# AC 2012-3096: EVALUATION OF THE EFFECTIVENESS OF ADDITIONAL CLASS CONTACT TIME ON STUDENT PERFORMANCE IN STATICS

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# Evaluation of the Effectiveness of Additional Class Contact Time on Student Performance in Statics


## ABSTRACT

The effect of additional class contact time on at-risk student performance in statics is investigated. Comparisons are made between the final exam and final course grades of at-risk students placed in two versions of the same statics course. A standard version of the course meets three hours per week over the course of a fifteen-week semester while a second version meets four hours per week. During the eleven year timeframe covered by this study the four-hour course has been populated by students identified as at-risk using an informal screening procedure. For comparison purposes, using the same enrollment data, a second group of at-risk students were identified from within the standard three-hour course using a more formal logistic regression based screening procedure. A performance comparison between the two groups shows that the extra contact hour had a minor, statistically insignificant effect on final exam and final course grades.


## I. Introduction

The retention and recruitment of engineering majors, particularly those from under represented groups, is an area of considerable interest among educators. A great number of factors have been correlated with student success and retention in engineering. Among those it has been found that performance in statics is a strong predictor of success in follow-on engineering courses and retention in the engineering majors. As a student's introduction to the rigors of engineering problem solving, statics creates a number of well-documented difficulties for many studentsv (Goldfinch, T., A. Carew, T. McCarthy, (2008)).

A variety of strategies and interventions to improve retention of at-risk students and students in at-risk classes have been studied with active learning, project based learning, peer teaching and tutoring among them. Many of the techniques considered, however, have been documented in the literature as having mixed results. Most notable are conflicting studies that indicate that traditional tutoring, problem solving sessions and unstructured group work does little to improve the outcomes of at-risk students. Common one-on-one tutoring has been shown to both help retention and do little to improve student performance. Some literature indicates that group problem solving sessions are effective at retaining at-risk students while others do not. Treisman (1992) reported that an intensive "work shop course" as an adjunct to the regular course helped at-risk students outperform all other students in the class. Fullilove (1990) implemented a similar intervention in which group sessions were formed involving at-risk and not at-risk students. Attendance in the session was voluntary. Fullilove (1990) found that participating students were 2-3x more likely to succeed than students who didn't attend the sessions. In addition, increased persistence in major and graduation rates, as well as the acquisition of positive social and study skills, were reported.

The most widely discussed among group intervention techniques is Supplemental Instruction (SI). SI differs from other intervention strategies most notably in that it is not a remedial approach to retention; it focuses on at-risk courses rather than at-risk-students thus avoiding any of the stigmas associated with programs that focus on at-risk student. To foster this non-remedial approach SI is typically a voluntary activity open to all of the students enrolled in a course. It uses peer-led and peer-assisted meetings that use carefully constructed collaborative learning assignment to focus on complex course concepts. The technique differs from tutoring, problem sessions, re-lecture, recitation and group study in a variety of ways. It does not use a one-on-one strategy, facilitates student interaction and is not lead by an instructor. In addition, SI peer-leaders have nothing to do with grades. The success of SI in improving student retention and outcomes is well documented in the literature.

Efforts similar to those presented in the literature have been made at the author's institution in an attempt to improve student performance in statics. One effort, common to several courses, is the use of peer-led group study sessions. These sessions typically meet 3-4 hours a week during the evening when no classes are in session and are staffed by students who have received As in statics and submit to a faculty interview. The problem-solving sessions are voluntary and typically focus on the solution of recent homework problems. They do involve group interaction but these activities are spontaneous and unstructured. In addition to peer-led activities a strong emphasis is also placed on one-on-one faculty tutoring. Tutoring sessions are frequent, not uncommonly 5-6 hours per week per faculty member, and are promoted as an important part of instruction.

Our most invasive effort, used over the last 12 years, has been to identify at-risk students and place them in a special statics course (EM211A). The course has additional contact time in comparison to the traditional statics course (EM211) and is staffed by senior statics instructors.

The at-risk statics students in EM211A are identified using an informal screen performed by hand that considers a combination of SAT Math scores and first semester freshman grades in calculus and chemistry. When possible students with a SATM score below 600 and a D or F in either Calculus I or Chemistry I were placed in EM211A. Students in these sections, which have the same content, pacing and syllabus as the traditional EM211, have smaller section sizes than in EM211 and receive an additional hour of class weekly. How the additional hour is used is left to the discretion of the instructor. Typically, the extra hour is used for additional lecture time to reinforce previous concepts or, in other cases, as a more traditional recitation or problem solving session. Anecdotal evidence has shown improved performance of at risk students placed in EM211A. This conclusion, as discussed above, is in contrast with existing literature that suggests traditional recitation sessions, tutoring and unstructured peer-groups are ineffective at improving student performance (Hodges (2001)). For these reasons a formal evaluation of the effectiveness of the extra hour of contact at improving student performance in statics was conducted.

Concerns about student performance and retention and the commitment of the additional resources required to offer EM211A have led to a reexamination of the effectiveness of the course. Ideally, an evaluation would be performed by placing a representative group of EM211A students in the traditional statics course while leaving the remainder in EM211A. The performance of each group could then be reasonably compared. No such controlled study has been conducted, however. To avoid conducting such a study, and the potential of placing at-risk students at a disadvantage, a statistical analysis of the existing record has been performed. Using 11 years of legacy data—all the data available at the time of this study—a statistical profile of the at-risk students in EM211A was developed using a logarithmic regression analysis, a technique well represented in the literature for the identification of at-risk students. The analysis was performed using seven student characteristics: ethnicity, gender, SAT Math, SAT Verbal, Calculus I final exam grades, Chemistry I final exam grades, and freshmen year, second semester, grade point averages. Of the seven, four relate to entry characteristics: ethnicity, gender, SAT Math, SAT Verbal; two relate to first semester freshmen year academic performance: Calculus I final grade, Chemistry I final grade; and one characterizes the student's performance in the second freshmen semester: spring semester grade point average. The resulting profile was then used to screen the legacy EM211 data to identify students that had a statistical profile similar to those students placed in EM211A. These newly identified students, also considered to be at-risk by the new measure, will be described as EM211A-Like. At-risk students are present in EM211 for three primary reasons. Firstly, screening the students by hand naturally results in unintentional errors in placement. Secondly, practical considerations such as faculty resources and section size constraints limit the number of EM211A sections that can be offered, ultimately placing some at-risk students in EM211. Thirdly, the formal logistic regression screen characterizes the EM211A students using a wider range of characteristics than used in the informal screen.

As a result of this analysis three groups of students were identified: a core group of not-a-risk students placed in EM211 (EM211-Core), a group of at-risk students placed using the informal screen (EM211A) and a group of at-risk students placed in EM211 that have the broad characteristics of an EM211A student (EM211A-Like).

## II. Results

This study uses student enrollment and performance data in the introductory statics courses EM211 and EM211A. The study compares the performance of at-risk and not-at-risk students on a common final exam and final course grades using eleven years of data extending from the fall of 2000 through the fall of 2010. These calendar years correspond to academic years 2001 through 2011, as defined by year of graduation.

Student enrollment during this eleven year period totaled 4114. Of those registered 110 or 2.7% withdrew from the course. The remaining 4004 students were divided into at-risk and not at-risk groups using the informal at-risk screen: 3495 (87.3%) were enrolled in the traditional statics course, EM211, and 509 (12.7%) were enrolled in the at-risk statics course EM211A. Because of course and graduations requirement no students repeat EM211A while a very small number (156 over 11 years or 4.5%) repeat EM211.

During the dates covered by the analysis 156 EM211 and 45 EM211A sections were offered resulting in average sections sizes of 22.4 and 11.3, respectively. Of the withdrawals 89 were from EM211 and 21 were from EM211A representing 2.5% and 4.1% of their respective courses. The rate of Ds, Fs and withdrawals (DFW) for the combined statics courses is 18.4% with a DFW of 14.8% and 42.8% for EM211 and EM211A, respectively. Overall, neither the combined statics courses, EM211 and EM211A, or EM211 alone would qualify as an at-risk course according to the commonly accepted threshold of 30% DFW discussed in the literature. In contrast, EM211A, with a concentration of at-risk students qualifies as an at-risk course.

A logistic regression analysis was used to identify two additional groups of statics students: EM211A-Like students, students placed in EM211 using the informal screen but deemed at-risk using a logistic regression analysis; and EM211-Core students, not at-risk EM211 students representing the balance of EM211. Of the 4004 students completing the course 1883 (47%) were excluded from the logistic regression because their record was missing one or more of the characteristics predictors listed in the previous section leaving 2121 student records for use in the analysis. An informal inspection of the excluded students showed that the vast majority were excluded because they received validations in one or more of the courses considered in the study, Calculus I or Chemistry I, and thus had an invalid grade as defined by the analysis. For this reason these students were assumed to be not-at-risk and were placed in the EM211-Core student pool for the remainder of the analysis. The distribution of students by type and academic year is shown in Table 1.

| | | EM211-Core | | EM211A | | EM211A-Like | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | Count | Percent | Count | Percent | Count | Percent | Count | Percent |
| Academic Year | 2001 | 306 | 80.7% | 62 | 16.4% | 11 | 2.9% | 379 | 100% |
| | 2002 | 270 | 79.6% | 5 | 19.2% | 4 | 1.2% | 339 | 100% |
| | 2003 | 261 | 80.1% | 62 | 19.0% | 3 | 0.9% | 326 | 100% |
| | 2004 | 337 | 85.5% | 45 | 10.2% | 12 | 3.0% | 394 | 100% |
| | 2005 | 341 | 88.8% | 40 | 10.4% | 3 | 0.8% | 384 | 100% |
| | 2006 | 332 | 85.8% | 48 | 12.4% | 7 | 1.8% | 387 | 100% |
| | 2007 | 344 | 85.6% | 48 | 11.9% | 10 | 2.5% | 402 | 100% |
| | 2008 | 324 | 87.6% | 39 | 10.5% | 7 | 1.9% | 370 | 100% |
| | 2009 | 241 | 85.5% | 33 | 11.7% | 8 | 2.8% | 282 | 100% |
| | 2010 | 327 | 88.9% | 36 | 9.8% | 5 | 1.3% | 368 | 100% |
| | 2011 | 326 | 87.4% | 31 | 8.3% | 16 | 4.3% | 373 | 100% |
| | Total | 3409 | 85.1% | 509 | 12.7% | 86 | 2.2% | 4004 | 100% |

Table 1 EM211-Core, EM211A and EM211A-Like Distribution

The logistic regression considered the ethnicity (ETHNICITY), gender (GENDER), SAT Math (SATM), SAT Verbal (SATV), Calculus I final exam grade (CALC1), Chemistry I final exam grade (CHEM1), and freshmen year, spring semester, grade point averages (SGPA) of the students enrolled in EM211 and EM211A to identify at-risk students in EM211. Through the logistic regression analysis students in EM211A were found to be well characterized (Sig. $< 0.05$) by their SAT Math score, Spring GPA, and their Calculus 1 and Chemistry 1 final grades, each having a significance of 0.00. In contrast SAT verbal scores, and ethnicity and gender, were found to weakly characterized EM211A students. The data, listed in Table 2, show that ethnicity and gender are very poor predictors of placement in the at-risk statics course EM211A with significances of 0.597 and 0.816, respectively. The weak correlation between gender and ethnicity and at-risk placement has been reported elsewhere in the literature. The most significant predictor of EM211A placement is SGPA with a weighting score, B, of -1.775. This is not surprising in that SGPA indicates how a student performs in the current academic setting. The same is true of Calculus 1 and Chemistry 1 grades with the next highest weightings of -1.356 and -0.420, respectively. In contrast the least important significant predictor, SAT Math, with a weighting factor of -0.021, is a trailing indicator.

| Student Regression Predictor | B | Sig. |
|---|---|---|
| ETHNICITY | -.026 | .597 |
| SATV | .002 | .089 |
| SATM | -.021 | .000 |
| GENDER | .052 | .816 |
| SGPA | -1.775 | .000 |
| CALC1 | -.420 | .000 |
| CHEM1 | -1.356 | .000 |

Table 2 Student Regression Predictors

The academic characteristics of the EM211-Core, EM211A and EM211-Like students were compared and are shown in Table 3. The table shows the mean data for the five academic characteristics considered as well as the statistical significance of the differences observed between the values of the at-risk groups (Sig). All exam, course and GPA figures are reported with respect to a four-point scale. The data clearly show the pronounced difference between the entry and performance characteristics of the core not-at-risk group and the at-risk groups. Also importantly, the data show that the two at-risk groups (shaded) are significantly similar (Sig < 0.05) in 4 of the 5 categories. The characteristic with a significant difference, SATM, is not surprising considering that it is one of the primary filtering characteristics of the informal screen used for placement in EM211A. Despite the significance of this difference it's magnatude is relatively small at slightly greater than 3%. Consequently, the EM211A-Like students are statistically quite similar to the EM211A students in several important academic and demographic characteristics and represent a suitable comparison group for the study.

| | EM211-Core | EM211A-Like | EM211A | |
|---|---|---|---|---|
| | Mean | Mean | Mean | Sig |
| SATM | 695 | 620 | 600 | 0.002 |
| SATV | 649 | 602 | 591 | 0.151 |
| SGPA | 3.15 | 2.32 | 2.24 | 0.055 |
| CALC1 | 3.14 | 2.29 | 2.29 | 0.979 |
| CHEM1 | 2.90 | 1.65 | 1.64 | 0.861 |

Table 3 Predictor Characteristic Comparison

Using the defined groups a comparison was made between the final exam grades and course grades of not-at-risk students, at-risk students placed in the at-risk course EM211A and at-risk students placed in the traditional statics course EM211. Table 4, referenced to a four-point scale, shows that on both measures the not-at-risk EM211-Core group substantially outperformed both at-risk groups while the EM211A students modestly outperform the EM211A-Like students in both measures. The differences are quite small in two important ways. Firstly, the grades differ only slightly (shaded). EM211A students improved their final exam grade and final course grade with respect to the EM211A-Like students by 0.19 and 0.12 quality points, respectively. This corresponds to a small grade increase of 4.75% and 3.00% on a one hundred-point scale. Secondly, these differences are statistically small in that in all instances they are found to be statistically insignificant (Sig. < 0.05). Consequently, what minor improvements are shown cannot be attributed to the additional contact hour but are rather indistinguishable from expected random fluctuations.

## III. Conclusions

In an attempt to improve student retention in engineering a dual-track statics course sequence was created at the author's institution. One course, EM211, is typical of other statics courses offered at other universities and colleges in that it is taught for 3 hours per week for approximately 15 weeks. In contrast, a second course, EM211A, which covers the same material at the same pace, is taught for 4 hours per week for 15 weeks. The additional contact hour,

| | EM211-Core | EM211A-Like | EM211A | Sig. | Diff. |
|---|---|---|---|---|---|
| Statics Grade | 2.71 | 1.48 | 1.67 | 0.225 | +0.19 |
| Statics Final | 2.29 | 0.99 | 1.11 | 0.725 | +0.12 |

Table 4 EM211A, EM211A-Like Outcome Comparison

typically devoted to re-lecture and problem solving, is used at the instructor's discretion to best serve the needs of the students in the class. The EM211A course is reserved for at-risk students as identified by an informal screening criteria that considers SAT Math and freshman calculus and chemistry grades. Because of the additional resources required to offer EM211A, and concerns about its impact on student performance, a formal study was implemented to determine its effectiveness.

Direct comparison of at-risk students in EM211A to at-risk students in EM211 was not attempted because there was no desire to conduct such an experiment and put at-risk students at a disadvantage by placing them in EM211. In addition, the vast majority of at-risk students, as defined by the informal screen, were already placed in EM211A and the number of similar at-risk students in EM211 was certain to be small. Consequently, a direct comparison was not possible. To overcome this difficulty a logistic regression analysis, considering a broader range of student characteristics, was performed using the EM211 and EM211A students. The analysis was used to define a second group of at-risk students enrolled in EM211. These EM211A-Like students possessed many of the characteristics of the at-risk students enrolled in EM211A but were not selected using the informal screen. It is the performance of these two at-risk groups, as measure by final exam and final course grades, which were compared (Table 4).

The results of the logistic regression analysis, Table 3, showed that the two at-risk groups possessed very similar academic profiles. The primary academic difference was, not surprisingly, in SAT Math scores, one of the primary characteristics used in the informal screening procedure. Of considerable note is the indication that, in agreement with the existing literature, the demographic characteristics of ethnicity and gender were not reliable predictors of placement in the at-risk group, EM211A.

Using these statistically similar at-risk groups a comparison was made between their performance in statics. It was found that when controlled for SAT Math, SAT Verbal, Calculus I final exam grades, Chemistry I final exam grades, and freshmen year spring semester grade point averages, improvements on a common final exam and final course grades due to the additional class hour were minor and not statistically significant (Table 4). Consequently, the additional contact hour, as implemented in the course, is ineffective at improving student outcomes in statics. This supports the majority of the literature, which shows that unstructured problem-solving session and re-lecture do little to improve student outcomes.

Because of the results of this study a number of actions are under consideration for implementation alone or in combination with each other. The intervention most supported by the literature would be a Supplemental Instruction (SI) model. A strict implementation of this technique would not be possible at our institution, however, a number of its elements are being considered. One would be to develop an at-risk course based intervention by extending the additional contact hour to all statics students. This would differ from a strictly SI approach in that due to institutional requirements it would be faculty led and attendance would be mandatory. This course format would, however, allow for a faculty-led “supplemental instruction” activity. If carefully constructed and implemented there is reason to believe that the benefits observed from similar voluntary, peer-led instruction could be realized. This approach is not justified as a strong majority (81.6%) of statics students complete the course with a grade of C or better.

In conjunction with the at-risk course approach, or as a standalone effort, the supplemental instruction model could be extended to our existing peer-led study sessions. With additional faculty input and oversight the sessions could be more formally structured to model the SI technique. Doing so would, however, would eliminate the students' access to homework help which is believed to be the prime motivation for attending the sessions.

Other actions being considered include eliminating the EM211A course and integrating those students into the EM211. While the data doesn't indicate that this will improve (or hurt) outcomes it is expected to improve moral among the students normally selected for EM211A. Another option under serious consideration, unrelated to course pedagogy, would be the implementation of intensive advising for at-risk statics students. This approach would ideally allow for earlier intervention and more effective use of available student academic support services.

## IV. REFERENCES

Fullilove, R. and P. Treisman, "Mathematics achievement among African American undergraduates and the University of California, Berkley: An evaluation of the Mathematics Workshop Program." *Journal of Negro Education* 59.3 (1990): 463-478.

Goldfinch, T., A. Carew, and T. McCarthy, "Improving Learning in Engineering Mechanics: The significance of understanding." Proceedings 20th Annual Conference of the Australasian Association for Engineering Education. Yeppoon, Australia.

Hodges, R., W. White, “Encouraging high-risk student participation in tutoring and supplemental instruction.” *Journal of Developmental Education*, 25.3 (2001): 2.

Treisman, U., (1992) “Studying students studying calculus: A look at the lives of minority mathematics students in college.” *The College Mathematics Journal*, 23.5 (1992): 362-372.

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