Evaluating a Non-Randomized Trial: A Case Study of a Pilot to Increase Pre-Collegiate Math Course Success Rates

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Abstract

This article presents a case study of a two-year pilot to increase pre-collegiate Math course success rates at a large community college. The pilot involved the use of computerized software that allowed students to practice math problems in a lab during class time. Additional components of the pilot included the administration of the College Student Inventory motivational assessment and in-class counseling support. Pilot students achieved a course success rate of 15 to 20 percentage points higher than other students in the same math courses. End-of-class survey data as well as enrollment data suggest strong student demand for pilot courses. However, for students moving from Pre-Algebra to Elementary Algebra and Intermediate Algebra to College Level (to a lesser degree) courses, success rates for pilot students lagged behind other students. Pilot students moving from Elementary Algebra to Intermediate Algebra achieved similar rates of success as their peers. The article discusses the difficulties in evaluating a non-randomized trial and suggests that the math department focus on improving the transition in pilot sections from Pre-Algebra to Elementary Algebra.

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Background

In 2006 the New York Times wrote about the high percentage of college students needing remediation in mathematics as well as the low success rate of students in remedial math courses in the United States (Schemo, 2006). The definition of mathematics remediation varies by institution but generally implies that a college student has not advanced beyond Intermediate Algebra. The determination of whether a student needs remedial math in college is made by each institution and can be independent of a student's high school achievement (See, for example, Bettinger and Long, 2005, p7). Students placing into remedial courses such as Pre-Algebra, Elementary Algebra, and Intermediate Algebra, have course success rates of about 50% as compared to success rates of about 70% in other courses (Spurling, 2006). This gap has resulted in new textbooks and programs aimed at improving course success rates in remedial mathematics (Bardige, 2007).

De Anza College, a large community college with about 23,000 full and part-time students, occupying a suburban campus in the Silicon Valley, has not been immune from the national trends in remedial mathematics education. Student success rates in Pre-Algebra, Elementary Algebra, and Intermediate Algebra are 20-30 percentage points below the college-wide course success average for all students. This disparity resulted in a student protest in the winter of 2004. As the student newspaper editorialized:

> "De Anza College's math department is failing to address abysmal student failure rates -- especially among racial minorities -- according to Students for Justice, an on-campus activist club." (Edwards, 2004).

The success rate disparity also resulted in Foothill De Anza Community College District Board of Trustees reports on remedial or basic skills efforts (Barr, 2005 and Miner, 2006).

University of California (UC) and California State University (CSU) admission standards require mathematics coursework above Intermediate Algebra and De Anza College policy requires Intermediate Algebra for an associate's degree; consequently; the math department redoubled its efforts to improve student success in remedial math courses in 2004-05. This effort resulted in a new curriculum for the Pre, Elementary, and Intermediate Algebra in Fall 2005. The effort also resulted in an examination of computer software that might assist students in completing their homework in math. This focus on practice by some faculty members in the department was founded on the belief that students were not spending enough time at home working on math problems (for various reasons, including work commitments) to master the material.

In the Spring of 2005 the Department of Mathematics at De Anza College agreed to a partnership aimed at improving the success rates in remedial math courses:

> "As we discussed during our visit to the campus, we are proposing a three-way partnership with De Anza College, Enablearning, and Noel-Levitz aimed at improving student success in developmental mathematics and in subsequent math courses taken by these students." (Noel Levitz, 2005)

The core of the partnership involves computerized software that acts as the students' textbook. The mastery based software aims to give students practice in solving mathematical problems. New sections of each of the 3 remedial courses were formed that included a computer lab component where students worked on homework problems as part of the regular class meeting time. The partnership also included other interventions aimed at assessing students' motivational needs through Noel Levitz's College Student Inventory (CSI) as well as counselor support for students' non-academic needs.

According to a recent study prepared for the U.S. Department of Education, the research results for using computer assisted instruction were mixed:

> "Even so, the studies we reviewed that specifically addressed the effectiveness of technology have found that, relative to the traditional instructor-led format, CAI and CAS resulted in higher, lower, or no difference in pass rate, no difference or higher rates of persistence to higher- level math, and no difference in final grades. Clearly, this is an area ripe for further study." (Golfin, Jordan, Hull, Ruffin, 2005, p33)

The focus of the math department's effort is on increasing the time a student spends practicing math problems, with the technology seen as tool to achieve that goal, rather than as the intervention. Subsequent survey data indicated that about 40% of students thought they should have spent more time doing homework to receive the grade they wanted. In addition, data from the pilot show a strong correlation between the number of assignments completed and the final grade. Not surprisingly, students with the highest average number of assignments completed tended to receive the highest grade (LaManque, 2007).

Using the CSI in remedial mathematics courses is a new application of the survey. The CSI Form B is about a 100 question survey that aims to measure a students' motivation to complete college and their receptivity to assistance from college staff. It asks questions about confidence in math, financial need, and family support, among others. The CSI was developed as a tool to be used for first year college retention efforts. Given the link between success in developmental math courses and first year retention, the assumption is that administering the CSI in math courses can provide information useful for student success in the math course and in college generally. Previous research provides some evidence for this assumption (Rogers Autrey, 1998, p69).

In summary, the De Anza Developmental Mathematics Pilot involves three interventions:

1) computer software aimed at providing students the opportunity to practice math problems,
2) the administration of the CSI, with the results distributed back to the students,
3) the inclusion of counseling services in the classroom to provide education on the interpretation of the CSI to students and out of classroom assistance on non-academic issues.

The purpose of the partnership was to offer students academic as well as personal assistance to increase course success rates. The interventions are cited as effective practices by the California Basic Skills Initiative (Center for Student Success and the Research and Planning Group of the California Community Colleges, 2007).

A Non-Randomized Trial

Several "EnableMath" sections of each of the 3 developmental math courses have been offered during each of the last 6 quarters from Fall 2005 through Spring 2007.

Figure 1

De Anza College Math Pilot
Sections / Students, Fall 05 - Spr 07

Course	Group	Number of Sections	Number of Students*
Pre-Algebra			
	Pilot	14	428
	Control	55	1,755
Elementary Algebra			
	Pilot	21	723
	Control	88	3,045
Intermediate Algebra			
	Pilot	27	853
	Control	112	3,573
Total			
	Pilot	62	2,004
	Control	255	8,373

* for the Pilot Group, only includes students completing the CSI.

During all the quarters, except the first one, the courses were advertised in the schedule of classes as EnableMath, with the notation of computer use. Over the 6 quarters, about 20% (62 of 317) of all developmental math sections were run as EnableMath, with 1,976 out of 10,349 enrollments in an EnableMath section (see Figure 1). Students in both the

EnableMath and "Control" sections (all other sections) were required to take the placement test that determines which course they can take. It is assumed, given the placement policy, that academic ability is similar between students in the EnableMath and corresponding Control sections.

It is important to note that the placement of students into the 3 courses involves the use of cut off scores. Placement into Pre-Algebra includes a wider range of scores than the other two courses because it is defined as anyone below a certain score. A given Pre-Algebra section can have a wide range of student academic abilities. This fact has the potential to impact success rates in Pre-Algebra as well as success rates for students starting in Pre-Algebra and moving to Elementary Algebra. However, as noted above, this impact would assume to be applicable to both Pilot and Control sections.

Figure 2 below outlines 5 important demographic variables. The ethnic profile is similar between the two groups for Pre- and Elementary Algebra, with 40-50% of students identified as belonging to under-served minority groups. For Intermediate Algebra, 54% of Pilot students, but only 34% of Control students, were from under-served minority groups. It is unclear why this is the case and it is assumed not to have an impact on the outcomes of the study.

Student initial education goal is similar between the two groups across the 3 courses. Nearly three quarters of the students indicated that they wished to transfer or complete a degree or certificate. It is important to note that Intermediate Algebra is the requirement for an associate degree at De Anza College. Students wishing to transfer to a CSU or UC must also complete a college level course in math.

Student age and start term varied between the Pilot and Control student groups. These two variables are likely related as students with an earlier start term are likely to be older. The data indicates that the Pilot group was slightly older than the Control group of students. For both groups, the majority of students started at De Anza prior to the start of the Pilot in Fall 2005.

Even though there is a slight difference between the two groups in terms of demographic variables, given the placement test results, the differences are not thought to be large enough to significantly impact course success rates between the two groups. While the potential exists for a student self-selection bias in motivation and academic ability, the limited information students have about the courses, the placement test requirement and similarities in demographic variables between the two groups, suggest that any self-selection bias is small.

Figure 2

De Anza College EnableMath Pilot, Fall 2005-Spring 2007
Demographic Comparisons with Control Sections

Gender

		Female		Male		Total	
Course	Group	HC	% Row	HC	% Row	HC	% Row
Pre-Algebra							
	Pilot	240	56%	188	44%	428	100%
	Control	954	54%	801	46%	1,755	100%
Elementary Algebra							
	Pilot	393	54%	330	46%	723	100%
	Control	1,547	51%	1,498	49%	3,045	100%
Intermediate Algebra							
	Pilot	445	52%	408	48%	853	100%
	Control	1,773	50%	1,800	50%	3,573	100%

Ethnicity

		African American, Filipino, Latino, and Pacific Islanders		Asian, White, and All Other Groups		Total	
Course	Group	HC	% Row	HC	% Row	HC	% Row
Pre-Algebra							
	Pilot	206	48%	222	52%	428	100%
	Control	823	47%	932	53%	1,755	100%
Elementary Algebra							
	Pilot	288	40%	435	60%	723	100%
	Control	1,181	39%	1,864	61%	3,045	100%
Intermediate Algebra							
	Pilot	271	54%	233	46%	504	100%
	Control	1,209	34%	2,364	66%	3,573	100%

Initial Educational Goal

		Transfer/Award		Career/Undecided		Total	
Course	Group	HC	% Row	HC	% Row	HC	% Row
Pre-Algebra							
	Pilot	308	72%	120	28%	428	100%
	Control	1,292	74%	463	26%	1,755	100%
Elementary Algebra							
	Pilot	541	75%	182	25%	723	100%
	Control	2,273	75%	772	25%	3,045	100%
Intermediate Algebra							
	Pilot	666	78%	187	22%	853	100%
	Control	2,711	76%	862	24%	3,573	100%

Age

		Born Since 1987		Born Prior 1987		Total	
Course	Group	HC	% Row	HC	% Row	HC	% Row
Pre-Algebra							
	Pilot	262	61%	166	39%	428	100%
	Control	1,206	69%	549	31%	1,755	100%
Elementary Algebra							
	Pilot	373	52%	350	48%	723	100%
	Control	1,816	60%	1,229	40%	3,045	100%
Intermediate Algebra							
	Pilot	472	55%	381	45%	853	100%
	Control	2,292	64%	1,281	36%	3,573	100%

Start Term

		During Pilot		Prior to Pilot		Total	
Course	Group	HC	% Row	HC	% Row	HC	% Row
Pre-Algebra							
	Pilot	58	14%	370	86%	428	100%
	Control	366	21%	1,389	79%	1,755	100%
Elementary Algebra							
	Pilot	237	33%	486	67%	723	100%
	Control	611	20%	2,434	80%	3,045	100%
Intermediate Algebra							
	Pilot	194	23%	659	77%	853	100%
	Control	692	19%	2,881	81%	3,573	100%

Instructors were recruited to teach EnableMath sections. The Department Chair and Division Dean do not randomly assign faculty to teach EnableMath sections. Over the Fall 2005 to Spring 2007 period, 12 different instructors taught EnableMath sections. The percentage of sections taught by full-time faculty members teaching EnableMath courses was similar to Control sections for Elementary Algebra, but lower for Pre-Algebra and higher for Intermediate Algebra (Figure 3). Given the relatively small number of instructors it is difficult to speculate with confidence about the impact of the differences.

Faculty members teaching in the program are asked to achieve the same learning objectives as outlined for the Control sections. The objectives have been developed by departmental faculty and approved by the college curriculum committee. Each faculty assigns grades independently which are assumed to represent the same skill level; there is no independent assessment of achievement. The department does not have a learning outcomes assessment program. Course grades are used as a proxy measure of student success. Final exams are written by individual instructors; there is no independent measure of learning outcomes applied across departmental courses.

Figure 3

De Anza College EnableMath Pilot, Fall 2005-Spring 2007
Sections Taught by Instructor Type

	Instructor	Full-time		Part-time		Total	
Course	Type	Sections	Pecent	Sections	Pecent	Sections	Pecent
Pre-Algebra							
	Pilot	4	29%	10	71%	14	100%
	Control	27	49%	28	51%	55	100%
Elementary Algebra							
	Pilot	8	38%	13	62%	21	100%
	Control	44	50%	44	50%	88	100%
Intermediate Algebra							
	Pilot	24	89%	3	11%	27	100%
	Control	58	52%	54	48%	112	100%

The EnableMath sections required faculty to prepare for a new course. While the course outcomes are exactly the same as for the Control sections, the approach and book (the EnableMath software used in a computer lab setting) require new lesson plans. As with a regular section, each EnableMath instructor is given the freedom to decide what weight to assign homework completed using the computer software in the final grade (most EnableMath sections counted homework assignments as some fraction of the final grade, it is not known if the same practice is widespread across the department). The need to develop new teaching approaches might be assumed to translate into more enthusiasm in the classroom, at least initially. This might suggest that, on average, the program may have attracted a group of faculty more interested in student success than the department as a whole.

Purpose of the Evaluation

The purpose of the evaluation shifted during the project from demonstrating improved learning to demonstrating the usefulness of a seemingly popular approach to learning math. Instructor and student feedback about the EnableMath program has been positive. Most faculty members teaching in the program have wanted to stay with it for subsequent quarters. Student demand for the EnableMath sections has been strong with those sections often closing before other sections. In addition, end-of-class survey data indicates that most students believe the software helped them learn more than they would have otherwise (LaManque, 2007).

Given student and faculty interest, possible teacher self-selection bias, and no objective measure of student learning, the question asked by the department has shifted from "Does it work better" to "Do students do at least as well." The purpose of the evaluation shifted from determining whether all sections should be taught using EnableMath, to whether EnableMath should continue to be offered as one option of learning for students, in addition to traditional (lecture only) and distance learning sections. This purpose differs from an evaluation where random assignments are used:

> "A random assignment study (also called a social experiment) uses a lottery-like process to allocate people to the two or more groups whose behaviors (outcomes) are subsequently compared to determine the program's net impact. People in one group are enrolled in the test program, and the others are enrolled in a control group intended to show what would have happened in the absence of the program, that is, to provide a benchmark, or counterfactual, against which to assess the program's accomplishments (to determine its value added)." (Gueron, 2000, p3.)

The question "whether EnableMath should continued to be offered as one option of learning for students" means the focus of the evaluation is to show that students are not being negatively affected as compared to regular sections. Since the program entails only minimal additional cost (counseling time is shifted from the office to the classroom), unless there is conclusive evidence that students are being harmed, the recommendation by the Dean to the department will be to continue with the program. While the nature of the pilot may limit the research approaches possible, an evaluation is still important to ground discussion of the program.

The Results

Student Course Success

Student course success includes end-of-term grade comparisons of those students enrolled in the 4th week of classes. For the end-of-term grade comparisons, only those students still enrolled in the section at the end of the drop-add period ("census day") are included.

Students completing the course are broken into 3 groups:

1) Pass, grades of A, B, C or P
2) Did Not Pass, grades of D, F, I or NP
3) Withdrew, grade of W assigned when a student initiates a drop after the 3rd week.

While a D grade is considered passing at most colleges, typically a C grade or higher is necessary to move to the next course in the sequence.

Students in all math sections of the same course for a particular term are broken into two groups: Pilot Sections and Control Sections (all other sections of the course). Since the intervention includes both the EnableMath software and the CSI with counseling support, only students completing the CSI and purchasing the EnableMath license are included in the pilot group of the analysis. During the first year of the pilot about 80% of the students completed the CSI, this increased to 95% in the second year.

Over the two year period of the pilot (6 quarters) course success rates were consistently higher for the Pilot sections compared with the Control sections of the same course that term (Figure 4). The pilot sections have less students opting for a W grade than the other sections. There is some evidence that students receiving a W in the course will be less successful in the next course compared to students receiving a failing grade (Spurling, 2006).

Figure 4

Course Success of Fall 2005-Spring 2007 EnableMath Pilot Sections
Compared to All Other Sections (Control), De Anza College

		Pass		Did Not Pass		Withdrew		Total	
Course	Group	Grades	Percent	Grades	Percent	Grades	Percent	Grades	Percent
Pre-Algebra									
	Pilot	308	72%	76	18%	44	10%	428	100%
	Control	1,012	58%	391	22%	352	20%	1,755	100%
Elementary Algebra									
	Pilot	514	71%	138	19%	71	10%	723	100%
	Control	1,660	55%	664	22%	721	24%	3,045	100%
Intermediate Algebra									
	Pilot	641	75%	140	16%	72	8%	853	100%
	Control	1,977	55%	675	19%	921	26%	3,573	100%

Includes end of term grades of students enrolled at census (3rd week).
Note: Students in the Pilot group used the EnableMath Software and completed the CSI.

As previously reported (LaManque, 2007), the differences in success rates are statistically significant using a Chi Square test and the average course GPAs are statistically different using a T test of means. Given the limited purpose of the evaluation, the differences, while statistically significant, may not be policy relevant.

Success in the Next Course

Success in the next course is an additional proxy measure of learning that can be used to evaluate the program. This measure is limited as it also captures the teaching and learning taking place in the second course. The analysis examines the first grade in the start course and compares it to the first grade in the second course to control for repeats.

To focus on the learning taking place in the first course, the analysis only includes students that succeed in the first course and go on to attempt the second course. For this analysis students starting in the first 5 quarters of the pilot were considered. The spring 2007 (last quarter of the study) start students are not included because there was no time for them to have taken the second course. The number of quarters available to take the second course varies from 5 for students starting in Fall 2005, to 1 for students starting in Winter 2007, but again, the analysis only looks at students that actually took the second course (summer 2006 is not included).

The data depicted in Figure 5 shows that, of students that successfully completed the first course, a higher percentage of pilot students attempt the second course, as compared to the Control sections. This is most evident for Pre-Algebra, with little difference for Intermediate Algebra.

Figure 5

De Anza College EnableMath Pilot, Fall 2005-Winter 2007
Students Successful in First Course Attempting Second Math Course During Pilot Period

		Attempted		Did Not Take			
	First Course	Second Course		Second Course		Total	
Course	Group	Grades	% Row	Grades	% Row	Grades	% Row
Pre to Elementary Algebra							
	Pilot	210	80%	52	20%	262	100%
	Control	559	72%	214	28%	773	100%
Elementary to Inermediate Algebra							
	Pilot	262	81%	61	19%	323	100%
	Control	828	79%	220	21%	1,048	100%
Intermediate Algebra to College							
	Pilot	169	62%	105	38%	274	100%
	Control	540	55%	435	45%	975	100%

Note: College level math is not required for a De Anza degree.
Considers only the first attempt of both courses

For students attempting the second courses, the results vary, with Elementary Algebra Pilot students' second course success rates close to their peers taking the second course. However, as shown in Figure 6, 45% of Pre-Algebra Pilot students were successful in Elementary Algebra, compared with 55% for Control students. While the results were mixed, the data in Figure 6 suggests more research is needed to determine if the trend of lower second course success rates for EnableMath students continues.

Figure 6

De Anza College EnableMath Pilot, Fall 2005-Winter2007
Second Course Pass Rate for Students Successful in First Course

Course	First Course Group	Pass Grades	Pass % Row	Did Not Pass Grades	Did Not Pass % Row	W Grades	W % Row	Total Grades	Total % Row
Pre to Elementary Algebra									
	Pilot	94	45%	59	28%	57	27%	210	100%
	Control	305	55%	106	19%	148	26%	559	100%
Elementary to Inermediate Algebra									
	Pilot	168	64%	45	17%	49	19%	262	100%
	Control	545	66%	137	17%	146	18%	828	100%
Intermediate Algebra to College									
	Pilot	85	50%	36	21%	48	28%	169	100%
	Control	301	56%	97	18%	142	26%	540	100%

Note: Considers only the first attempt of both courses.

Figure 7 shows the second course group for Elementary and Intermediate Algebra (there is no Pilot group for College level courses). The detail reveals two important trends. First, about 50% of the Pilot students went on to take another Pilot section. Given the limited number of Pilot sections offered and the variability of student schedules, the 50% rate can be seen as an endorsement of the Pilot sections. Second, while the second course success rates of Elementary to Intermediate Algebra Pilot students are similar to the overall rates found in Figure 4, they are lower for the Pre to Elementary Algebra Pilot students. In this case, only 52% of students starting in a Pilot Pre-Algebra section and going on to attempt a Pilot Elementary section were successful. This compares with a success rate of 71% for all Elementary Algebra Pilot students. More research is needed to assess the reasons for this difference.

Figure 7

De Anza College EnableMath Pilot, Fall 2005-Winter2007
Second Course Pass Rate for Students Successful in First Course by Group

Course	First Course Group	Second Course Group	Pass Grades	Pass % Row	Did Not Pass Grades	Did Not Pass % Row	W Grades	W % Row	Total Grades	Total % Row
Pre to Elementary Algebra										
	Pilot	Pilot	60	52%	36	31%	20	17%	116	100%
		Control	34	36%	23	24%	37	39%	94	100%
	Control	Pilot	47	64%	14	19%	12	16%	73	100%
		Control	258	53%	92	19%	136	28%	486	100%
Elementary to Intermediate Algebra										
	Pilot	Pilot	97	80%	17	14%	7	6%	121	100%
		Control	71	50%	28	20%	42	30%	141	100%
	Control	Pilot	95	74%	24	19%	9	7%	128	100%
		Control	450	64%	113	16%	137	20%	700	100%

The data in Figure 8 indicates that students receiving an A in the Pilot start course successfully complete the second course at about the same rate as the Control students. However, students receiving a B or C in the Pilot course have success rates lower than Control students with B and Cs. The results vary by course, with Elementary Algebra Pilot students' second course success rates closer to their peers than is the case with other courses.

Figure 8

De Anza College EnableMath Pilot, Fall 2005-Winter2007
Second Course Pass Rate by Grade for Students Successful in First Course

			Second Course Grade											
	Start	First Course	A		B		C and P		DID NOT PASS		W		Total	
Course	Grade	Group	Grades	% Row	Grades	% Row	Grades	% Row	Grades	% Row	Grades	% Row	Grades	% Row
Pre to Elementary Algebra														
	A	Pilot	21	27%	17	22%	17	22%	8	10%	14	18%	77	100%
		Control	71	34%	58	28%	28	13%	22	11%	29	14%	208	100%
	B	Pilot			8	10%	16	20%	29	36%	28	35%	81	100%
		Control	15	9%	29	17%	40	24%	39	23%	47	28%	170	100%
	C, P	Pilot			3	6%	12	23%	22	42%	15	29%	52	100%
		Control	3	2%	22	12%	39	22%	45	25%	72	40%	181	100%
Elementary to Intermediate Algebra														
	A	Pilot	33	34%	30	31%	23	23%	6	6%	6	6%	98	100%
		Control	118	41%	80	28%	42	15%	19	7%	26	9%	285	100%
	B	Pilot	10	11%	15	17%	20	23%	20	23%	23	26%	88	100%
		Control	33	12%	69	24%	75	26%	48	17%	59	21%	284	100%
	C, P	Pilot	3	4%	9	12%	25	33%	19	25%	20	26%	76	100%
		Control	11	4%	35	14%	82	32%	70	27%	61	24%	259	100%
Intermediate Algebra to College														
	A	Pilot	20	32%	17	27%	12	19%	6	10%	8	13%	63	100%
		Control	45	29%	44	29%	30	20%	14	9%	20	13%	153	100%
	B	Pilot	3	5%	10	18%	11	19%	12	21%	21	37%	57	100%
		Control	9	6%	41	26%	40	25%	22	14%	45	29%	157	100%
	C, P	Pilot			6	12%	6	12%	18	37%	19	39%	49	100%
		Control	10	4%	38	17%	44	19%	61	27%	77	33%	230	100%

Note: Considers only the first attempt of both courses.

There are at least two schools of thought on the analysis of next course success that might help with the interpretation of the data:

A. The one quarter interventions helped the more marginal students succeed when they might not have otherwise. Without the continued support the next quarter these marginal students might have had difficulty the next quarter.

   Put differently, the learning skills (e.g. the importance of doing homework) had not become embedded in just one quarter and the student often reverts to pre intervention behavior. Academically weaker students in the Pilot group may have succeeded with the additional help, but similarly situated students in the Control group likely did not succeed in absence of this extra help and were "screened" from moving on to the next course. This school of thought suggests that we should not expect the relatively larger successful Pilot group to do as well in the next course as the Control group.

B. The students received B and C's with the help of the interventions. This grade should signal a certain mastery of learning outcomes. If B students (especially) from the Pilot group did not succeed at the same level as B students from the Control group, then the B grade for Pilot students is not reflective of the learning that should have taken place.

Implications for Departmental Policy

The above findings do not definitively answer the question "whether EnableMath should continue to be offered as one option of learning for students." First course success rates are 15 to 20 percentage points higher for the EnableMath students compared with other students in the same course. This means that several hundred additional students have been successful in math than might have been otherwise (although, given the instructor self-selection bias, this apparent "increase" in success rates may just have been a factor of the instructor grouping). End-of-course student evaluations are positive, with 2/3rds or more of the students indicating that they learned more with the computer software than they would have in a regular section. Positive feedback was also given to the usefulness of the CSI. However, the data on persistence to the next course raises some questions about the lasting effects of the program.

Given the non-randomized nature of the project it is difficult to separate the interventions from the teaching of the instructor. One might argue that the gains in course success for the Pilot students were the results of superior instructor teaching or instructor grading preferences rather than that of the EnableMath program. In addition, the fact that these students and instructors were given additional attention that was not given to Control sections, might have also contributed to increased success via a Hawthorne effect (Barr, 2007).

The data on the next course success rates suggest more research is needed to track students into the second and even third math courses. Additional analysis should examine patterns of repeating between the two groups. In addition, future research should examine the students withdrawing from the class to determine why the rate is lower for Pilot sections.

Particular emphasis should be placed on the analysis of the success of Pre-Algebra students. Second course success rates are similar for students moving from Elementary to Intermediate Algebra. Given the large variation in need and course taking patterns at the college level, differences in second course success rates from Intermediate to College Level may not be cause for immediate concern. The 10 percentage point difference in second course success rates for students moving from Pre-Algebra to Elementary Algebra should be examined in more detail.

Overall, the data suggests that there is value in offering a different approach to students, but claims of improved learning, especially the long term retention of material, can not be substantiated. Tracking of students should continue over the next year, and if the second course trends continue, an additional curricular review should be undertaken to improve student success in the next course.

Implications for Evaluating a Non-Randomized Trial

This case study demonstrates the difficulty of evaluating a new program in the "real world' of education. While multiple data approaches should be used in the evaluation to help inform the discussion, in the end the methodologies are limited in a non-randomized trial. Applying a more sophisticated set of statistical tools may help shine light on the issue, but statistical measurements require certain assumptions that are not necessarily met in a non-randomized trial. In 2002, Cook noted:

> "Despite widespread recognition of the superiority of random assignment, it is still too rare in research on the effectiveness of school-based strategies to improve student performance." (Cook, 2002, p.195)

Short of random assignments, independent outcomes assessments might go a long way in allowing a more definitive evaluation of programs aimed at helping students learn.

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