Retests: A Rescue Plan for the Sophomore Slump

Richard Kunz[1], Monika Bubacz[2], Jack Mahaney[3]

Abstract – Experience at Mercer University indicates that a substantial percentage of sophomore engineering students, when faced with their first real discipline-specific engineering courses (typically Statics and Electrical Fundamentals), fall behind early in the courses and never catch up. This can lead to poor grades, discouragement with the program, and ultimately transfer out of engineering. To address this issue, a pilot program of offering optional retests for the first major examination in these courses has been initiated, giving students who choose to take advantage of it a second chance not only to learn the material, but to re-tool their study habits. Preliminary data indicate a significant fraction of those who were headed for a D or F end up with a C or better in the course. More importantly, it is expected that the lessons learned by the students will result in increased success in upper-level courses.

Keywords: Retention; statics; retesting

INTRODUCTION

Entering freshman engineering students typically take calculus and science courses similar to (but more advanced than) courses they have taken in high school, along with introductory engineering courses designed to provide brief exposure to the various engineering disciplines as well as basic principles of design, working in teams, communication, and programming. Then, in the first semester of the sophomore year, they are confronted with the first real discipline-specific engineering core courses: typically Statics and Electrical Fundamentals. They have successfully completed the prerequisites and have a year of college under their belts; yet experience at Mercer University indicates that up to one-third will earn a grade of D or F on the first test in these two courses.

There are many possible reasons for this result, but the most obvious one may be the most overlooked: students tend to underestimate the amount of independent work outside of class necessary to succeed in these courses and in the upper-level engineering courses they will subsequently encounter. Systematic solution of problems involving multiple steps takes practice and a discipline that can best be achieved by working such problems on one's own. Students often learn this the hard way after scoring poorly on the first major test, and then are faced with the monumental task of both re-tooling their study habits and making up for a substandard grade. Some buckle down and recover; many others give up. As a result, these courses gain a reputation among the students as "weed-out courses," even though that was never the intent.

At Mercer, a pilot program of "retesting" for the first exam in Statics is in its second year. Students are eligible for a second chance on this exam, but only after completing and turning in a fairly substantial list of problems over and above the regularly assigned work: this is their "admission ticket" to the retest. Their recorded grade for the exam is a weighted average of their original score and their score on the retest. The intent is to provide the students with an

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opportunity to recover from a bad first grade, while demonstrating to them the benefits of hard work outside of class. This paper discusses the implementation and results to date of the Statics retesting program.

BACKGROUND AND MOTIVATION

Retention of engineering students has generated increased attention in recent years. In a study at Iowa State University, of 1,151 entering engineering students, 32% had graduated in engineering after 5 years, with 13% still enrolled in engineering [1]. Astin [2], using data from 300 institutions, found that of 25,000 first-year engineering students 43% graduated in engineering. Retention data at Mercer University School of Engineering indicate a substantial reduction in student population from entering freshmen to rising juniors: of the 2007 class of freshmen entering the School of Engineering 57% remained in engineering in the fall of 2009.

The early engineering curriculum at Mercer is fairly standard: freshmen typically take Calculus I and II, Chemistry, Physics and General Education courses outside the School of Engineering. Within engineering, they take three courses: Professional Practices (EGR 108), Introduction to Engineering Design (EGR 107), and Programming for Engineers (EGR 126). First semester sophomores take their first two discipline-specific engineering courses: Statics/Solid Mechanics (EGR 232), and Electrical Fundamentals I (EGR 244). In their second sophomore term they take Thermodynamics (EGR 235), Dynamics (EGR 236), Electrical Fundamentals II (EGR 245), and Probability and Statistics (EGR 252). This engineering core curriculum is summarized in Table 1.

Table 1. Mercer University Freshman and Sophomore Engineering Core Courses

Freshman	First Semester Sophomore	Second Semester Sophomore
EGR 107 Intro. to Engineering Design	EGR 232 Statics/Solid Mechanics	EGR 235 Thermodynamics
EGR 108 Professional Practices	EGR 244 Electrical Fundamentals I	EGR 236 Dynamics
EGR 126 Programming for Engineers		EGR 245 Electrical Fundamentals II
		EGR 252 Probability and Statistics

Summary grade distributions for the engineering core courses from the 2008-2009 academic year are shown in Figure 1. Possible grades are A, B+, B, C+, C, D, F, and W (for Withdrawn from the course). The distributions show a substantially higher percent of D, F, and W grades in the first term sophomore courses Statics/Solid Mechanics and Electrical Fundamentals. These two courses serve as pre-requisites and form the foundation upon which many of the upper-level engineering courses build. Students who do poorly in these two courses certainly have diminished chances for success later in the curriculum.

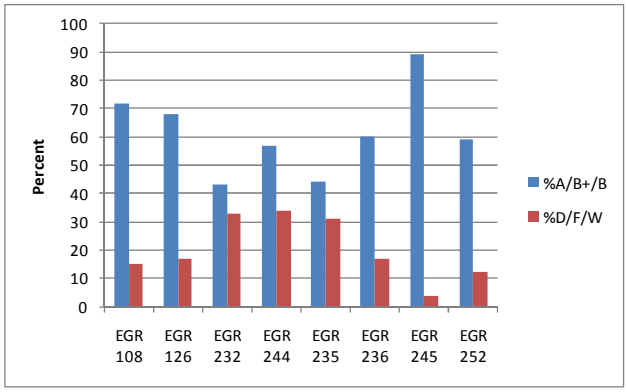

Figure 1. Grade distributions in Mercer Engineering Core Courses

There are many possible reasons for poor performance in these two courses: inadequate preparation at the high school level; lack of interest in engineering ("this isn't like what I thought it was going to be"); inadequate study habits; inability or unwillingness to put in the time and effort necessary to succeed. This list is by no means exhaustive, and every student, whether successful or not, has his or her own set of unique circumstances. Nevertheless, the fundamental engineering courses confront many students with a set of circumstances that are new to them and that they may be initially unprepared for:

- Concepts and techniques learned early in the course must be thoroughly mastered and applied throughout the course.
- Students must from day one have a firm grasp on concepts and techniques learned in prior courses as they are applied to the current course.
- Solution of problems, particularly as the course progresses, requires multiple steps involving the fusion of concepts and techniques learned both in the current course and in prior courses.
- Mastery of the subject requires a substantial amount of individual work outside of class involving independent problem solving. We often tell students that no one ever learned to play basketball or the piano by watching someone else; the same is true for engineering. Not all students initially believe this.

As a result of these factors, students often come into the first major test in these courses with a false sense of confidence, based perhaps on their success in earlier courses, and are ambushed due to a lack of adequate, focused preparation. They perform poorly on the first test and are faced with a daunting trifecta of making up for a poor grade, relearning the material covered on the first test, and keeping up with the rest of the class in the new material being covered. Some become discouraged and give up. A plan of retesting as described below is targeted at these students. It is intended to provide them with an opportunity to recover from a poor first-test result and to reinforce the need for independent study outside of class.

The concept of offering retests is not new, but the details of the implementation and the effectiveness vary. Juhler [3] used optional retesting in an intermediate algebra course and found that it resulted in improved performance for 90% of students who had earned a grade of C, D, or F on the initial test, while the course withdrawal rate decreased from 30% to 22%. Davidson [4] developed a retest policy for an introductory psychology course in part to address the problem of students underestimating the difficulty level of exams and then having no opportunity to recover; approximately 50% improved their grades. In a study by Deatsman [5], students were offered a retest on any test on which they had scored below 80%; grades were recorded as the higher of the two. The author reports that, while some students used the retests as intended and benefited, exam scores indicated that many abused the system by not preparing adequately for the first test and instead relying on retesting to raise their grades to an acceptable level. Also, some students appeared to take retests without significant additional preparation, apparently hoping that luck alone would increase their scores. Cates [6] instituted a program of one retest opportunity on each of several tests given during the term. Of 202 retests, 69% resulted in improved scores by an average of 3.5 percentage points, resulting in 47 of 100 students raising their course grade. However, the author noted significantly increased instructor workload and loss of class time as disadvantages of the approach.

A retest program is being piloted at Mercer in both first-term sophomore engineering core courses: EGR 232 Statics/Solid Mechanics and EGR 244 Electrical Fundamentals I. Details and results of this program to date are presented herein for the Statics course.

COURSE STRUCTURE AND RETEST IMPLEMENTATION

EGR 232 Statics/Solid Mechanics is a three-hour course meeting three hours per week over the fifteen week semester in traditional lecture format. The course is typically offered both fall and spring semesters, with 3 sections taught by different instructors in the fall and one section in the spring. Each instructor runs his or her section independently of the others, with no common assignments or tests. Grades are determined based on three hour exams, a three-hour final exam, and homework and/or 10-15 minute quizzes at the discretion of the instructor.

Instructor participation in the retest pilot study is voluntary. To date, three different Statics instructors have participated during academic years 2009-2010 and the current 2010-2011. Student performance data both with and without the retest option have been gathered for all three instructors. Data is presented for each of the three instructors (denoted as Instructors A, B, and C) and for the three instructors combined.

Figure 2 shows summary final grade distributions for each of the three instructors over several semesters prior to the pilot study. Grades are grouped into two categories: percent of students earning a final grade of either A, B+, or B, signifying students who have successfully completed the course; and those earning D, F, or W. While students with a final grade of D have passed the class, their prospects for success in upper-level classes depending on mastery of the material covered in the Statics class are significantly reduced. Furthermore, students in Mechanical Engineering are required to achieve a C or better in Statics to progress in the program. It is the goal of the retest program to reduce the number of students in the D/F/W category.

Figure 3 shows similar distributions for the grades earned on the first test of the semester. It is noted that the distributions are similar to the final grade distributions of Figure 2. Perhaps more significant, however, is Figure 4, which depicts the extent to which a student's grade on Test 1 is a predictor of his or her final grade in the course. The chart shows that, of those who earned A, B+, or B (D, F, or W) on Test 1, the percentage who finished the course with a final grade of A, B+, or B (D, F, or W). (In this context, W on Test 1 signifies a student who was registered for the course but did not take the test.) Overall, the performance on Test 1 predicts the final grade in the class for approximately ¾ of the students. This is probably not a coincidence. Those students that work hard from the beginning, apply a consistent work ethic, and keep current with the material have little trouble with Statics. On the other hand, many students who get behind from the beginning are unwilling or unable to overcome the early deficit. Some who may now realize that they need to work harder to succeed are too discouraged by the early failure to modify their study habits and simply give up.

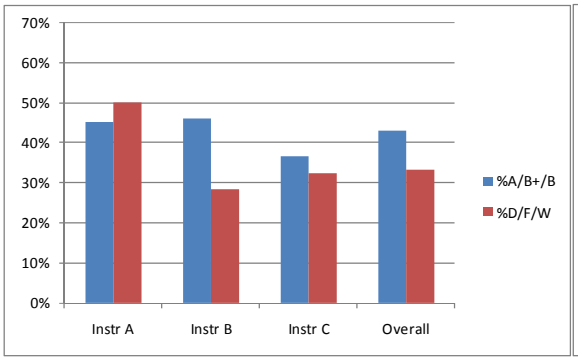

Figure 2. Statics final grade distributions prior to retest implementation

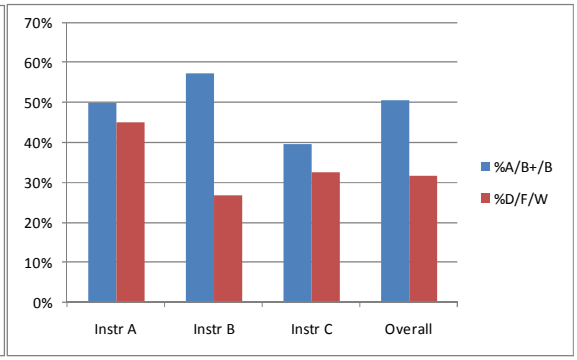

Figure 3. Statics Test 1 grade distributions prior to retest implementation

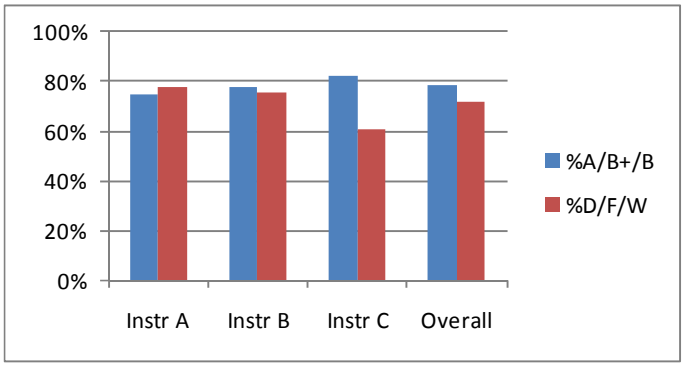

Figure 4. Test 1 as a predictor for final course grade

A retest of the first test is offered to all students in the class in an effort to reach this particular group. This is not merely a second chance to repeat the pattern that led to failure the first time, but rather an opportunity and

encouragement to modify their study habits and climb out of the early hole. The ground rules for the retest are as follows:

- The retest covers the same material as the original test, but the problems and questions are different.
- The score on the retest does not replace the score on the original; rather the final score is a weighted average of the two. We have typically used a weighting of 60% for the retest and 40% for the original.
- A student who sits for the retest must accept his or her score on the retest; opting out after seeing the exam is not allowed.
- To gain admission to the retest, the students must independently complete an assignment consisting of 15-20 problems spanning the material covered on the test. The worked-out solutions to these problems constitute an "admission ticket" to the retest. These problems may or may not be graded and returned to the students at the discretion of the individual instructor. Admission ticket problems are taken from the textbook, similar to the regular assigned homework for the course; some have answers in the back, others do not. Students are encouraged to discuss any problems they don't understand with the instructor prior to the retest.
- The retest is administered 10 days to 2 weeks following the original test. This is intended to allow the students time to complete the admission ticket and shore up their weak areas while recognizing that they need to be simultaneously keeping up with the normal work in the class.

The intent of the retest is both to give the students who performed poorly on the original test a second chance, and to demonstrate to them that putting in the requisite time and effort will have positive results. It is hoped that such students will "see the light" and carry this newfound appreciation for the hard work required through this course and on to success in their upper-level engineering courses.

RESULTS

Although the retest option is made available to all students in the course, the primary targets of the retest effort are those students who did poorly on the original first test, with a goal of reducing the number of final grades of D/F/W. The analysis which follows therefore focuses on those students who earned a D/F/W on the first test. To date, the retest option has been offered in three Statics sections taught by Instructor A, two by Instructor B, and one by Instructor C. Figure 5 shows, of all students earning D/F/W on the first test, the percentage of students who chose to take the retest. Participation ranged from 50 – 80% by instructor, with an overall participation of 60%. It is perhaps surprising that these number are as low as they are. Clearly, the retest program will only help students who are willing to put in additional work to achieve a better result.

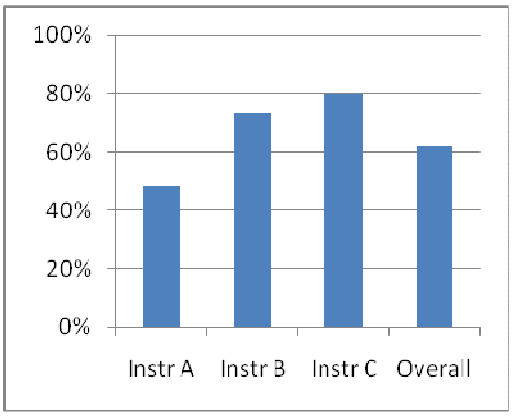

Figure 5. Percent of students earning D/F/W on Test 1 choosing to take the retest

Of those taking the retest, their change in grade from the original to the retest is shown in Figure 6. Tests were graded on a 100 point scale. A few students did worse on the retest than on the original, but the majority scored over 10 points higher on the retest, with 47% improving on their original score by over 20 points.

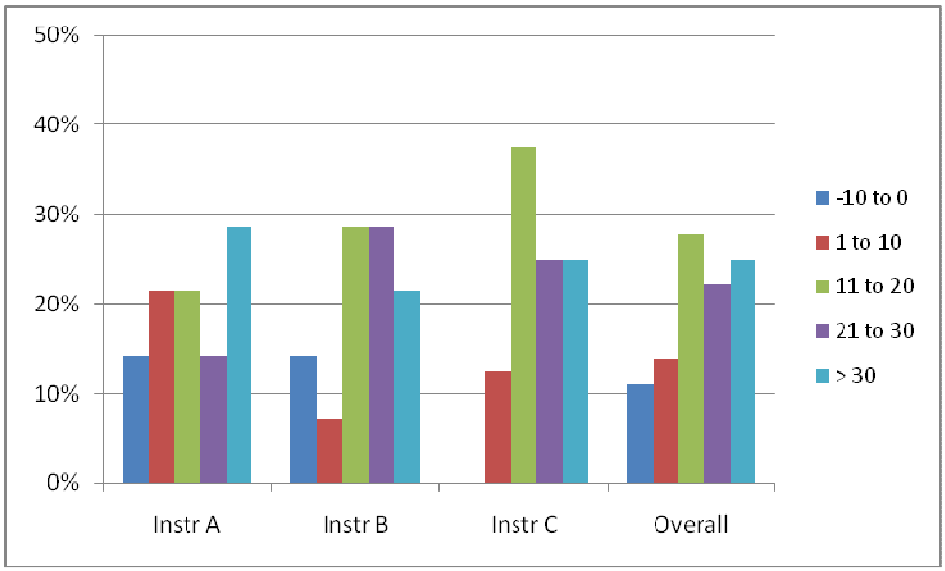

Figure 6. Change in score between original Test 1 and retest.

Figure 7 shows, of all students who earned D/F/W on the original Test 1, the percentage who finished the course with a D/F/W grade, broken into those who took the retest and those who did not. The latter group includes both those who chose not to retest, and those prior to Fall 2009 for which no retest was offered. While the differences are perhaps not as dramatic as one would hope, the figure suggests that the opportunity to improve the first test grade provided a longer-term benefit to a substantial number of student participants.

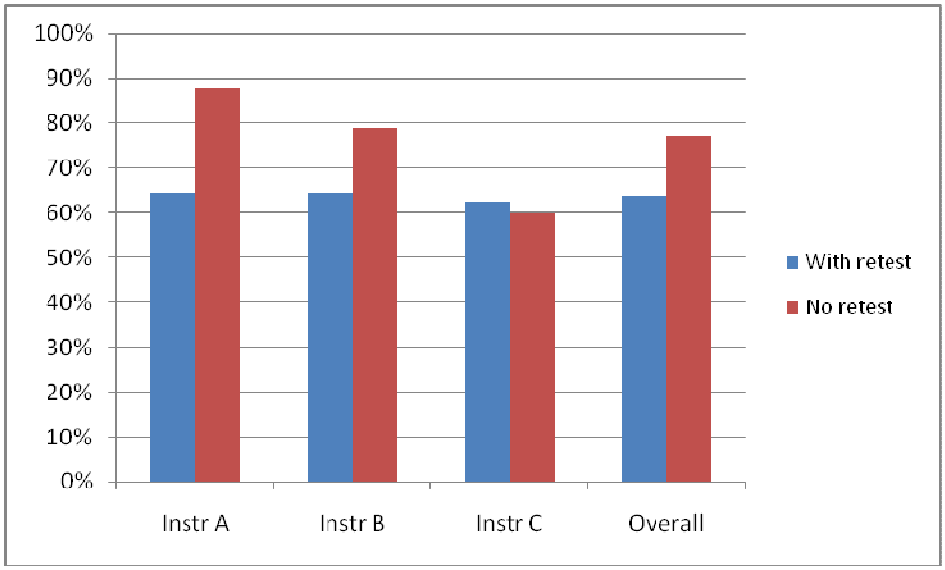

Figure 7. Of students getting D/F/W on original test 1, percent with final grade of D/F/W with and without retest.

CONCLUSIONS

Based on the above results and the experiences of the faculty participating in the study, the following conclusions may be drawn:

- Performance on the first test in Statics is a fairly reliable predictor of final course grade (Figure 4). The first test covers fundamental material that is crucial to understanding the remainder of the course. Failure to grasp this material early on leaves the student at a distinct disadvantage throughout the course.

- A large majority of students taking the retest after having done poorly on the first test were able to improve their score (Figure 6). It is the expectation that, by requiring the admission ticket involving a substantial amount of work to prepare for the retest, students gain an appreciation for the amount of effort that is required to succeed. It is hoped that this appreciation will pay off not only in Statics, but in subsequent engineering courses as well.

- Of all students who did poorly on the first test, those taking the retest were more likely to improve their final grade in the course than those who did not (Figure 7).

- The cost of administering the retest in terms of instructor time investment is not onerous. The investment involves making up, proctoring, and grading one additional test for approximately one-third of the class. The decision to offer a retest on only the first test was based primarily on the importance of the fundamental material covered, but instructor time required is a factor that cannot be ignored.

- The requirement of the admission ticket is a significant component of the program. Students are not allowed to take the retest without doing a substantial amount of additional preparation. It is hoped that students will grasp the correlation between their increased effort and the improved performance on the retest. There are still some unresolved issues with respect to how individual instructors treat the admission ticket: Should quality of the solutions on the additional problems be a condition for admission to the retest? Should solutions to admission ticket problems be provided to the students ahead of the retest? To date, different instructors have handled this differently.

It would be naïve to expect that the retest program as described above, implemented in one or two sophomore engineering courses, will solve the problem of low retention in engineering. Its intent is to provide a mechanism for rescuing those who find themselves ambushed by the amount of time and effort required to succeed. If the first test is a wake-up call, the retest provides an opportunity to wake up before the train leaves the station. While perhaps not all students are willing to invest the effort required, there will be some who, although they may have stubbed their toes early, are willing to do what it takes to succeed once that path is made available to them. It is these students who are most likely to benefit from the retest program.

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