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The Effect of Supplemental Web-Assisted Exercises on Student Performance in Remedial Algebra

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Abstract

The frustrations and difficulties that students placed in a remedial mathematics course experience are compounded by low pass-rates especially when there are exit exams associated with these courses. The standard classroom pedagogy of writing on the blackboard, followed by explanation fails to reach many weaker students who often appear passive in their approach to learning mathematics. Technology, in particular web-based technology with its versatility and accessibility, holds the promise of actively engaging students and its use has experienced tremendous growth in mathematics education. This article documents the improvement of students' performance on their exit exam through the introduction of a web-based course management system, used as a supplement to direct "traditional" instruction at an urban community college in the City University of New York (CUNY) system. This process expands the role of the instructor to include class manager of online homework and encourages students to become more active in their learning process.

I Literature Review

Remediation and Low Pass-Rates

Remedial courses are a wide spread phenomena in education. The National Center of Education Statistics reports that, in the Fall of 2000 over 70% of U.S. colleges and universities offered remedial courses in mathematics (typically 2 courses). Public two-year colleges were more likely than other types of institutions to provide remedial education (97%). Furthermore, students in public community colleges spend much more time in remediation than other postsecondary institutions in the U.S. (Owings,J.,2000)

The influx of students into community colleges with deficient study skills in mathematics has led to low pass rates in these remedial classes and low student retention at these institutions. A longitudinal study of 12th grade graduates from 1992 to 2000 by Clifford Adelman of the National Center of Education Statistics reported that while, 65% of the

students who did not require remediation obtained a Bachelors or Associate degree in this time frame only 37% who required a remedial mathematics course did so by the year 2000. (Adedman,C.,2004)

The Promise of Technology

The traditional method, of lecture accompanied by exercises on the blackboard, "chalk and talk paradigm" (Engelbrecht & Harding I, 2005, p.236) which is associated with the objectivist or instructivist view that, learning is the transmission of knowledge from the teacher to the learner, is clearly not working for these weaker students. Englebrecht and Harding commenting on the dramatic increase in the use of technology in mathematics education note: "The Internet has seen phenomenal growth over the last few years, and similar growth is expected for the e-learning sector." (Engelbrecht & Harding I, 2005, p.235) In a review article, Kaput and Thompson use the analogy of, "deep-water ocean waves," (Kaput and Thompson, 1994, p.676) in reference to the effect of technology on mathematics education and its research. They note that technology has produced, "tidal changes" in creating a "pedagogical shift to more active and responsible engagement on the part of the students." (Kaput and Thompson, 1994, p.678)

While most mathematical educators would grant the positive effect on students of accessible and interactive mathematical exercises, Gilbraith notes there are those who bemoan the lack of, "solid research evidence validating the nearly boundless optimism of technophiles." (Gilbraith, 2006, p277) Likewise, Kaput and Shaffer sound a cautionary note when they state, "rhetoric that we hear about computers today was used in the past about motion pictures, radio, film strips, television and other new media," (Kaput and Shaffer,1994,p.98) yet despite this cautionary note they argue that, computational media is qualitatively different from many of the technologies that have promised educational change in the past and failed to deliver, they compare its radical effect to that of the printing press, "the printing press and computational media, have profound cognitive and social consequences." (Kaput and Shaffer, 1994, p.114)

EngelBrecht and Harding state that, educational literature reflects a paradigm shift linked to education and the web due to the, "anytime, anywhere promise." (EngelBrecht and Harding,I, 2005, p.236) They site authors who argue that, the paradigm shift should occur in the interaction between pedagogy (from instructivist to constructivist). This constructivist approach would involve, "shifting from teaching and the transfer of knowledge, to learning

and the facilitation of learning processes, supported by appropriate educational environments." (EngelBrecht and Harding,I, 2005 p.237) This observation on the interaction between classroom instruction and use of web-based technologies can be viewed as separate (albeit related) strands first, the shifting role of the instructors from lecturer to a class manager who interprets, "the actions of students with technology, intervening appropriately," (Laborde, 2007, p.73) and second, the introduction of constructivism into online pedagogy.

While there are many success stories of authors using constructivist material, Graff and Lebens argue against the use of constructivist exercises and in favor of exercises that offer direct instruction for weaker students, "constructivist-inspired reform pedagogy does not serve the needs of all target groups and has adverse effects on low achievers. "(Graff,M., Lebens, M.,2007, p.98) In a case study with web-based exercises that offered direct instruction these authors conclude that, "web-based learning can significantly enhance the mathematics performance of a socially disadvantaged and ethnically diverse student population." (Graff and Lebens, 2007, p.102)

This article makes no claims on the constructivist versus direct instruction debate however, the eloquent remarks of Galbraith are most appropriate, "the success or failure of any teaching approach resides ultimately in the quality with which students engage the learning mediums provided." (Gilbraith, 2006, p.279)

The web-based software used in this teaching-research study was a course management system (MathxI/MyMatLab) developed by the textbook publishing company. (Pearson) It closely followed the text, for each homework problem in the text there was as a corresponding problem in the web-based system. Thus, this case study like that conducted by Graff and Lebens uses e-exercises based on direct instruction with the goal to enhance, "course delivery by engaging students in active learning, they (students) learn at the time, in the place, and according to the style that best suits them." (Speckler, 2005, p.2)

Taxonomy of Web-assisted Exercises

Kaput and Thompson (Kaput and Thompson, 1994) list three criteria for web-based instruction to be effective: first, it must be interactive second, support service must be available in the learning environment –as opposed to offline and third is connectivity i.e. the software must link students to students and students to instructors. Czaes et. al. (Czaes, et. al. 2006) analyze in more detail the didactic interactive-support environment that web-based instruc-

tion should provide: first, a help button to provide, hints or "explanation on a specific difficulty" second, a place for student input or answers and third feedback this can be "a simple analysis of the student's answer" as well as "a detailed solution to the problem, that students can read, understand and, compare it to their own solution." (Czaes, et. al., 2006, p.331) The software used had multiple aspects of tutorial assistance: there was a HELP SOLVE button in which students assisted by the software solved the exercises in a step-by-step manner, a SIMILAR EXERCISE button which allowed students to work out the problem while viewing a similar exercise being solved. The students also had access to visual/audio online tutorials for selected exercises, as well as textbook pages explaining the appropriate content. In addition to homework, students could take tests, and quizzes online all of which were graded and recorded for the instructor. Thus, the software clearly satisfies the criteria set forth by Kaput and Thompson.

The web-based exercises, like the algebra textbook they accompanied, began at the operational level, in which students were told what operation to use when asked to solve a problem and progressed to problems in which students had to determine what strategy, procedure or sequence of procedures was appropriate to solve a problem. In this, it would appear to follow the recommendations set forth by Fitzsimmons and thus offer the hope of being able to: "reintegrate remedial or weak students into the class." (Fitzsimmons, 2005, p.772)

II Methodology

Student's Frustrations with Remedial Classes

Sierpinska in (Sierpinska,2006) looks at the sources of frustration in students of "prerequisite" or remedial mathematics courses at the college level. Sources of frustration include: the fast pace of the course, inefficient learning strategies, lack of moral support from teachers, and their own poor performance. These students' sentiments express a lack of confidence in their own ability and a sense of disappointment in themselves and the educational system. These frustrations are compounded even more when students are unable to pass exams mandated for exit from remediation and are thus unable to proceed with their education, such as is the case in the CUNY system.

Background of the Study

Hostos Community College with a student enrollment of approximately 4,700 students is

situated in the 16th Congressional District of the South Bronx. The majority of Hostos students (52.3%) live in this area; where the residents are largely poor underserved (82% of Hostos students are in households that earn less than $30,000) and underrepresented Hispanics (90% minorities). Fewer than half of the Fall 2005 entering freshmen attended a New York City public high school and 80.3% required at least one remedial course, approximately 24% of the students at Hostos have a GED. (Hostos Office of Institutional Research, Hostos-OIR 2006)

Students at Hostos Community College (HCC) are given an exam for both placement into and exit from remediation. The pass rate for the algebra portion of this exam (M2) has remained about 50% at this college since the test was first given in the Fall 2004 semester. As a community college in a system (CUNY) with open enrollment many of the students have poor attitudes towards mathematics and their own ability to pass. This attitude so frequently encountered among remedial mathematics students is succinctly described in a report by the American Mathematics Association of Two Year Colleges, Beyond the Crossroads, "They believe that they are to be passive in the learning process. They may also view mathematics as a collection of rules, facts skills and algorithms that need to be memorized." (AMTYC,2006) These students often appear to be waiting for the instructor as the ultimate authority to enlightenment them in the mysteries of algebra.

Class Methodology

The courses were taught in the traditional manner using lecture and blackboard, following the textbook. After the introduction of the web-based software the homework (which corresponded to the homework in the textbook) was assigned using this course management software; it was optional or supplemental for the students and approximately 70-85% of the class purchased and enrolled in this web-based course management system. The classes had a tutor session once a week however, this session did not have Internet access. After the introduction of the web-based software; both Baker and Dias would take their class to a lab with computer access early in the semester to register the students. One distinction between Baker and Dias in methodology; Baker continued to take his class to the computer lab about once every other week to insure the students continued to work on the web-based exercises Dias had success by requiring students to work with the software on their own.

For both instructors each homework assignment completed in the software with at least a grade of 60-70% was counted as one extra credit point on the corresponding partial exam

given during the semester. In this manner, students could clearly understand the relationship between the online work done and their grade.

Samples & Data Collection Part I

The primary data for this study consists of students' pass-rates on the elementary algebra portion (M2) of the ACT/COMPASS CUNY mandated exit from remediation exam. It was supplied by the HCC Office of Institutional Research (OIR). The instructors for the courses involved were Baker and Dias; data was collected both before and after the introduction of supplemental web-based supplemental.

Baker taught two elementary algebra courses from Fall 2004 to Spring 2006 before deciding to use the software and two elementary algebra courses using the course management software system between Fall 2006 to Fall 2007. Dias taught seven elementary algebra courses from Fall 2004 to Spring 2006 before using the web-based exercises/course management system. From Fall 2006 to Fall 2007 Dias taught three sections of elementary algebra using the web-based exercises.

The data on students' pass-rates per course is collected and distributed each semester by the HCC - OIR and distributed to the mathematics department, each individual faculty member is given a list of how their students did on the exit exam. The pass-rates of all sections in mathematics are recorded and compared both to the pass-rates of other semesters as well as the pass-rates of other CUNY colleges.

In the first part of the data analysis, a p-test was used to determine whether the improvement of students' pass-rates on the exit exam after the introduction of web-based exercises was statistically significant. First, a p-test was used to compare the pass-rate of Baker's and Dias' algebra sections using the course management system (experimental groups) to the departmental average (control group). The sample size was approximately 15-18 students per section (This number represents those students who completed the course and the exit exam) the standard deviations used were those of the department.

A second p-test was conducted to determine if the pass-rates after the introduction of the course management system (experimental group) was significantly higher than Baker's and Dias' sections before the use of web-based exercises (control group). The standard deviations used were those of the department.

Samples & Data Collection Part II

In the second part, the correlation of students' effort on the web-based homework, during the semester with their performance on the exit exam was analyzed.

A sample (approximately 75 students) representing all students who participated in the course management system during the semester, completed the course and the end of the year exit exam in the two algebra sections of Baker that used the software and the two algebra sections of Dias that used the software were further studied. The data collected for this part of the study consisted of student's scores on: the pre-algebra (M1) portion of the ACT/COMPASS exam at placement, the student's initial scores on the algebra portion (M2S) at placement, student's final scores on the M2 (M2F) when they exited the course, students' scores on the homework.

Note, the same exam is given for both placement into and exit from remediation; students had passed the M1 and failed the M2 to be placed into the algebra course and thus only the M2 portion of the exam was given at exit. The data was collected from the CUNY data base Student Information Management System (SIMS).

The course management system graded each homework assignment submitted by the students and recorded students' average grade on all assignments for the course instructor; it also recorded the number of assignments the student submitted. It was determined that, the average grade was not a valuable indicator of students' learning because a student who did only a few assignments (but received a high average grade) may not have learned as much from using the web-based exercises as one who received a lower grade but worked through out the course. Likewise, counting the number of assignments was biased towards students who only did a few of the easy exercises in each homework assignment and submitted many poor quality assignments. Thus, in analyzing the data from the course management system the homework score (HW) was determined as the product of the students average score with the number of assignments completed. As stated this data was supplied by the course management software and thus was impartial, easily attainable and provided a reliable indicator of the quantity/quality of students' effort using the web-based exercises during the semester.

The relationship between students' performance on the web-based exercises during the semester and their initial abilities in arithmetic and algebra in predicting their success on

the algebra exit exam was then analyzed. This analysis was conducted using a multivariable factorial Analysis of Variance (MANOVA) with students' performance on the supplemental homework exercises and their placement scores as independent variables to predict their exit scores at the end of the semester (dependent variable).

Results Part I Analysis by p-Test

Baker's pass-rates before using the course management system were below the departmental average.

Baker taught two elementary algebra courses from Fall 2004 to Spring 2006 before deciding to use the software. The pass rate on the algebra portion of the exit exam for these two classes (experimental group) was 48.3% (0.483) (total n = 29 students) compared to the departmental average (control group) of 54.7% (0.547) with standard deviation (SD) of 0.143. This represents a statistical significant difference at the 0.01 level.

Baker's pass-rates were above the departmental average after the introduction of the course management software.

Between Fall 2006 to Fall 2007, Baker taught two elementary algebra courses using the course management software system, (experimental group) the pass rate on the algebra portion of the exit test was 76.3% (0.763) (total n = 35 students) while the departmental average (control group) was 48% (0.48) with a SD of 0.148. This represents a statistically significant difference at the 0.01.

The increase in Baker's pass-rates before/after the introduction of the course management software was significant.

When the course pass-rate of Baker's sections, before using the software (0.483) with departmental SD (0.14313), n = 29 (control group), was compared to the course pass-rate, after the introduction of the course management system (0.763) with departmental SD (0.148), n = 35 (experimental group) the resulting increase is statistically significant increase at the 0.01 level.

Dias' pass-rates were above the departmental average both before and after the

introduction of the course management software.

Dias taught seven elementary algebra courses from Fall 2004 to Spring 2006 before using the web-based exercises (experimental group). The average pass-rate for students in these sections was 59% (0.59) (total of n =105 students) compared to the departmental average (control group) of 54.7% (0.547) with SD of 0.143. From Fall 2006 to Fall 2007 Dias taught three sections of elementary algebra using the web-based exercises (experimental group), the average pass-rate for these sections was 68.3% (0.683) (total n = 51 students) compared to the departmental average (control group) of 48% with SD 0.148. Both these represent a statistically significant difference above the departmental average at the 0.01 level.

The increase in Dias's pass-rates before/after the introduction of the course management software was significant.

When the pass-rate for Dias' seven courses before the introduction of the course management system (0.59), departmental SD (0.143), n = 105 (control group) was compared to the pass-rates for Dias' three sections after the introduction of the course management system, (0.683), departmental SD (0.148), n = 51 (experimental group) the resulting increase is statistically significant at the 0.01 level.
Clearly there is a documented statistically significant increase in students' pass- rate for both Baker's and Dias' algebra sections after the introduction of the course management system. However, one could argue that there may be other factors beside the use of the web-based software influencing student's performance. This leads to the next research question; to what extent does students' performance on the web-based homework correlate with their scores on the exit exam?
The answer to this question is found in part II when the performance of all students in both Baker's and Dias' sections who used the course management system were studied to determine the relationship between their: initial or placement scores in arithmetic (M1) and algebra (M2S), their homework scores (HW) during the semester as graded by the course management system and their exit scores on the algebra portion (M2F) at the end of the semester.

Results Part II Correlations and Regression Analysis

The correlations between students' initial placement scores, M1 and M2S, homework scores (HW) and their grade on the exit from remediation exam M2F are listed in table 1, for ap-

proximately n = 75 students.

Table 1 Correlation between M1, HW, M2S and M2F

	HW	M1	M2S	M2F
HW:Correlation	1	−.005	.072	.319**
Significance		.967	.542	.005
n	75	74	75	75
M1:Correlation		1	.263*	.238*
Significance			.023	.041
N		75	74	74
M2S:Correlation			1	.463**
Significance				.000
n			75	75

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed)

The homework scores correlated ($p < 0.01$ significance level) with students' scores on the exit exam. Their placement scores M2S on this same exam also correlated ($p < 0.01$ significance level) with their exit scores M2F as was to be expected. Their placement scores on the arithmetic or pre-algebra portion M1 correlated ($p < 0.05$) with their scores on the algebra exit exam but with a lower level of significance.

A multivariable linear regression analysis using the students' homework score HW and their initial placement score in algebra M2S as independent variables to predict their grade on the algebra exit exam M2F was conducted. See table 2 (n = 75).

Table 2 Regression Analysis to predict students' score on the M2F

Variable	Unstandardized Coefficient	Standard Error	Significance
Constant	−2.566	7.973	0.748
M2S	1.736	0.388	0.000**
HW	0.567	0.195	0.005**

** significant at the 0.01 level (2-tailed).

The R/R2 value for this model was 0.545/ 0.30 and thus approximately 30% of students' grades on the algebra exit exam (M2F) was determined by their placement scores (M2S) and their homework scores using the software during the semester.

III Conclusion

In conclusion, after the introduction of the Internet web-based exercises as a supplement to direct classroom instruction the students' pass-rates in Baker's classes on the end of the year ACT/COMPASS algebra exit exam (M2) went from below the departmental average to above the departmental average. Furthermore, the increase in students' pass-rates was determined to be statistically significant ($p<0.01$). Thus, the introduction of the course management system transformed the student's pass-rates on this exit exam in Baker's class; this alone demonstrates the power and influence that technology can have in improving student's learning in the mathematics classroom.

The pass-rate in Dias' algebra courses was above the departmental average both before and after the introduction of the course management software. However, when the pass-rates of students in Dias' algebra courses before the introduction of the course management software were compared to those afterwards there was an observed increase and this increase in pass-rates was statistically significant at the ($p<0.01$).

Thus, the conclusion from the first part of this case study confirmed the results of Graff and Lebens; web-assisted exercises that closely followed the standard textbook (based on direct-instruction) significantly enhanced students' mathematics performance on the end of the

semester ACT/COMPASS exit from remediation exam for a socially disadvantaged and ethnically diverse population at this urban community college in the CUNY system.

In the second statistical analysis, the scores that students received on the homework exercises proved to be more important than their initial pre-algebra scores and almost as important as their initial algebra scores in predicting how they would perform on the end of the semester exit from remediation exam. This result together with the results of part I indicate that, while there may have been other influencing factors, the students' web-based homework was an important and significant part of their success in passing this exit exam.

The authors note that while these results give statistically evidence of remedial students having success and thus reintegrating into a college level math class, we noted that many of the weakest students were not able to take advantage of the software, they seemed unable to understand the content of what they saw in the HELP and SIMILAR EXERCISE features of the software. More research is needed to look at the weakest students and analyze the effects of such web-based technology on their efforts to achieve success.

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