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The Effect of a Practice Placement Exam on Placement Exam Scores and Success in Calculus I

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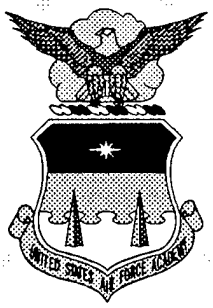

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Most colleges administer mathematics placement exams to "place" students into their first mathematics course. According to Hassett, Downs, and Jenkins (1992), the importance of these placement exams is not communicated to the students. As a consequence, students do not prepare for the exams and may be forced to register for courses they had already passed at a different institution. In this study, we analyze the effect of mailing a practice algebra and trigonometry placement exam with solutions to all incoming first year students. Our results indicate that a small amount of study resulted in significantly higher placement exam scores ($p=0$) and reduced enrollment in remedial mathematics. The practice placement exam did not inflate placement exam scores -- students who took the practice placement exam were as successful in Calculus I as those who did not take the practice placement exam.

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The Effect of a Practice Placement Exam on Placement Exam Scores and Success in Calculus I

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The Effect of a Practice Placement Exam

Abstract

Most colleges administer mathematics placement exams to "place" students into their first mathematics course. According to Hassett, Downs, and Jenkins (1992), the importance of these placement exams is not communicated to the students. As a consequence, students do not prepare for the exams and may be forced to register for courses they had already passed at a different institution. In this study, we analyze the effect of mailing a practice algebra and trigonometry placement exam with solutions to all incoming first year students. Our results indicate that a small amount of study resulted in significantly higher placement exam scores ($p = 0$) and reduced enrollment in remedial mathematics. The practice placement exam did not inflate placement exam scores -- students who took the practice placement exam were as successful in Calculus I as those who did not take the practice placement exam.

The Effect of a Practice Placement Exam on Placement Exam Scores and Success in Calculus I

Mathematics placement testing is a common element of Freshmen registration at most colleges and universities. The Assessment Standards for School Mathematics (National Council of Teachers of Mathematics [NCTM], 1995) recommends the following ground rules for formal assessment: "Before their learning is assessed in a formal way, all students are informed about what they need to know, how they will be expected to demonstrate that knowledge, and what the consequences of assessment will be" (p. 17). In reality, students may be misinformed about the format, content, criteria, and consequences of these all-important placement tests (Hassett et al, 1992; Wood, 1972).

In many institutions, placement exams are barriers for those wishing to enroll in calculus courses. Lappan and Phillips (1984) found that a majority of students with three to four years of high school math were placed into remedial math courses. A large number of students elect to take a calculus course during their senior year of high school. According to Ferrini-Mundy and Gaudard (1992), students who are accelerated into calculus may not have had the time to develop a solid algebra background. These students arrive at college to find that they must pass an algebra placement exam before they are permitted to continue their study of calculus. In this sense, the placement exam acts as a "filter instead of a pump in the mathematics pipeline" (Hassett et al, 1992, p. 70).

The importance of correct placement cannot be overemphasized. Placement into remedial mathematics courses seriously limits career choices (Lappan & Phillips, 1984). Lappan and Phillips (1984) found that between 10 and 40 percent of students surveyed did not know that they would need math for their chosen career. Students with career interests in science or engineering start from an inferior position if they are placed into remedial mathematics courses (Waits & Demana, 1988). And, while placement exams have served to keep unprepared students

out of calculus, there has been an increase in the number of university degree programs requiring a calculus course (Waits & Demana, 1988).

Over two decades ago, Wood (1972) found that the use of prototype of math placement exams by students resulted in greater numbers of students in the appropriate course as a matter of choice. Wood concluded that the practice exams served to induce well-prepared students to review weak topic areas and gain confidence in strong topic areas. Adcock, Leitzel, and Waits (1981) found that the use of practice placement exams by high school juniors resulted in a 73 percent increase in the number of students registering for mathematics courses their senior year of high school and reduced the number of remedial mathematics enrollments when those students entered college.

Many studies have shown significant correlations when mathematics placement exam scores were used to predict mathematics course grades (Edge & Friedberg, 1984; Noble & Sawyer, 1989). Placement exams may not be as accurate as they could and should be. The use of practice placement exams should improve the placement process: more students in the appropriate courses.

In this study, we posited the following research questions:

(1) Does the use of practice placement exams result in higher placement exam scores?

(2) Are students who studied using practice placement exams successful in Calculus I?

Method

Participants

The sample for the experiment consisted of all appointees of the United States Air Force Academy (USAFA) for the 1996-1997 academic year. The USAFA has high admission standards. To qualify for admission, students must have good grades and athletic and leadership experience (Air Force Academy Admissions Office, 1995). In addition, students must be unmarried, without dependents, and between the ages of 17 and 21 (USAF Academy Admissions Office). The mean Scholastic Achievement Test (SAT) math aptitude score for incoming Air Force Academy students

was 649 (recomputed to reflect the 1995 recentering of the SAT) and the mean for the math portion of the American College Test (ACT) was 29.1. Approximately 88% of entering cadets ranked in the top fifth of their high school class (USAF Office of Institutional Research, 1996).

Appointees were placed into their first math course via a series of placement exams. All incoming students were required to take an Algebra/Trigonometry placement exam. A series of three calculus placement exams was optional, but, required for validation credit in Calculus I, Calculus II, and Calculus III. Appointees scoring less than 52.5% on the Algebra/Trigonometry placement exam were placed into Precalculus, the remedial course at the USAFA. All USAFA students are required to complete a sequence of core courses which includes at least two semesters of calculus.

The entering class consisted of 1230 students. Included were 226 minority members (18.4%) and 220 women (17.8%). Of the minority students, 80 (6.5%) were Black, 85 (6.9%) were Hispanic, 47 (3.8%) were Asian American, and 14 (1.1%) were Native American (USAF Office of Institutional Research, 1996).

Of the 1230 appointees, 1073 received the practice placement exam. Of those who received the exam, 661 took the exam. From that group, 539 identified deficiencies. Of those who identified deficiencies, 508 took action to remedy their deficiencies (see Figure 1).

Instruments

Academic Composite (ACACOMP) Score. The Admissions staff at the Air Force Academy calculates an academic composite (ACACOMP) score for each incoming student. The ACACOMP is derived from high school rank and either the Scholastic Achievement Test (SAT) or American College Test (ACT) score. An ACACOMP of 2700 is required for admission.

Algebra/Trigonometry Placement Exam. The Algebra/Trigcnometry placement exam contained 40 multiple choice items and was machine scored. The exam was validated for content in 1995 by faculty members of the USAFA math placement team. The exam was found to have high predictive validity for placing students into Precalculus as their first mathematics course

(W. A. Kiele, personal communication, April 5, 1995). Many of the placement exam items are anchored, that is, used again from year to year. The use of anchored items improves test stability and reliability.

The placement exam was administered under standardized conditions a few days after the students arrived at the Air Force Academy. Students took the exam in large lecture halls proctored by instructors. Standardized directions were printed on the first page of the exam and read aloud by the proctors. All students had identical time limits. The use of calculators was not permitted.

Placement Survey

As part of the placement process, all students completed a placement survey. The survey contained questions about the practice placement exam to determine how many appointees received the exam, how many took the exam, how long appointees studied for the placement exam, and which study methods the students employed.

Treatment and Control Groups

The treatment group consisted of the 661 students who took the practice placement exam. The control group consisted of 412 students who did not take the exam. Assignment to these groups was not random but based primarily on self-selection by the appointees. Because the treatment group was found to have slightly higher academic composite (ACACOMP) scores, ACACOMP was included as a covariate in the analysis (see Table 1).

Procedure

Our forty-item short-answer practice placement exam was written in the Spring of 1996. In coordination with the Director of Admissions, we sent each appointee a copy of the exam, a letter from the Department Head, instructions for scoring the exam, and suggestions for brushing up on weak areas. The forty questions were grouped into six major skill areas. We recommended to students that they meet with a high school instructor if they missed more than one question in any skill area. Within days of arrival at the USAFA, we administered our multiple-choice

Algebra/Trigonometry exam. In a survey administered along with the placement exam, we asked several questions pertaining to students' use of the practice placement exam package.

Results

The means and standard deviations for the entire sample and for the treatment and control groups on the placement exam and ACACOMP are reported in Table 1.

Analysis

Practice Placement Exam Effect

Hierarchical multiple regression was used to compare the placement exam scores of the two groups while controlling for ACACOMP. Table 2 shows the results of these regressions as the group membership variable was added. Tests of the semi-partial correlation coefficient revealed that, when ACACOMP was controlled for, the treatment group scored significantly higher on the placement exam than the control group. Adjusted placement exam scores were calculated to control for the difference in ACACOMP (see Table 2).

Aptitude-Treatment Interaction

To determine whether the effect of the practice placement exam differed according to ACACOMP, we added an interaction variable (ACACOMP $\times$ treatment) and performed another regression. No interaction was found and we concluded that the practice placement exam was equally effective for students with both low and high ACACOMP scores (see Table 2).

Success in Calculus I

As a result of placement exam scores, 494 students were placed into Calculus I. We were concerned that placement exam scores could be inflated for students who took the practice placement exam. With ACACOMP used as a control variable, we found that students who took the practice placement exam were as successful in Calculus I as those students who did not take the practice placement exam.

Study Time

One of the survey items asked students to code the approximate time spent taking the practice placement exam and correcting deficiencies. Response choices were: (a) less than two hours; (b) between two and four hours; (c) between four and six hours; and (d) more than six hours. Just over half of the appointees studied less than two hours and another 40 percent studied between two and four hours. By averaging the means of the intervals, we estimated a mean study time of less than two hours. The categorical study time variable did not account for a significant proportion of variance in placement exam score above what had already been accounted for by ACACOMP (see Table 3).

Study Method

Another survey item asked students to code their study method from the following options: (a) I reworked problems and/or conducted a review of selected topics on my own; (b) I met with a math teacher at my high school and practiced problems in my weak areas; (c) I got help with students at my school; and (d) other. About half of the students responded that they reworked problems, about 16 percent met with their high school teacher, and about 5 percent received help from other students.

Discussion and Conclusions

Students who took the practice placement exam achieved significantly higher placement exam scores than those who did not, resulting in fewer students being placed into Precalculus and more students being placed into Calculus I. These results were obtained with an average study time of less than two hours. These findings are in agreement with results reported by Adcock, Leitzel, and Waits (1981) and Wood (1972). The mean difference in scores was 5.6 percent (see Table 1).

The practice placement exam did not artificially boost placement exam scores. Students who took the practice placement exam did as well in Calculus I as those who did not take the practice placement exam.

Several factors may limit the generalizability of this study. Although the sample was large, the subjects, being military academy appointees, may not be representative of typical high school or college students. Overall, students attending the USAFA are a fairly homogeneous group with similar academic and career goals. The limited external validity due to the controlled atmosphere at the Air Force Academy serves to strengthen the internal validity of the study. Threats due to subject characteristics, mortality, location, history, and subject attitude have been minimized due to the controlled environment at the USAFA (Fraenkel & Wallen, 1993).

Now that baseline data has been collected, the use of practice mathematics placement exams should continue. In addition, different variations of practice placement exams should be tested across a wide variety of students and institutions.

In future studies, students should be questioned on their motivation to take the practice exam and study for the placement exam.

Practice placement exams allow an institution to follow the assessment standards of the National Council of Teachers of Mathematics: "It is only reasonable that students should know how they are to be assessed, what mathematics they will be expected to do, the criteria for judging their performance, and the consequences of the assessment" (p. 4).

Correct placement is critical. Students who are successful in their first mathematics course are much more likely to succeed in college than those who fail (Steen, 1992).

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Figure 1.

Numbers of students receiving and responding to practice placement exam.

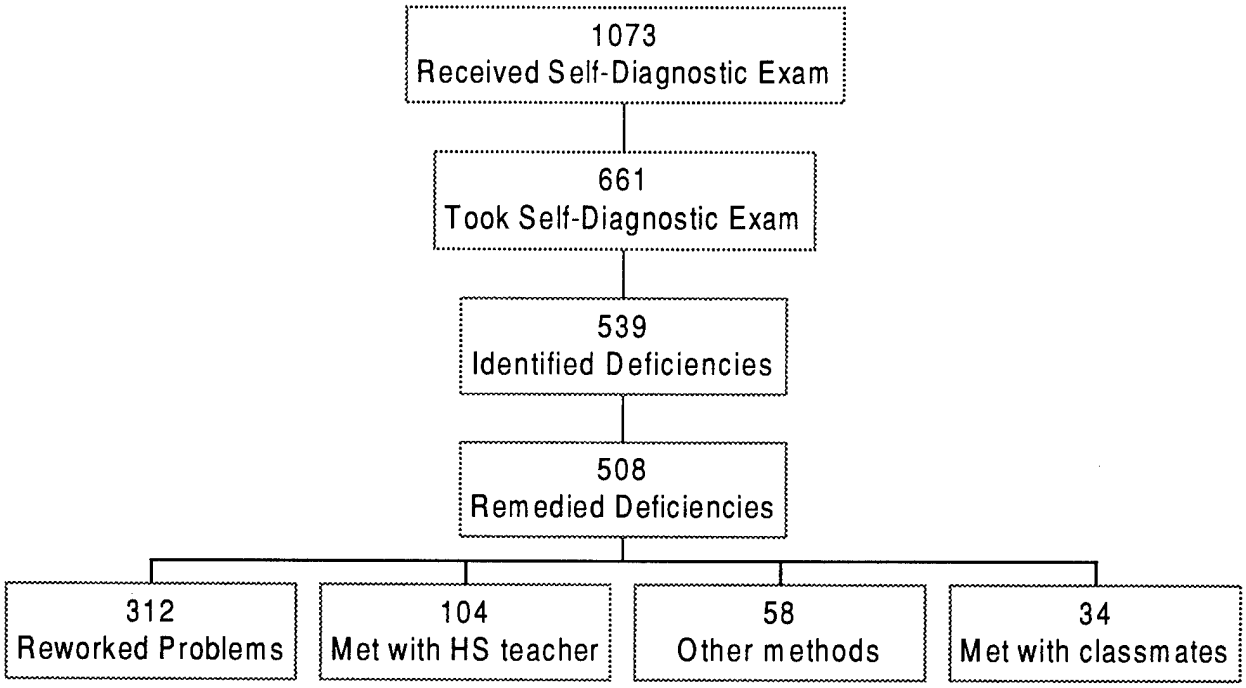

Table 1

Descriptive Statistics for Placement Test and Academic Composite (ACACOMP) Score

	All Students	Treatment Group (took practice placement exam)	Control Group (did not take practice placement exam)
		Placement Exam Scores	
N	1230	661	569
M	62.44	66.64	57.56
SD	19.31	18.74	18.83
min	2.5	12.5	2.5
max	100	100	100
		Academic Composite (ACACOMP) Scores	
N	1230	661	569
M	3188.86	3233.63	3136.86
SD	286.66	291.80	271.71
min	2438	2438	2508
max	3983	3983	3975
		Placement Scores Adjusted for ACACOMP	
		66.64	61.04

Note. Placement exam scores are measured in percent.

Table 2

Multiple Regression Analysis - Main Effect and Interaction Effect

Independent variables	Cumulative R^2	df	F	Variables added	Increment to R^2	df	F of the increment
ACACOMP	.558	1,1228	555.62 *	ACACOMP			
Group membership	.576			Group membership	.020	1, 1227	25.47 *
Interaction (ACACOMP × Group)	.576			Interaction (ACACOMP × Group)	.000	1,1226	0.045

*$p < .001$

Table 3

Multiple Regression Analysis - Study Time Effect

Independent variables	Cumulative R^2	df	F	Variables added	Increment to R^2	df	F of the increment
ACACOMP	.554	1, 659	555.62 *	ACACOMP			
Study Time	.559			Study Time	.005	4, 655	.909

*$p < .001$

Table 4

Calculus I Course Grades for Treatment and Control Groups

	All Students	Treatment Group (took practice placement exam)	Control Group (did not take practice placement exam)
		Calculus I Course Grade	
N	494	252	242
M	78.052	79.295	76.757
SD	8.577	8.303	8.682
min	47.200	47.200	48.500
max	97.470	97.470	95.470
		Calculus I Course Grade Adjusted for ACACOMP and Placement Exam Score	
		77.201	76.756

Note. Calculus course grades are measured in percent.