Impacts of Instruction by Undergraduate Interns on Developmental Mathematics Students[1]

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Abstract

A significant problem facing all 23 campuses of the California State University (CSU) is the fact that each year over 50% of the entering freshmen require some form of mathematics remediation. California State University, Chico has embarked on a very bold and controversial approach to solving this problem with a developmental program that simultaneously provides a significant student-centered learning experience for senior mathematics majors. Each semester 100-200 developmental students are enrolled in remedial coursework taught solely by undergraduate mathematics majors who are planning careers in teaching at the secondary level. This article reports on the success achieved by students taught by undergraduates compared to students taught by regular faculty. The complete mathematics histories of all of the students who first enrolled and completed Math 1A (beginning algebra) between fall of 1991 through spring of 1999 were compiled and analyzed. A total of 58 sections were offered during this period. Regular and part time faculty taught 28 of these sections and supervised undergraduate interns taught the remaining 30 sections. The subsequent success of these students in their general education math courses was compiled. Students first taught by faculty were compared to those first taught by interns. The data indicates that students who are first taught by interns succeed as

[1]Support for this report was provided by a CSU, Chico summer scholars research award, summer 2000.

well or better in their subsequent general education mathematics courses as those who are first taught by faculty.

Introduction

The California State University (CSU) each year accepts a large percentage of students who are underprepared for college-level mathematics courses. These students are identified through administration of the Entry Level Mathematics (ELM) exam. Each year this exam identifies approximately 50% of entering freshmen as needing some form of remediation in mathematics. Students who score in the bottom quartile of those failing this exam are required to enroll in the Intensive Learning Experience (ILE) developmental program. They must successfully complete the standards-based, reform curriculum in a yearlong, 10-unit ILE program before they can enroll in their required college-level general education (GE) mathematics course.

In response to the needs of the CSU to ensure access to higher education without at the same time unduly draining resources, the Department of Mathematics and Statistics at CSU, Chico has developed the Interactive Mathematics Teacher Preparation (IMTP) program. This approach provides significant student-centered learning opportunities for upper-division mathematics majors who intend to pursue careers in secondary teaching by preparing them for a highly-supervised team-teaching experience in the ILE program. The success of the IMTP program in preparing secondary mathematics teachers has been well-documented in Fisher & Ford, (1999). The least understood and most controversial aspect of this program is the impact on students in the developmental program. To that end, this study addresses two questions:

- To what extent is the instructor a factor in students' success in developmental mathematics?

- To what extent is the instructor a factor in effectively preparing students for success in their college-level mathematics courses?

Background

Prior to 1994 the CSU, Chico ILE program was taught exclusively by full and part time faculty. In 1994, through the Interactive Mathematics Teacher Preparation (IMTP) Program, undergraduate mathematics majors (interns) began teaching the ILE courses. The IMTP program was developed with support from an NSF grant (DUE-9354776). The primary objective of the program was to serve the needs of undergraduates planning to become secondary mathematics teachers. Meeting the developmental needs of ILE students was the secondary objective.

The IMTP program includes a sequence of mathematics education courses designed to develop an understanding of current mathematics education issues and research. The courses follow the general guidelines of the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards* (1989), the *Professional Teaching Standards* (1991), and the *Principles and Standards for School Mathematics* (2000). Over the three-semester sequence, preservice teachers learn about the mathematical and pedagogical issues addressed in the Standards. They also become actively involved in practicing these Standards. This active involvement is accomplished through teaching internships. Math majors who successfully complete the first two courses are offered internships to teach the ILE courses. Each intern team-teaches (in pairs) under supervision by mathematics education faculty. Each intern pair is fully responsible for all aspects of ILE coursework including all lecturing, leading cooperative group activities, exam and quiz construction, assessment, and assigning final grades. Weekly seminars and close contact with university faculty provide essential support to the interns to help

ensure that they effectively carry out their duties. Each intern is paid approximately $1400 per semester. A complete program description can be found in Fisher & Ford, (1999).

The least understood and most controversial aspect of this program is the impact on the developmental students. Furthering our understanding and knowledge of this impact is the central focus of this report. These fragile students are paying tuition and deserve the highest quality education. Do the intern-taught ILE classes enable them to succeed in their college-level mathematics courses? Is this really a win-win-win situation? Or are these students suffering at the hands of the interns?

There is much discussion about the purpose and place of developmental education at the university level. Weissman, Silk, and Bulakowski (1995) propose that “developmental education programs are designed so that students can gain the skills necessary to complete college-level courses successfully” (p. 3). In a 1999 report, Davis notes that "Cohen and Brawer (1996) define developmental education as activities to keep students in school and to help them improve their basic skills so that they can complete an academic or vocational program satisfactorily" (p. 3). Miller’s definition (1996) is broader and includes both academic and social/psychological support services for underprepared students. Whatever the viewpoint, it seems that one vital measure of success of developmental programs is the success of students in their future college-level courses.

A report by the American Mathematical Association of Two-Year Colleges (AMATYC) found that “developmental programs must not simply replicate the high school experience” (Cohen, 1993, p. 34). The report calls for the integration of arithmetic, algebra, and geometry into an in-depth applications driven curriculum. In the context of the preceeding, CSU, Chico

has chosen to use a modified version of the standards-based, NSF-funded *Interactive Mathematics Program* for the curriculum in the ILE program.

Adoption of standards-based reform curriculum is facilitated by "broadened views of pedagogy, classroom structure, and the mathematics that is appropriate (for students)" (Ziebarth, Slezak, Lagrange & Kleinfelter, 1997, p. 2). This entails "preparing teachers to be able to manage a variety of classroom situations" (p. 7), "learning more and better ways to assess students" (p. 8), and "developing a much broader knowledge of mathematics" (p. 8). These requirements are echoed in the AMATYC report (Cohen, 1993). These goals are incorporated into the IMTP coursework. Only four regular faculty members who taught the ILE courses participated in this professional development required of all interns.

Davis (1999) identified the following positive characteristics for teachers of developmental mathematics courses (p. 14).

- Experience in teaching arithmetic, beginning and intermediate algebra is more important than the level and type of degree possessed by the instructor.
- Understanding of the various backgrounds of typical students.
- Student centered instruction.
- Belief that students can learn.

The 1993 AMATYC report (Cohen) identifies the following special qualities of successful developmental mathematics instructors:

- knowledgeable mathematicians who have demonstrated understanding of the special instructional needs of developmental students.
- available for extra assistance, and
- ready and willing to play a special mentoring role in addition to teaching (p. 37).

The senior undergraduate interns who are preparing to be secondary mathematics teachers are many times able to exhibit these qualities.

Methods and Analysis

Outcome Measures and Statistics

The measures used to compare the impacts of intern-taught and faculty-taught ILE sections were (1) ILE passing rates, (2) GE mathematics enrollment rates, (3) GE mathematics passing rates, and (4) comparative sample means of grade distributions in GE courses.

The z-statistic was used to compare completion and passing rates. T-tests were used to compare sample means in GE mathematics courses.

Null Hypothesis

The question we are looking at is whether the interns are more successful than regular faculty in the four outcome areas. Consequently, the null hypothesis is that the intern completion, enrollment, and passing percentages and GPA means are not as high as those rates earned by faculty. One-tailed p-values are used. Standard rejection criteria is applied ($p < .05$)..

Data

The transcripts of all students (n=1471) who enrolled in Math 001A (ILE Mathematics) between fall, 1991 through spring, 1999 were examined. Data records for each student were created showing all subsequent mathematics courses taken at the university and the grade earned.

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Sample record

The information in each record includes year and MATH 1A section, name, social security number, grade earned in the MATH 1A course, remediation completion, GE

mathematics completion, current enrollment status, and all mathematics courses and grades earned subsequent to the initial MATH 1A course. Data regarding remediation completion rates, GE mathematics passing rates, and GE mathematics grade distributions were extracted from these records and analyzed.

• ILE Passing Rates

The number and rates of ILE students who completed their ILE coursework successfully are provided below.

Total Number of Students	Number Completed Remediation	Total Number Intern Taught	Intern Taught and Completed Remediation	Total Number Faculty Taught	Faculty Taught and Completed Remediation
1471	**946**	**833**	**564**	**638**	**382**
	64.2%		**67.7%**		**59.9%**

The z-value of 3.10 corresponds to a p-value of 0.001, indicating rejection of the null hypothesis. The intern-taught student completion rate of 67.7% is significantly higher than the faculty-taught student completion rate of 50.9%.

GE Mathematics Enrollment Rates

Many students who pass their ILE coursework fail to follow through and enroll and complete a required GE math course. The table below summarizes the number of ILE students who persisted to earn a grade in a general education mathematics course. The data includes both passing and non-passing grades.

Total Number of Students	Number Completed	Total Number Intern Taught	Intern Taught and completed	Total Number Faculty Taught	Faculty Taught and Completed GE course

	GE course		GE course		
1471	**834**	**833**	**489**	**638**	**345**
	56.7%		**58.7%**		**54.1%**

The data produced a z-value of 1.774 corresponding to a p-value of 0.038 indicating rejection of the null hypothesis is warranted. GE enrollment rates by intern-taught students who pass their ILE coursework is significantly higher.

GE Mathematics Passing Rates

The rates of passing GE mathematics for cohorts of developmental (ILE) students between fall, 1991 through spring 1999 are as follows:

Total Number of Students	Number PASS GE	Total Number Intern Taught	Intern Taught and Passed GE	Total Number Faculty Taught	Faculty Taught and Passed GE
1471	**718**	**833**	**428**	**638**	**290**
	48.8%		**51.4%**		**45.5%**

The z-value of 2.258 corresponds to a p-value of 0.012, indicating rejection of the null hypothesis again is warranted. The GE passing rate earned by intern-taught students is higher.

GE Mathematics Grade Distributions

GE math course grades of all ILE students who completed a general education math class were examined and converted to grade points. If a student took more than one GE math course, only the first GE math course completed was included.

Only 817 of the 834 who took a GE course are included in this computation since 17 of those students were simply granted "credit" for their GE math and no actual grade was provided. Students were granted 4 grade points for earning an A, 3.7 for an A-, 3.3 for a B+, 3.0 for a B,

etc. The students who earned credit but no grade were excluded from the GPA calculations. Students who earned "no credit" were included in the calculations and were granted 0.0 grade points.

The grade point average earned by the combined group of 817 who took a GE math course was computed at 1.962. The grade point average earned by the intern-taught group (n = 481) was 2.01. The grade point average earned by the faculty-taught group (n = 336) was 1.90. The data produces a t-value of 1.45 corresponding to a p-value of .074. The null hypothesis can not be rejected. Though the difference in grade point means is not statistically significant at the 95% confidence level, the interns produced a mean that was 6% higher than that produced by faculty. This data is summarized below together with p-values for a 1-tailed t-tests assuming equal variances in the populations.

ALL GE CLASSES		COMBINED	INTERNS	FACULTY
GRADE AVE		1.962	2.008	1.904
STANDARD DEV		1.087	1.069	1.111
N		817	481	336
TTEST	0.074			

Comparative GPA Data Sorted by Course

CSU Chico offers several different mathematics courses that satisfy the GE requirement. These courses vary widely in their degree of difficulty. If one group all took calculus for their GE math course while the other all took math for liberal arts majors, similar overall grade point distributions would not indicate similar developmental teaching results. To examine this question student records were sorted by GE course taken. T-test statistics were computed for

each GE course. Transfer grades were excluded and only grades for courses taken at CSU Chico were included in this analysis. The results are provided below.

MATH 50AB'S (elementary ed.)		COMBINED	INTERNS	FACULTY
GRADE AVE		1.923	2.063	1.805
STANDARD DEV		1.031	1.154	0.908
N		118	54	64
TTEST	0.088			

MATH 10'S (liberal arts math)		COMBINED	INTERNS	FACULTY
GRADE AVE		2.105	2.152	2.042
STANDARD DEV		1.041	0.982	1.1145
N		438	251	187
TTEST	0.136			

MATH 45'S (business math)		COMBINED	INTERNS	FACULTY
GRADE AVE		1.620	1.713	1.446
STANDARD DEV		1.125	1.071	1.224
N		69	45	24
TTEST	0.175			

MATH 5'S (prob and stat)	COMBINED	INTERNS	FACULTY
GRADE AVE	1.873	1.831	1.986

STANDARD DEV		**1.104**	**1.113**	**1.084**
N		131	96	35
TTEST	**0.240**			

MATH 4 & 6'S (trig / precalc)		COMBINED	INTERNS	FACULTY
GRADE AVE		1.519	1.766	1.142
STANDARD DEV		1.245	1.253	1.166
N		48	29	19
TTEST	0.045			

MATH 46 & 7'S (calculus)		COMBINED	INTERNS	FACULTY
GRADE AVE		1.742	1.667	1.817
STANDARD DEV		1.309	1.379	1.361
N		12	6	6
TTEST	.427			

It is of interest to note that in calculus courses (math 46 and math 7, n=17) and statistics (math 5, n=131) the faculty-taught group earned slightly higher grades. The most significant difference is in the group of students taking pre-calculus classes (math 4 and math 6, n=48). The p-value of 0.045 is sufficient to reject the null hypothesis and conclude that, with respect to trigonometry and precalculus, the intern-taught group performs significantly better than the faculty-taught group. For all other course categories, the p-values indicate no statistically significant differences between cohorts of ILE students taught by interns compared to those taught by regular faculty, though in most GE courses cohorts taught by interns earned higher mean grades than those taught by regular faculty.

Conclusion

The mathematics histories of ILE students between 1991 and 1999 reveal significant differences in the ILE completion rates, general education enrollment rates, and general education passing rates. In each case the intern taught group out performed the faculty group. Though the intern-taught group earned higher grades on average in their subsequent general education math course, the difference was not sufficient to reject the null hypothesis. The data does not reveal significant differences in grades earned between the two groups in any specific general education mathematics course, except precalculus/trig. Intern-taught students earned statistically higher grades. The data clearly shows that the interns are doing a very good job compared to regular faculty.

References

Allan, B., Bartek, B., Melton, F., Runk, P., & Schaffer, L., 1995. Exemplary practices: Cost effectiveness in developmental education. 1992-1995 grant project. *Results of the survey of developmental education practices (Report No. JC 950 500)*. National Center for Research on Teacher Learning, East Lansing, MI. ERIC ED 387 195

Cohen, A. M. & Brawer, F. B., 1996. *The American Community College* (3rd ed.) Jossey-Bass, San Francisco.

Cohen, D. (ed.), 1993. Standards for curriculum and pedagogical reform in two-year college and lower division mathematics. American Mathematical Association of Two-Year Colleges. ERIC ED 362 248

Davis, J., 1999. Developmental course-taking in community colleges. University of Illinois at Urbana-Champaign. ERIC

Eiseman, J., Fairweather, J., Rosenblum, S., & Britton, E., (1996) *Case Study Summaries from the Evaluation of the Division of Undergraduate Education's Course and Curriculum Development Program* , Andover MA: The NETWORK

Fisher, W., & Ford, R., (1999). An Undergraduate Intern Model for Mathematics Teacher Preparation, *Journal of Math and Science* [**2**] p71-90

Ikenberry, S. O. & Stix, N., June, 1998. Should colleges offer remedial education programs for students? Symposium conducted in *Insight on the News, Washington Times Corporation*, Washington, DC.

McGregor, E. N. & Attinasi, L. C., Jr., 1996. Developmental course-taking and subsequent academic performance at Pima Community College (Report No. JC 970 574). National Center for Research on Teacher Learning, East Lansing, MI. ERIC ED 413 018

Miller, K. J., 1996. Developmental education at the college level. *Fastback 404 (Report No. HE 030 001*). National Center for Research on Teacher Learning, East Lansing, MI. ERIC ED405763

National Council of Teachers of Mathematics; (1989). *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA: NCTM

National Council of Teachers of Mathematics; (1991.) *Professional Standards for Teaching Mathematics*. Reston, VA: NCTM

National Science Foundation Technical Review Committee, (1996) Evaluation of the Division of Undergraduate Education's Course and Curriculum Development Program, Andover MA: The NETWORK

Weissman;, J., Bulakowski, C., & Jumisko, M. K., 1997. Using research to evaluate developmental education programs and policies. In J.M. Ignash, ed., *Implementing effective policies for remedial and developmental education, New Directions for Community Colleges: No. 100*, p. 73-80. Jossey-Bass, San Francisco.

Weissman;, J., Silk, E. & Bulakowski, C.,1995. Assessing developmental education through student tracking. Association for Institutional Research Annual Forum, Boston, May 29, 1995.

Zhai, M. & Skerl, J., 1999. The impact of remedial mathematics courses on student college-level mathematics performance and persistence. West Chester University, PA. ERIC