Leveraging technology to improve developmental mathematics course completion: Evaluation of a large-scale intervention

Claire Wladis
Kathleen Offenholley
Michael George
Borough of Manhattan Community College at the City University of New York

ABSTRACT

This study hypothesizes that course passing rates in remedial mathematics classes can be improved through early identification of at-risk students using a department-wide midterm, followed by a mandated set of online intervention assignments incorporating immediate and elaborate feedback for all students identified as "at-risk" by their midterm score. A sample of over 20,000 students was used to evaluate the intervention, which was implemented department-wide over several semesters in all developmental mathematics courses at a large diverse urban community college. The intervention was assessed by evaluating course passing rates (a proxy for passing rates on standardized exit examinations) and student time spent in the Intervention Lab. Students from semesters prior to the intervention were used as a control, with fall semesters compared to fall semesters and spring to spring, to control for possible variation in student enrollment. Highly statistically significant differences were found between student passing rates pre- versus post-intervention, with passing rates improving by as much as 50%. The size of this study and the diversity of the student population involved suggests that results are likely widely applicable to other institutions across the country. In particular, the interventions tested were chosen specifically because they can reasonably be implemented even across relatively large and diffuse departments with limited resources.

This is an Accepted Manuscript of an article published by Taylor & Francis in the *Community College Journal of Research and Practice* on 8 May 2014, available online: http://www.tandfonline.com/doi/abs/10.1080/10668926.2012.745100?journalCode=ucjc20.

Leveraging technology to improve developmental mathematics course completion: Evaluation of a large-scale intervention

Nationwide, about 60 percent of community college students enroll in at least one developmental, or remedial, math or English course (Bailey, Jeong, & Cho, 2010). At the University system which is the focus of this study, about 75% of students needed remediation in at least one developmental subject in 2011, and a quarter needed remediation in all three (Foderaro, 2011).

Developmental mathematics courses give students who come to college with inadequate preparation the chance to succeed in college level courses and therefore to obtain a degree (Brothen & Wambach, 2004; Day & McCabe, 1997). Yet pass rates in remedial math courses tend to be low compared to college-level classes. According to Achieving the Dream, an organization that collects data from 130 institutions across 24 states, only 36% of students referred to one level of developmental math completed the course in one attempt. If a student was referred to two levels of remedial math, the rate of completion in one attempt dropped to 26% (Achieving the Dream Data Notes, 2011).

Many recent reform efforts in developmental mathematics have focused on how technology, usually through computer homework and learning systems, can help students achieve college readiness. Epper and Baker (2009) report that most institutions that participated in mathematics course redesign through technology found significant improvements, but they note that it is not enough to simply add technology to the current curriculum and practices; it is important to use the technology to approach the course in a different way.

In the Fall of 2009, the mathematics department at the college which is the focus of this study undertook the task of reforming our developmental math courses, with the goal of improving student pass rates and mathematical understanding. We initiated a departmental midterm as an "early alert" structure in conjunction with required online intervention assignments for students who did not pass the midterm. The intervention assignments were constructed within online homework systems which gave students immediate and elaborate feedback on the problems they completed and afforded students the opportunity to redo assignments for which they had earned low grades. In this way, the use of technology was combined with a structure to screen for students at risk of failing the course.

Implementing reforms in developmental mathematics courses posed a formidable challenge, especially given the scale of our remedial program. The college offers approximately 225 remedial mathematics course sections containing approximately 5000 students taught by about 165 instructors each semester. Over three-quarters of these instructors are adjuncts teaching nine or fewer hours at the college, and as many as thirty of these may be teaching at the college for the first time each semester. Because our department is so large and diffuse, we sought a reform that could be uniformly implemented across hundreds of course sections taught by both full-time and adjunct faculty with a wide range of pedagogical approaches and degrees of teaching experience. After reviewing the research literature on recent successful reforms in developmental mathematics courses and considering the unique culture of our own department, a committee of mathematics faculty came to the conclusion that online homework technology, combined with an "early alert" structure which would identify which students would be required to complete the online intervention assignments, offered the most promising means of reaching every student across these many sections while still enabling us to make changes that were

compatible with our current program structure and our prevalent departmental culture of faculty autonomy in the classroom.

REVIEW OF THE RESEARCH LITERATURE

"Early Alert" Structures

Many universities have implemented some form of "early alert" structure by contacting students with poor grades or high absences early in the semester or at the midterm, but there is mixed empirical evidence of success. For example, Brothen, Wambach & Madyun (2003) and Hansen, Brothen, & Wambach (2002) found that contacting students either in paper form or via email to inform them of excessive absences or low grades and urging them to spend more time in the classroom had no significant effect on student performance in an introductory psychology class, and Rudman (1992) found that neither G.P.A., pass rates, credits earned, nor college retention at one year were significantly improved by sending failing students letters at the midterm urging them to talk with an advisor to improve their course performance. In contrast, Green (1996) found that when a student advisement center initiated contact with students through an "intrusive advisement" procedure, student retention rates in preparatory and basic skills courses improved significantly. These conflicting results may be the result of differences in what follows the identification of at-risk students: if the "early alert" structure does not compel the student to take some sort of specific action to improve their course performance, then the alert alone may not be enough to improve student outcomes.

The Role of Feedback

Feedback has traditionally been an integral part of the educational process in the form of grades, and both verbal and written comments from the instructor. However, a growing body of empirical research has shown that the type and timing of feedback can have a strong effect on its

effectiveness. In a review of the research literature, Kulik and Kulik (1988) found that in actual classroom studies, immediate feedback was more effective than delayed feedback in improving student performance on actual course assignments. And Chase and Houmanfar (2009) found that students in an introductory psychology course who were given "elaborate" feedback (defined as feedback that explained why an answer was correct or incorrect) on assignments did significantly better on exams and in the course than students who were only given "basic" feedback (defined as marking an answer as correct or incorrect and displaying the correct answer only).

Online homework systems are one way of providing students with immediate and elaborate feedback. These systems allow students to complete assignments online, and instructors can create assignments where students are given immediate feedback on each problem; where the feedback provides for step-by-step solutions of the problem or similar problems, videos, excerpts from the relevant sections of the textbook, and other forms of guidance; and where students are given the opportunity to redo the assignment multiple times, either with the same questions or with questions generated to be slightly different than the originals.

Online Homework Systems

A number of studies have used some form of immediate and/or elaborate feedback through online systems to improve student outcomes. For example, Yoshioka, Nishizawa, & Tsukamoto (2001) used an online system in conjunction with teaching assistants to provide students with immediate basic feedback on sets of paper exercises which students with low course grades were required to complete. They found that the better that students did on these problems, the better they did on the tests, and that students who participated in these sets of exercises had higher scores on tests of fundamental mathematics taken several years later when compared to students in the control group. More recently, Bassett & Frost (2010) redesigned the remedial course

sequence at their community college so that students were able to complete work at their own pace, completing online modules on their own followed by a proctored test, while class time was restructured to eliminate lecturing and increase time that students spent solving problems on the computer. The developmental course sequence was also replaced with course shells in which students could complete the modules, and students were only required to complete those modules which would be relevant to their particular major, reducing the number of remedial topics that most students would be required to master. They found that retention, passing rates, and post-test scores were all higher in the pilot sections.

The intervention evaluated in this article builds on the principals of "early alert" systems and on the benefits of both immediate and elaborate feedback by combining these approaches into a single intervention. Furthermore, unlike the types of changes made to courses by Yoshioka, Nishizawa, & Tsukamoto (2001) or Bassett & Frost (2010), this intervention does not require significant numbers of extra teaching assistants; a major restructuring of the way that faculty teach; or a change in the developmental course sequence as it is currently offered at a particular institution (although these changes may perhaps be used in conjunction with the reforms tested here to improve outcomes even further).

METHODOLOGY

Hypothesis

This study hypothesized that:

- Using a department-wide midterm as an "early-alert" system to identify at-risk students in remedial mathematics classes and then requiring students who fail the midterm to complete online elaborate-feedback intervention assignments will raise course passing rates and student passing rates on the university-wide final exam.

- The amount of time that students spend on the Intervention Assignments will be positively correlated with course and final exam passing rates.

Intervention Design

This intervention involved changes to all courses in the standard required remedial mathematics program covering arithmetic and/or elementary algebra. All requirements were implemented department-wide simultaneously. In particular, the following changes were made:

1. *Online homework* was implemented in all developmental mathematics course sections.
    - Faculty members on the department remediation committee worked throughout the summer to create common homework, quiz and practice test assignments for all algebra and pre-algebra classes. Faculty were not required to use these assignments in their classes, but students were required to purchase a version of the course textbook which also provided access to the online system, and the assignments were provided automatically in an online course shell for every course section so that allstudents would have access to them.
    - Full- and part-time faculty members attended workshops on the online system and the new program policies at the beginning of each semester, and regular paper and electronic memos were distributed to faculty at the beginning and throughout the semester to remind them of policy changes, offer technical assistances, and to remind them of upcoming deadlines. Further workshops on the online homework system and on program policies were also offered in the middle and at the end of the semester. Twice a semester, the Department Remedial Coordinator contacted faculty who did not seem to be using the system, to offer assistance with any technical issues and to solicit feedback from instructors on any problems they might be having with the new

course structure.

2. *A common departmental midterm* was created and administered to all students in all remedial sections during the seventh week of classes. Faculty members were required to submit student midterm results to the department.
3. All students who did not pass the midterm with a 70% or better were required to do common *intervention assignments*.
    - These assignments covered both the material on the midterm and the material leading up to the final exam.
    - Students who passed the midterm were exempt from completing these assignments, but encouraged to complete them to prepare for the final exam; all other students were required to complete them in order to qualify to take the final exam.
    - These assignments were in addition to any online or paper homework required by the instructor. Students were allowed to retake assignments as many times as they liked, until they obtained a 75% or better.
4. *An Intervention Lab* was provided. This lab was equipped with computers and tutors, and was open from the midterm until the final exam. In later semesters, the budget was not available for a separate intervention lab, but students continued to be supported in their intervention work by the math lab, which is also equipped with computers and tutors who are familiar with the online system[1].

[1] Have a separate intervention lab did seem to help the initial implementation of this reform effort proceed more smoothly, in particular because attendance at the intervention lab was required during the first semester. However, we were able to gradually reduce the hours of availability of the intervention lab and after several semesters to rely on the math lab to fulfill the function of the intervention lab without significant issues. Student attendance at the intervention lab reduced dramatically once the attendance requirement was removed, and even further but more gradually in later semesters. Anecdotal evidence suggests that this may be because both students and instructors were more comfortable with the technology and no longer needed as much outside assistance; for example, many instructors began registering their students into their online course section during class the first week of the

It is worth noting what was not changed: we did not require any change in instructional technique. The department continued to use two tries at a common departmental final, followed by the university-wide-administered COMPASS exam, as the exit criteria for the course. Students were required to pass the final exam by the second try, in order to be allowed to take the COMPASS exam. *Students could only pass the course if they passed the COMPASS exam.* Thus, passing rates in the course also measured the rate at which students passed the COMPASS pre-algebra and/or algebra exams, depending upon the subject of their developmental mathematics course.

Integrating Faculty into the Reform Project

One of the major challenges in the implementation of this new course structure was responding productively to faculty and student resistance. Some faculty members did resist these changes, typically when we as a department did not integrate them sufficiently into the process. So as the reform proceeded, the department took a number of steps to ensure that all faculty were included in the decision-making process. All new course materials were developed by a remediation committee, and all full- and part-time faculty members were invited to join. All changes in policy were first voted on by that committee, and then by the department as a whole, after the department had had sufficient time to discuss the reforms. The department took a number of steps to train instructors in the use of the new technology by offering workshops at the beginning and middle of the term, and to inform and regularly remind faculty members of the changes in policy by distributing electronic and paper memos. Surveys were also used to solicit faculty feedback, and student enrollment in online homework sections was monitored so that faculty who were not using the system could be contacted and offered one-on-one technical

---

semester. Now all students who would like technical assistance or mathematical tutoring are referred to the math lab.

assistance.

Student resistance was sometimes an issue when implementing this reform. For example, some students complained that they were being "punished" for failing the midterm by being required to complete the intervention requirements. In an attempt to change this impression, the department changed the wording on the syllabus and on intervention referral forms to say that all students were required to complete the intervention assignments, but that students who passed the midterm would be exempt (although because students who spent significant time on the intervention assignments did significantly better on the final exam, they were still strongly encouraged to complete them). Student resistance also seemed to decrease dramatically as instructors became more comfortable with the new course structure.

Research Design

This research used a quasi-experimental historically-controlled structure to compare the effects of the intervention on the passing rates of students in remedial courses. Because the intervention was implemented in fall 2009 for the first time, all students enrolled in remedial mathematics classes at the college in fall 2008 and spring 2009 were classified as the control group, and all students at the college enrolled in remedial mathematics classes in fall 2009 and 2010 and spring 2010 were classified as the experimental group. During the analysis, spring semesters were compared to spring semesters and fall to fall to control for possible seasonal variations in enrollment (e.g. possible higher proportions of repeaters enrolling in the spring).

At the time of the study, the college had four developmental mathematics courses: 1) MAT 010, a six hour course in arithmetic; 2) MAT 011, a three hour course in arithmetic; 3) MAT 012, a six hour course which combines elementary algebra with arithmetic; and 4) MAT 051, a

four hour course in elementary algebra[2]. Passing rates for each of these courses were assessed individually, and also combined to create a total for all remedial courses. Students are placed into each of these courses depending upon their scores on the computerized COMPASS placement tests in pre-algebra (arithmetic) and algebra. So students in the same remedial course in both the control and experimental groups were comparable with respect to placement test scores. Students were also required to pass the COMPASS pre-algebra or algebra examinations (depending upon the remedial course taken) in order to pass the remedial class in which they were enrolled. In this way, passing rates also served as a proxy for passing rates on the COMPASS exit examination, because no instructor was able to award a student a passing grade in the course if they had not passed the exit examination.

Data and Analysis: The dependent variable in this analysis was course passing rates. For each student included in the analysis, the student's final course grade, including withdrawal status, was collected. In the remedial courses at the college, the possible grades that could be assigned varied during the experiment as college policy changed: at all times students were either awarded a simple pass/fail grade, or they were awarded either a letter grade ranging from C- to A or a failing grade. No D grades were permitted in these courses. Any students with incomplete grades at the end of the semester were excluded from the analysis.

This study focused on two different independent variables in the analyses that follow. The first dependent variable was a categorical variable indicating whether or not a student was a part of the experimental group. The second dependent variable was a ratio-level quantitative variable indicating the number of hours a student spent in the Intervention Lab. Students swiped their

[2] Students who are required to take both arithmetic and algebra take either MAT 010 or MAT 011 followed by MAT 051, or take only MAT 012, depending upon their initial arithmetic placement score. Students with high enough arithmetic placement scores are required to take only MAT 051.

student ID upon entering and exiting the Intervention Lab, so precise measures for student time spent in the lab could be obtained.

To assess differences in passing rates between the control and experimental sections, the entire sample was used. To assess differences between passing rates based on time spent in the Intervention Lab, two approaches were used: 1) The passing rates of students who attended the intervention lab at least once were compared with passing rates for all students in the same semester; and 2) The passing rates of a random sample (chosen using Microsoft Excel's random number generator) of thirty students who spent at least twenty hours in the intervention lab during the first semester of the intervention were compared to with the passing rates for all students that semester. Standard *z*-tests for comparing two proportions were used to assess significance, and significance levels of 0.05 for statistical significance and 0.01 for high statistical significance were used.

Subjects: The total number of students for each of the five semesters was approximately 4000-5000 per semester, for a total sample size of 21,221. Just over 80% of incoming freshman at the college are placed into one of the remedial courses included in this study. At the college, approximately ten percent of entering freshmen hold a GED rather than high school diploma, and 32% come from homes where one or both parents never completed high school. About 42% of students have a household income below $15,000 per year, and about two-thirds below $25,000 per year, with about ten percent of students supporting children. About 15-20% of incoming students each semester are placed into English-as-a-second-language courses. Blacks make up about 34% of the students at the college, Hispanics 38%, and white and Asian/Pacific Islander groups each make up about 15% of the student population. The median student age is 22, and about two-thirds of students at the college are female.

RESULTS

Passing rates improved by a significant margin in all remedial classes when comparing pre- to post-intervention fall-over-fall and spring-over-spring. While most of the gains were obtained during the first year of the intervention, further improvements were also seen during each observed semester of the intervention.

Looking at the first semester of the intervention and comparing data fall-over-fall from 2008 to 2009 the passing rate rose from 31.9% to 43.7%, or 34.7% to 51.1% if WU[3] grades are excluded from the analysis (see *Table 1*). The passing rate for all courses accordingly improved by 37.1% after only a single semester of the curriculum changes, and by 47.1% if WU grades are excluded. In particular, approximately 500 remedial students passed their courses in fall 2009 who would otherwise have failed based on fall 2008 passing rates.

For the second semester of the intervention, comparing the spring semesters from 2009 to 2010, the passing rate rose from 28.1% to 36.7%, or 31.2% to 35.8% if WU grades are excluded from the analysis (see *Table 2*). Thus, the passing rate for all courses improved by 30.5% after two semesters of the curriculum changes, and by 46.8% if WU grades are excluded. Again, approximately 500 remedial students passed their courses in spring 2010 who would otherwise have failed based on spring 2009 passing rates.

For the third semester of the intervention in Fall 2010, these gains were improved further (see *Table 1*). Comparing data fall-over-fall (from 2008 to 2010) the passing rate rose from 31.9% to 47.4%, or 34.7% to 54.4% if WU grades are excluded from the analysis. Thus, the passing rate for all courses improved by 48.8% after three semesters, and by 56.6% if WU grades are excluded. All of the above results are highly statistically significant (α=0.01).

[3] WU grades are given to students who stop attending after the tenth week of classes.

In addition to overall increases in passing rates, there was also a relatively strong association between a student's attendance in the Intervention Lab or time spent on Intervention Assignments and his/her passing rate. In fall 2009, students were required to be physically present at an intervention lab in order to do the intervention assignments. That semester, a total of 2009 students failed the midterm. Of these, 70%, or 1410 students, visited the Intervention Lab, and 1418 logged into the intervention assignments online to complete work. Although students who fail the midterm are considered "at-risk," the passing rate for students who attended the Intervention Lab even once was 31.6% (see *Table 3*) -- higher than the passing rate of students as a whole in spring 2009, and comparable to the pre-intervention passing rates of all students.

The range of total time spent in the Intervention Lab over the course of the semester was 7 sec to 32 hrs, and so some students may not have spent a significant amount of time on the intervention work. In order to analyze the outcomes for students who actually completed the intervention requirement in the lab (rather than simply attended once or twice), we selected a random sample of 30 students who completed 20 hours or more in the Intervention Lab during the fall 2009 semester; these results can be seen in *Table 4*. Students who spent at least 20 hours in the Intervention Lab had a passing rate of 65% for their remedial courses, which is significantly higher than the general course passing rate of 43.7% for the semester, even though these students were already at higher risk of failing the course because they had already failed the midterm. This group of students who had the commitment to spend 20 hours in the Intervention Lab may have been somewhat self-selecting – perhaps they would have studied hard even without the intervention structure. However, the rise in overall pass rates indicates that

requiring students to complete Intervention Assignments likely did have a positive impact on student passing rates.

DISCUSSION

Variation in Passing Rate Improvements

This paper analyzes the improvements in passing rates during the first three semesters of the intervention, but the interventions described here have continued to be a permanent part of the college's developmental mathematics curriculum, and it is believed[4] that improvements in passing rates that were obtained in fall 2009 and 2010 have been sustained in subsequent semesters.

The greatest gains in course passing rates were seen in the three-credit pre-algebra course, Math 011. While the overall improvement for all courses from Fall '08 to Fall '10 was 48.8%, the Math 011 pass rate improved by 80.9%, suggesting that the intervention used in this study may be particularly effective for students who already have some mastery of the material. These students were placed in Math 011 rather than Math 010 because their Compass pre-algebra scores were higher; perhaps these are the students who most feel like they already know the material, so that the midterm functioned as an "early alert" for them more than others; or perhaps because these students had already mastered some of the material, the intervention assignments were more likely to be effective in helping them to master the remaining material. Further research exploring whether this intervention has a greater effect on students who were closer to placing out of remediation could perhaps be another fruitful area of research.

[4] The standardized exit exam which was used for many years at the university was discontinued shortly after the semesters included in this study, and as a result, course passing rates in subsequent semesters could no longer be used as a proxy for passing rates on the standardized exit examination, and are therefore not comparable to the passing rates used in this study. Thus, while course passing rates seem to have remained high, it is difficult to determine what the exact contribution of the intervention has been to the sustained higher passing rates. (As of the writing of this article, a new standardized exit examination is to be implemented in fall 2012.)

Furthermore, we note that while almost all improvements were highly statistically significant, the change in passing rates in the beginning algebra course MAT 051 was not significant in spring 2010. We believe that the reason for this was that the passing rate in MAT 051 on the departmental midterm in that semester was half the rate of the previous semester, dropping from 42% to 19%. After a combination of careful examination of the individual questions, student and instructor feedback, and some preliminary statistical analysis, the departmental committee charged with writing and revising the midterms determined that this was likely because the midterm form used in that semester was too difficult and/or contained invalid or confusing questions. As a result, the committee revised that midterm for subsequent semesters.

Possible Impact of the Difficulty of the Midterm on Passing Rates

This difference in course passing rates in MAT 051 during spring 2010 also points to an interesting tension that had to be continually addressed during the implementation of this project: if more students are identified as "at-risk" by failing midterm scores, then more students would be required to do the intervention work and therefore more students would benefit from the intervention practice; however, more students would also be likely to be discouraged from completing the course and/or be more likely to be disqualified from taking the final exam because they did not complete the intervention assignments, even though some of them may have the skills necessary to pass the final exit examination. We found that throughout the course of this intervention most courses had a midterm passing rate in the range of 40-60%, and so the results obtained in this study were obtained under the condition in which about half of all students who took the midterm passed it. The pattern observed with the MAT 051 midterm examination in spring 2010 suggests that passing rates as low as 20% on the midterm are likely

so low as to discourage too many students from completing the course, so that course passing rates overall may not improve as a result. Further research looking at the correlation between different midterm passing proportions and course completion rates could be fruitful in clarifying what the ideal range of midterm passing proportions might be in order to maximize student course completion[5].

Is it Necessary to Require Physical Attendance at an Intervention Lab?

Another important consideration during the design of this study was whether or not students should be required to go physically to an intervention lab to complete intervention assignments, or whether it would be effective enough for students to be required to complete the intervention assignments until they obtained a particular grade, without any kind of physical attendance requirement. Students were only required to spend time physically in the Intervention Lab during the fall 2009 semester; in subsequent semesters, students were instead required to obtain a 75% grade or higher on all Intervention Assignments, which they could complete in the Intervention or Math Labs with the help of tutors, or which they could complete at home or elsewhere. These changes were made because it was so difficult to provide enough lab space and tutors to serve all two thousand students each semester who were likely to be required to complete Intervention Assignments. In subsequent semesters, the Intervention Lab was available to students, should they need computer access or technical or tutoring help, but it was not required, and in these semesters a significantly smaller number (about 10-15% of those who attended during the first semester of mandated attendance) of students physically attended the Lab.

[5] Obviously the validity and reliability of the midterm examination is also an important consideration. During the implementation of this intervention, the department did undertake some preliminary analysis in an attempt to determine how reliable questions on the midterm examinations were, and a committee of faculty wrote and revised the exams each with the aim of ensuring validity. Our preliminary analysis suggested that the midterms seemed to be equally as reliable as the final examinations administered during these developmental courses.

Despite the lack of mandatory physical attendance in the Intervention Lab, student passing rates in these courses continued to rise during the second and third semesters of the intervention, so we suspect that mandatory physical attendance is not essential in obtaining significantly improved passing rates. However, because we did not compare groups of students in the same semester who were randomly assigned to either mandatory physical attendance requirements or requirements that did not require physical attendance, we must be careful about drawing any firm conclusions on this point. This is another area that may benefit from further research.

Study Limitations and Questions for Future Research

This study was not conducted using a random sample of students; rather it was implemented department-wide. It seems feasible to assume that students in prior semesters who were placed into remediation were likely comparable to students taking remedial courses during the study, especially since all students were placed into specific remedial courses based on the same scores on the college's math placement tests; however, without true randomization it is impossible to guarantee total equivalence on all factors that might contribute to student success and retention. Given the large effect of the intervention, it seems reasonable to conclude that the intervention was in fact effective, even if there is the possibility of reduced effect size with a true random sample; however, further studies are necessarily to see to what extent these results can be replicated.

It is also important to note that this particular course redesign did not include changes in teaching practices or student outcomes. It may be possible to obtain even more dramatic improvements if changes in pedagogy or curriculum were combined with the structural changes undertaken here.

CONCLUSION

At the college in this study, the mathematics department sought to improve outcomes in remedial courses by implementing a departmental midterm as an "early alert" structure to identify at-risk students followed by a mandatory set of online intervention assignments incorporating immediate and elaborate feedback for all students who failed the midterm.

The semesters in which this intervention was implemented corresponded to significant increases in course passing rates, with passing rates as much as 50% higher than those from comparable semesters prior to the intervention. Furthermore, passing rates also improved with each subsequent semester of the intervention, suggesting that the intervention was likely a significant factor in increasing these rates. In addition, attendance at the Intervention Lab and total time spent on Intervention Assignments also correlated strongly with higher passing rates, suggesting a possible causal relationship. For example, in this study, students who spent twenty hours over the course of the entire semester on intervention assignments had successful course completion rates that were approximately twenty-two percentage points higher than those of the average remedial student in the same semester.

REFERENCES:

Achieving the Dream. (2011, Jan./Feb.). Developmental education: Time to Completion. *Data Notes*, *6*(1).

Anderson, J. (2000). Cognitive Psychology and its Implications. New York: Worth.

Bailey, T., Jeong, D. W., & Cho, S. (2010). Referral, enrollment, and completion in developmental education sequences in community college. *Economics of Education Review, 29*(2), 255-270.

Baker, W., & Dias, O. (June 2008). The Effect of Supplemental Web-Assisted Exercises on Student Performance in Remedial Algebra, *Mathematics Teaching-Research Journal*, *2*(3)

Bassett, M. J. & Frost, B. (2010). Smart Math: Removing roadblocks to college success, *Community College Journal of Research and Practice*, *34*: 869–873.

Brothen T., Wambach C.A. & Madyun, N. (2003). Early Alerts II: An Experimental Evaluation, *Research &Teaching in Developmental Education*.

Brothen T., & Wambach C.A. (2004). Refocusing developmental education. *Journal of Developmental Education*, 28, 16–22, 33.

Chase, J.A. & Houmanfar, R. (2009). The Differential Effects of Elaborate Feedback and Basic Feedback on Student Performance in a Modified, Personalized System of Instruction Course. *Journal of Behavioral Education*. *18* (3), 245.

Day, P.R., Jr., & McCabe, R.H. (1997). *Remedial education: A social and economic imperative.* Washington DC: American Association of Community Colleges.

Epper, R.M., Baker, E.D. (2009). *Technology Solutions for Developmental Math: An Overview of Current and Emerging Practices.* Retrieved from http://polk.edu/businessandcommunity/officeofinstructionalresearchandreporting/Documents/technology-solutions-for-developmental-math-jan-2009.pdf

Findlay, M., & Cooper, H. (1983). Locus of control and academic achievement: A literature review. *Journal of Personality and Social Psychology*, 44, 419–427.

Foderaro, L. (2011). CUNY Adjusts Amid Tide of Remedial Students. *The New York Times*, March 3

Green, J. T. (1996). Effectiveness of Floyd College Studies 101 on subsequent student success. Unpublished doctoral dissertation, University of Alabama.

Hansen, G., Brothen, T., & Wambach, C. (2002). An evaluation of early alerts in a PSI general psychology course. *The Learning Assistance Review*, *7*(1), 14-21.

Kulik, J.A. & Kulik, C.I. (1988). Timing of feedback and verbal learning. *Review of Educational Research Journal*, *21*, 79-97.

Lenz, L. (2010). The Effect of a Web-Based Homework System on Student Outcomes in a First-Year Mathematics Course. *Journal of Computers in Mathematics and Science Teaching*, 29(3), 233-246. Chesapeake, VA: AACE. Retrieved from http://www.editlib.org/p/32318.

Nelson, E. S., & Kristi, E. M. (1995). The relationships among college students' locus of control, learning styles, and self-prediction of grades. *Education Research and Perspectives*, 22, 110-117.

Rudman, J. (1992). An Evaluation of Several Early Alert Strategies for Helping First Semester Freshman at the Community College and a Description of the Newly Developed Early 10 Alert Software (EARS). Irvine, CA: Irvine Valley College. (ERIC Document Reproduction Service No. ED 349 055).

Shepherd, S., Owen, D., Fitch, T. J., & Marshall, J. L. (2006). Locus of control and academic achievement in high school students. *Psychological Report*, 98, 318-322.

Stage, F. K., & Kloosterman, P. (1991). Relationships between ability, belief, and achievement in low level college mathematics classrooms. *Research and Teaching in Developmental Education*, *8*, 27-36.

Weiner, B. (1979). A theory of motivation for some classroom experiences. *Journal of Educational Psychology*, 7l, 1–25.

Yoshioka, T., Nishizawa, H, & Tsukamoto T. (2001). Method and Effectiveness of an Individualized Exercise of Fundamental Mathematics. *Community College Journal of Research and Practice*, *25*(5-6), 373-78.