Remedial Mathematics Students:
A Randomized Controlled Trial Comparing
Traditional Remediation and Introductory Statistics

Objective

The purpose of this experiment was to determine whether remedial mathematics students would be at least as successful in passing college-level, introductory statistics with extra support as they would be in passing traditional remedial elementary algebra.

Theoretical Framework

Nationally, colleges assess about 60% of new college freshmen as needing remedial (developmental) courses (Grubb et al., 2011). In addition, less than 50% of students assigned to remediation complete the whole sequence, and students designated as remedial are less likely to complete college (Bailey & Cho, 2010; Bonham & Boylan, 2012).

Remedial courses, particularly in mathematics, constitute the largest specific blockage to students graduating with a college degree. This completion challenge may be due to the additional time, expense, and/or stigma involved in having to take these courses. Helping remedial students to complete their remediation could significantly increase the percentage of Americans who have college degrees, widely acknowledged as critical for a positive national economic future (http://chronicle.com/blogs/ticker/percentage-of-young-americans-with-college-degrees-increases-slightly/45499). In fact, it has been stated that: "providing effective 'remedial' education would do more to alleviate our most serious social and economic problems than almost any other action we could take" (Astin, 2000, p. 130).

The City University of New York (CUNY) assessed 69% of its 18,434 fall 2012 new community college freshmen as needing remediation in mathematics, and only 38% of students who started the highest-level mathematics remedial course (elementary algebra) in fall 2012 passed that course. At CUNY, as is the case nationally, the need to pass remedial mathematics delays or prevents more students from graduating than any other academic cause (see Attewell, Lavin, Domina, & Levey, 2006).

It should also be noted that remedial students are more likely to be members of underrepresented groups than are students entering college with no remedial needs. Thus

remedial needs could be contributing to the lower probability of students from underrepresented groups completing college degrees (Attewell et al., 2006).

CUNY is one of the most diverse universities in the nation (see Tables 1 and 2). Further, among entering fall 2013 associate degree-seeking freshmen at CUNY community colleges, 66% of White and Asian students (combined) were designated as needing remediation, compared to 76% of Black and Latino students (combined). Thus, at CUNY, as is the case nationally, students from underrepresented groups are more likely to enter college with the difficult challenge of needing to complete remedial courses prior to beginning college-level work.

One approach for addressing the large proportion of students for whom remedial mathematics is a block to a college degree is simply to place them in college-level courses which, it is claimed, many of them can pass. However, analyses of the success of remedial students taking college-level courses, which have been primarily quasi-experimental, have yielded conflicting results (Calcagno & Long, 2008; Moss, Yeaton, & Lloyd, 2014; Rodriguez, 2014; Scott-Clayton & Rodriguez, 2012).

A related approach is to place many such students in a college-level, credit-bearing mathematics course but with extra support. Two examples of this approach are the Accelerated Learning Program (ALP) for remedial writing students at the Community College of Baltimore County, and a similar program with remedial mathematics students at Austin Peay State University. However, although both programs have shown encouraging results, research involving controlled experiments has not yet been conducted with either (Boatman, 2012; Jenkins, Speroni, Belfield, Jaggars, & Edgecombe, 2010).

Methods

We used a randomized controlled trial to determine whether students, assessed by their community colleges as needing an elementary algebra (remedial) mathematics course, could instead succeed at least as well in a college-level, credit-bearing introductory statistics course with extra support (a weekly workshop).

We randomly assigned one-third of the participants to one of three types of courses: traditional elementary algebra; traditional elementary algebra plus a weekly workshop; or college-level, credit-bearing, introductory statistics plus a weekly workshop. The statistics course was a standard introductory statistics course. The weekly workshops were each two hours in length. Students assigned to elementary algebra with workshops or statistics with workshops were required to attend the workshops, which were facilitated by a trained, supervised, advanced undergraduate student (the workshop leader). In addition to leading their workshops, each workshop leader also attended the regular class sessions with the students in his/her workshop. During the workshops the students, individually and in groups, reviewed and discussed what they had learned so far, including the specific topics that they were finding difficult. Thus, in comparison to

traditional remedial mathematics students, this experiment treated such students differently in three ways: by placing them into a college-level instead of a remedial course, by placing them into introductory statistics instead of the elementary algebra course, and by the addition of a weekly workshop for extra support.

The experiment was conducted at three urban CUNY community colleges: Borough of Manhattan Community College (BMCC), Hostos Community College (HCC), and LaGuardia Community College (LCC). Most of the students at these three colleges need remediation and are from underrepresented groups (see Table 3).

There were 717 participants combined across the three colleges. Their mean age was 21.0 years (SD = 5.4), and 54.0% of them were female. At the time of their recruitment into the experiment, participants were not intending to major in a subject requiring college algebra.

Prior to the start of the fall 2013 semester, at each college, research assistants spoke with or emailed students whose mathematics placement was (remedial) elementary algebra, describing the experiment to these students. Students indicated their desire to participate by signing a consent form. We then randomly assigned them to one of the three course types (Group R: traditional elementary algebra; Group RW: traditional elementary algebra plus a weekly workshop; or Group SW: college-level, credit-bearing, introductory statistics plus a weekly workshop). To control for instructor effects (Weiss, 2010), a full-time faculty member taught one section of each of the three types of courses, with a total of four sections of each type (and thus four participating full-time faculty members) at each of the three colleges. Most of the instructors had prior experience teaching both elementary algebra and introductory statistics.

Data Sources

The data consisted of each participant's fall 2013 college grades, demographic information, high school records, and placement test scores.

Results and Conclusions

Table 4 shows the overall pass rates of the students who started each of the three types of course. The pass rate for Group R (39%), traditional remedial elementary algebra, is similar to the overall pass rate for the same course the preceding year at the same colleges (37% in fall 2012). The pass rate for Group SW (56%), college-level introductory statistics with a workshop, is less than the overall pass rate for introductory statistics at these colleges in the preceding year (69%).

Although adding the workshop to the traditional remedial course resulted in a higher pass rate for Group RW as compared to Group R (from 39% to 45% of the students who started the course), this difference does not reach statistical significance with these

sample sizes ($p = .220$). However, the greater pass rate of the students in Group SW as compared to either Group R (56 vs. 39%) or Group RW (56 vs. 45%) is significant ($p < .001$ and $p = .019$, respectively). Students in Group SW were about 10 percentage points more likely to pass than those who were in Group RW, even after controlling for students' mathematics skill levels (Compass scores), motivational variables (full- vs. part-time status, early consent to participate), demographic variables (age, gender, race, and first language), and instructor variables (tenure, years of experience). The average marginal effect was .098 (95% confidence interval [.012, .185].

In order to determine which remedial mathematics students might be most likely to succeed in college-level introductory statistics, we examined the relationships between passing statistics and various student characteristics. First, within Group SW, of the 217 students who had Compass (placement) test scores, these students' final grades are positively correlated with their scores on the two components of the Compass (component 1 [arithmetic]: $r[215] = 0.135$, $p < .05$; component 2 [algebra]: $r[215] = 0.292$, $p < .01$). Examined in another way, of the 105 Group SW students with a score of greater than or equal to 43 on Compass component 1 (arithmetic), and a score of greater than or equal to 19 on Compass component 2 (algebra), 71 (68%) passed statistics (almost identical to the 69% pass rate in introductory statistics at these three colleges in fall 2012, as shown in Table 4). Group SW's students' final grades are also positively correlated with these students' overall high school grade point averages ($r[167] = 0.231$, $p < .01$;), as well as with their high school grade point averages for mathematics ($r[114] = 0.260$, $p < .01$; see Bowen, Chingos, & McPherson, 2009, for similar findings regarding high school grades and college success). Further, Group SW's final grades are negatively correlated with the dates at which these students agreed to participate in the experiment and registered for the class ($r[244] = -0.152$, $p < .05$).

Table 5 shows the numbers of credits attempted and earned by the three groups of participants in fall 2013, the semester in which the experiment was conducted. The students in Group SW both attempted and earned significantly more credits than did the students in the other two groups.

Table 6 shows the percentage of the experiment's participants who re-enrolled in the following semester and, for those students who did enroll, the mean number of credits they attempted. Group SW's participants attempted more credits, but this difference did not reach statistical significance ($p = .172$). Continuing research will be needed to determine whether Group SW's students will continue to exceed the other two groups in terms of total earned credits.

Adding a weekly workshop to a traditional remedial elementary algebra course seemed to improve students' performance above the usual (low) pass rate. However, students in college-level introductory statistics with a weekly workshop passed at an even higher rate. Students with relatively high placement test scores and grades in high school, and students who registered for their classes relatively early, were particularly likely to pass the statistics course.

Due to ethical considerations and CUNY remedial mathematics policies, we could not place remedial mathematics students into introductory statistics without any additional support, and thus could not directly assess the role of the weekly workshop in the relatively high pass rate of the students randomly assigned to introductory statistics (Group SW). However, the results comparing Groups R and RW (elementary algebra without and with the workshop, respectively) suggest that the weekly workshops were a useful factor in the relatively high pass rate of Group SW.

Given that the course content for Groups R and RW (elementary algebra) was different from that for Group SW (statistics), it is also not possible to assess whether the students in Groups R and RW learned more or less than the students in Group SW. However, what can be stated definitively is that, with instructors who were, in most cases, experienced at teaching both elementary algebra and statistics, more students passed statistics than passed elementary algebra. Further, it can be argued that, for students who do not need college algebra for their majors, as was the case for the participants in the current experiment, statistics is ultimately a more useful quantitative course than is college algebra (see http://www.carnegiefoundation.org/statway).

Significance

Many remedial mathematics students can be successfully placed into college-level statistics with extra support. Such placement may help these students progress more quickly to a college degree, incurring less personal, college, state, and federal expense, and may also decrease any stigma that these students feel in being labeled remedial. Placing some remedial mathematics students in college-level statistics with extra support may therefore result in higher graduation rates, including for students from underrepresented groups, students who are more likely to need remediation than are students from other groups.

Table 1

Diversity of Fall 2013 CUNY Undergraduates

	Percentage of Students		
Asian	Black	Latino	White
20%	26%	30%	24%

Table 2

Demographics of CUNY Community College Students

Characteristic	Percentage of Students
Born outside U.S.	40%
First language other than English	45%
First in family to attend college	51%
Pell recipient	57%

Table 3

Demographics of Students at Borough of Manhattan Community College, Hostos Community College, and LaGuardia Community College

College	Number of First-Time Freshmen	Percentage of These Students Needing Remediation	Percentage of Students Who Are White
BMCC	5403	67%	12%
HCC	1237	74%	3%
LCC	3008	65%	16%

Table 4

Pass Rates in the Three Course Types

Non-Research Sections Fall 2012:	Research Sections Fall 2013:			Non-Research Sections Fall 2012:
	Group R:	Group RW:	Group SW:	
Elementary Algebra	Elementary Algebra	Elementary Algebra + Workshop	Introductory Statistics + Workshop	Introductory Statistics
36.8% (n=5573)	39.3% (n=244)	44.9% (n=227)	55.7% (n=246)	69.0% (n=4149)

Notes. Group R consisted of traditional remedial elementary algebra, Group RW consisted of traditional remedial elementary algebra plus a weekly workshop, and Group SW consisted of a college-level, credit-bearing, introductory statistics course with a weekly workshop (Group R compared to Group RW: $X^2[1] = 1.508$, $p = .220$; Group R compared to Group SW: $X^2[1] = 13.125$, $p<.001$; Group RW compared to Group SW: $X^2[1] = 5.465$, $p = .019$). The n values indicate the number of students who started each of these three types of courses, and the percentage values indicate the percentage of the starting students who received a grade of pass (elementary algebra) or a grade of D or above (statistics).

Table 5

Mean Number of Credits Attempted and Earned

Group	n	Attempted in Fall 2013* M(SD)	Earned in Fall 2013** M(SD)	Earned by Start of Spring 2014*** M(SD)
Group R: Elementary Algebra	244	8.9(3.6)	6.1(4.5)	7.8(7.2)
Group RW: Elementary Algebra + Workshop	227	8.7(3.3)	5.7(4.2)	6.8(5.8)
Group SW: Introductory Statistics + Workshop	246	12.1(3.5)	8.3(5.1)	9.3(6.7)

* $F[2,714] = 74.765$, $p < .001$

** $F[2,714] = 22.705$, $p < .001$

*** $F[2,714] = 8.465$, $p < .001$

Table 6

Spring 2014 Re-Enrollment of Participants

Group	Percentage Who Re-Enrolled*	Number of Credits Attempted M(SD)**
R	85%	10.9(4.0)
RW	81%	10.8(4.0)
SW	85%	11.5(4.4)

*The differences among the groups were not significant ($\chi^2[2] = 1.88$, $p = .391$).

**The differences among the groups were not significant ($F[2,598] = 1.76$, $p = .172$).

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