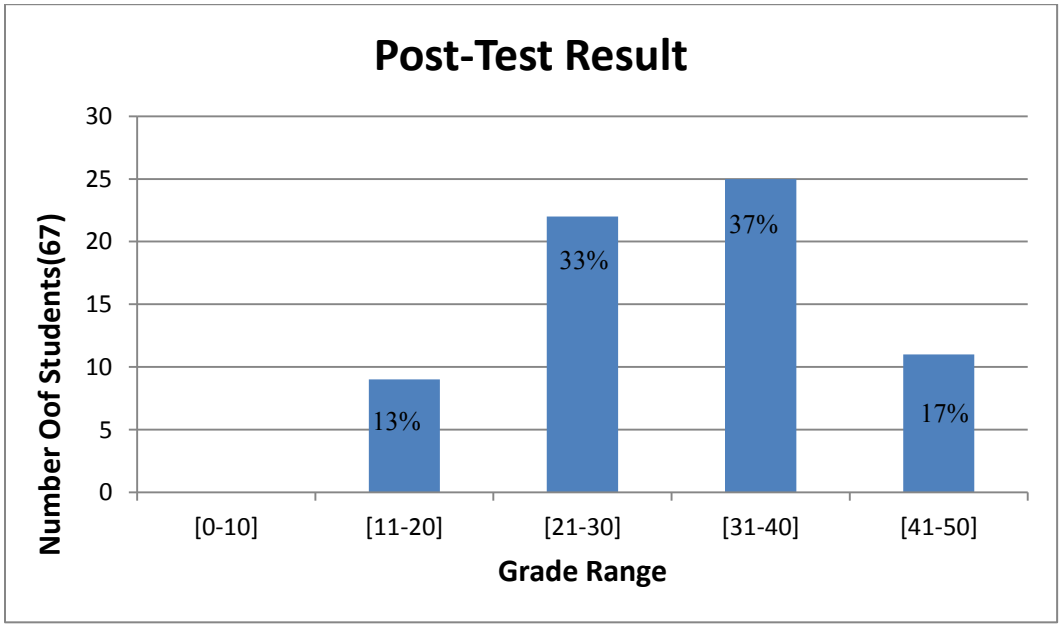

Figure 4: Assessment Test Results at the End of Fall 2012 Semester

Very similar improvement can be seen in the result of Fall 2012. According to Figures 3 and 4, in Fall 2011, 75% of the students obtained a score in the range of 20 or below in the pre-test while in the post-test, just 13% of the students' scores fall in that range. On the other hand, none of the students' grade was in the range of 0-10 in the post-test although 24% of the students earned a score between 0-10 in pre-test. In addition, students with score of 41-50 have increased from 0% to 17%.

As the results show, the mathematical skills significantly improve during each semester. The overall average (for all sections) increased by 63.7% in 2011, and by 98.3% in 2012.

Table 1 summarizes the average scores for each section in Fall 2011 and Fall 2012. The students with the highest scores in the initial assessment exam (pre-test exam) were transferred into section one, second highest in section two, and so forth. The students with that scored lowest in the initial assessment (and were placed into the highest section numbers) improved their scores by the highest percentage (by more than 100%).

Table 1 Pre- and Post-Assessment Exam Average scores for each section in 2011 and 2012

	Fall 2011			Fall 2012		
	Pre-Test Average (50 pts.)	Post-Test Average (50 pts.)	Increase in percentage	Pre-Test Average (50 pts.)	Post-Test Average (50 pts.)	Increase in percentage
Section 1	27.5	37.5	36.3%	25.0	39.1	56.5%
Section 2	15.5	28.1	81.4%	17.1	32.8	91.6%
Section 3	8.86	22.0	148%	12.9	28.9	124%
Section 4				7.73	23.2	198%

Conclusions

The reformed Introduction to Engineering course provides an opportunity for students with different math skills to thrive by transferring students to sections corresponding with their initial tested math skill levels. Specifically, we have increased retention by scheduling multiple sections of the Introduction to Engineering course at the same time, assessment testing the students during the first week of class, transferring the students during the second week to a section corresponding to their tested math skill level, and documenting this transfer directly to the Registrar's office.

Of course, students having solid mathematical skills are not guaranteed success in engineering classes. The students also need to be motivated to study, and need to have connections with the real world. Therefore, applying for summer internships and career development is also heavy emphasized in the course.

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