122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society

Paper ID #12071

The Effect of Additional Statics Class Time on At-Risk Student Performance

Prof. John Burkhardt Ph.D., U.S. Naval Academy

John Burkhardt is an Associate Professor at the U.S. Naval Academy in Annapolis, Maryland. He received his Ph.D. and M.S. degrees in Theoretical and Applied Mechanics form the University of Illinois, Urbana-Champaign. His bachelor of engineering degree is in Civil Engineering was awarded by The Cooper Union in New York City.

The Effect of Additional Statics Class Time on At-Risk Student Performance

ABSTRACT

The academic performance of at-risk engineering students in the core classes statics and dynamics was studied to determine if an additional hour of class time in statics improved outcomes. This was possible because two version of the same statics course was offered. A standard version of the statics course met three hours per week over the course of a fifteen-week semester while a second version met four hours per week. Students identified as at-risk using an informal screening procedure populated the four-hour statics course. For comparison with this group, using the same enrollment data, a second group of at-risk students were identified from the three-hour statics class using a more formal logistic regression based screening procedure. A performance comparison between the two groups showed that the extra contact hour in statics had a minor, statistically insignificant effect on student final exam and final course grades in both statics and dynamics.

I. Introduction

In a variety of engineering curricula the concepts developed in statics and dynamics impact the study of both introductory (e.g. strength of materials, fluid mechanics) and advanced courses (e.g. machine design, structural mechanics and vibrations). Despite their importance students often complete these courses with their pre-course conceptions and misconceptions largely unchanged. The study by Halloun and Hestenes[1] reported that "Common sense notions about motion are generally incompatible with Newtonian theory" and that "conventional physics instruction does little to change that."

For these reasons considerable effort has gone into developing improved pedagogical techniques for the teaching of basic engineering mechanics as well as methods for assessing learning in these classes. Examples include active learning[2], project based learning[3], peer teaching[4], intrusive advising[5], supplemental instruction[6] and one-on-one tutoring[7] among them. Many of the techniques considered or their core elements, however, have been documented in the literature as having mixed results. Of note are conflicting studies that indicate that traditional tutoring[8], problem based learning[9], problem solving sessions and unstructured group work[10] do little to improve student outcomes. While contradictory, the referenced studies lead not to the conclusion that all intervention methods are ineffective, but rather that they are highly dependent on their implementation for success.

One intervention, used for 12 years at our institution, 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). 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 receive an additional hour of class weekly. Anecdotal evidence has shown improved performance of at risk students placed in EM211A. To test this conclusion, a

formal evaluation of the effectiveness of the extra contact hour at improving student performance in statics and dynamics was conducted.

II. Results

This study uses student enrollment and performance data in the introductory statics courses EM211 and EM211A and in the follow-on dynamics course EM232. Using two categories of at-risk students and a complimentary group of not-at-risk students this study compares their performance 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. During the period under study in excess of 20 instructors taught the course with varying levels of experience and expertise and course times varied throughout the morning and afternoon. Instructor specific data was available but the decision was made to homogenize the data across instructors to generate a larger student pool rather than to control for instructor. In addition, because the desired student course outcomes remained unchanged, great care was taken to produce different but consistent final exams from year to year.

Student enrollment in the statics class during this eleven-year period totaled 4004 students. These students were initially divided into at-risk and not-at-risk groups using the informal at-risk screen: 87.3% (N = 3495) were enrolled in the traditional statics course, EM211, and 12.7% (N = 509) were enrolled in the at-risk statics course EM211A. 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 analysis. An informal inspection of the excluded students showed that the vast majority were excluded because they received validation credit (e.g. through college-level high school classes) in one or more of the courses used in the logistic regression analysis. Of the remaining 2121 student records used in the analysis 1714 were enrolled in EM211 and 407 were enrolled in EM211A. The logistic regression analysis further divided the EM211 students into 1628 EM211-core students and 86 EM211-like students.

The academic characteristics of the EM211-Core, EM211A and EM211-Like students were compared and are shown in Table 1. The table shows the mean data for the five academic characteristics considered in the logistic analysis as well as the statistical significance of the differences observed between the values of the at-risk groups (Sig). 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. Consequently, the EM211A-Like students are statistically quite similar to the EM211A students in several important academic characteristics.

Type (# of records)	EM211-Core (1628)	EM211A-Like (86)	EM211A (407)	
	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 1 Predictor Characteristic Comparison

Using the defined groups a comparison was made between the final exam grades and course grades of the statics students. As outlined, 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 were considered. Table 2, 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 outperformed the EM211A-Like students. 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.

Type (# of records)	EM211-Core (1628)	EM211A-Like (86)	EM211A (407)	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 2 EM211A, EM211A-Like Outcome Comparison

Of the 4004 students who completed statics 3224 continued to the dynamics course EM232. Of those continuing into dynamics 2839 were EM211-Core students (88.1%), 341 were EM211A students (10.6%) and 44 were EM211A-Like students (1.4%). Using these defined groups a comparison was made between the dynamics final exam grades and course grades of not-at-risk student and at-risk students. Table 3, referenced to a four-point scale, shows that the not-at-risk EM211-Core group substantially outperformed both at-risk groups in the course and on the final exam. In contrast, the final exam and course performance of the two at-risk groups are very close. Again, the performance differences between these two groups are quite small in two important ways. Firstly, the grades differ only slightly: 0.01 and 0.07 quality points respectively. Secondly, the analysis finds these differences to be insignificant in comparison to potential random variations in the study.

Type (# of records)	EM211-Core (1628)	EM211A-Like (86)	EM211A (407)	Sig.	Diff.
Dynamics Grade	2.70	1.61	1.60	1.000	-0.01
Dynamics Final	2.27	1.07	1.14	0.948	0.07

Table 3 EM211A, EM211A-Like Outcome Comparison

III. Conclusions

In an attempt to improve student performance in statics and dynamics 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 three 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 four hours per week for 15 weeks. 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. The follow-on dynamics course, like EM211, follows a traditional format meeting three hours a week for approximately fifteen weeks.

To perform the comparison an additional at-risk group was identified using a logistic regression analysis. Identified as EM211A-Like students they possessed many of the characteristics of the at-risk students enrolled in EM211A but were not selected using the informal screen and instead were placed in EM211. It is the performance of these two at-risk groups, as measured by their statics and dynamics final exam and final course grades, which were compared. It was found that improvements on the common final exams and final course grades due to the additional class hour were minor and not statistically significant. Consequently, the additional contact hour, as implemented in the statics course EM211A, was ineffective at improving student outcomes in dynamics.

REFERENCES

[1] Halloun, I. and D. Hestenes, ''The initial knowledge state of college physics students,'' *American Journal of Physics*. Vol. 53, No. 11, 1985, pp. 1043–1055.

[2] Prince, M., "Does Active Learning Work? A Review of the Research," *Journal of Engineering Education*, Vol. 93, No. 3, 2004, pp. 223–23.

[3] Mills, J.E., and D.F. Treagust, "Engineering Education—Is Problem-Based or Project-Based Learning the Answer?" *Australasian Journal of Engineering Education*, 2003–2004, www.aaee.com.au/journal/2003/mills_treagust03.pdf.

[4] Fagen, A.P., Crouch, C.H., and Mazur, E., "Peer Instruction: Results from a Range of Classrooms," *The Physics Teacher*, Vol. 40, 2002, pp. 206–209.

[5] Heisserer, Dana L. and Phil Parette. 2002. "Advising at-risk students in college and university settings," *College Student Journal*, Vol. 36, No. 1, 2002, pp. 69-83.

[6] Arendale, D.R., "Understanding the supplemental instruction model," In D.C Martin and D.R. Arendale, (Eds.), Supplemental instruction: Increasing achievement and retention. San Francisco, CA: Jossey-Bass, 1994.

[7] Bloom, B.S., "The 2 Sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. *Educational Researcher*, Vol. 13, No. 6, 1984, pp. 4–16.

[8] Hodges, R., and W.G. White, Jr., "Encouraging high-risk student participation in tutoring and supplemental instruction," *Journal of Developmental Education*, Vol. 24, No. 3, 2001, pp. 2-10.

[9] Colliver J, "Effectiveness of Problem Based Learning Curricula," *Academic Medicine*, Vol. 75, 2000, pp. 259-266.

[10] Golub, E., "An Experiment on the Learning Effectiveness of Lectures and Recitations," *Journal of Engineering Education*, Vol. 62, No. 8, 1972, pp. 928 ff.