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Improving students' mathematics achievements using classroom interventions

Alioune Khoule[1], Nana Osei Bonsu[2] and Hassan El Houari[3]*

Department of Mathematics, Engineering and Computer Sciences, LaGuardia Community College, CUNY, NY, USA

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Abstract

Increasing retention and success rates, using innovative techniques, is one of the core objectives in community colleges. Several researches have shown that interventions strategies boost such rates in high and middle schools. The purpose of this study is to examine how classroom interventions impacts student's mathematics achievements in a remedial mathematics course at a community college. This quantitative research used cluster sampling to obtain a sample of 44 students from two fundamental algebra sections in Fall 2018 semester at LaGuardia Community College, New York City, US. The instruments used in this study are the first and second attempts of two departmental exams and the final exam scores. After each departmental exam, students were divided into two groups, a basic and advance group, based on their performances on the exam. Each group had a 4-hour intervention session separately before they were given a second attempt for the departmental exam. The difference between the first and second attempt of departmental exam 1 and departmental exam 2 average scores were calculated to evaluate students' improvements after the interventions. Correlations were performed to assess the strength of the relationship between each departmental exam and the final exam. The result of this quantitative research showed that the classroom interventions helped students improve their departmental exams scores. However, departmental exam 2 intervention had more positive impact on the final exam scores than departmental exam 1 intervention.

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Introduction

Over the last few years, an increasing emphasis on low student success rates in remedial mathematics courses at the community college level has created an urgency to develop new strategies for improvement. Most community colleges have a 30 percent progress rate in these remedial courses, according to the National Council on Academic Transformation (Twigg, 2003). Furthermore, the overall completion rate, in three-years, for community college students nationwide was 24 percent for the 2000 cohort and 20 percent for the 2010 cohort (NCES, 2014). Although data on success rates vary among community colleges, the number of students placed in remedial mathematics courses is increasing, while completion and retention rates remain substandard or decreasing. Students are less likely to complete college mathematics across various stages of developmental courses (Bailey, 2009). Thus, these remedial mathematics courses have become an academic and career unyielding gatekeeper to college students' success. Colleges constantly search for solutions to increase the retention and success rates of students through mathematical curriculum and pedagogies. Nationwide, efforts to increase student success rates have been focused on implementing new strategies. For students experiencing mathematics difficulties, classroom interventions have become an essential aspect to improve student's mathematics ability, hence preventing subsequent failure.

In general terms, classroom intervention is a set of measures an instructor takes to help students improve in their area of weakness by removing educational barriers. This type of intervention which specifically addresses an

[1] Assoc. Professor, Department of Mathematics, Engineering and Computer Sciences at LaGuardia Community College, New York, USA **Email:** akhoule@lagcc.cuny.edu ORCID: 0000-0001-8795-8075
[2] Assoc. Professor, Department of Mathematics, Engineering and Computer Science, LaGuardia Community College, Long Island City, New York, USA **Email:** nbonsu@lagcc.cuny.edu ORCID: 0000-0003-3926-6407
[3] Corresponding author, Department of Mathematics, Engineering and Computer Sciences at LaGuardia Community College, New York, USA **E-mail:** helhouari@lagcc.cuny.edu ORCID: 0000-0001-6825-4515

"observed weakness" is called an Intentional Intervention (Lynch, 2019). Research indicates that students who struggle in mathematics can be successful given they receive additional instructional time and support (Burris, Heubert, & Levin, 2006). To be effective, this additional instruction and support must be in addition to and integrated with the regular classroom (Balfanz, Mac Iver, & Byrnes, 2006). A study provides eight concrete suggestions for instructors, principals, and school administrators, to improve their ability to succeed in the classroom (Gersten et al. 2009). This study used "Response to Intervention" to identify students who need assistance in mathematics and addressed the needs of these students through focused interventions. A study investigated whether students who are exposed to interventions programs will show growth in their mathematics achievements (Hines, 2016). Using a qualitative and quantitative method, the results revealed the effectiveness of the two interventions used and the relationships between academic growth and teacher perception. The target population was made up of middle school students.

Problem of the Study

Based on previous studies, whole-class mathematics interventions have shown the longest enduring effects on student performance (Griffin, 2004; Conner et al. 2009). The common goals for these interventions were to increase students' self-efficacy in mathematics and re-teach critical concepts and skills. Yet, most of these studies focused on middle school or high school students. This study will examine the effects of classrooms interventions on community college students' mathematics achievements in remedial courses.

Methodology

Research design

There are three major exams (2 departmental Exams and a CUNY Final Exam) in fundamental algebra that students must successfully complete to have a great chance of passing the class. Each exam includes 25 multiple choice questions. The departmental exams are taken online in the computer lab, during the fourth and the eighth weeks, using Lumen platform and the CUNY Final Exam is taken at the end of the semester in the school testing center. Students have two chances to take the departmental exams and the highest score is counted toward their grades.

The second chance of the exam is usually given a week after students take the first attempt of the exam. The departmental exams and final exam represent 65% of students' final grade and a student needs an average of 70% or higher to pass the course.

The group interventions were designed to re-teach missed concepts and skills based on student's performance on departmental exam 1 and departmental exam 2. The goals were to increase students' grades as well as their procedural flexibility in mathematics. The first intervention ran during the fifth week of class (after departmental exam 1) and the second intervention took place during the ninth week (after departmental exam 2). The step-by-step process of the interventions were as follows:

Departmental Exam 1:

Step 1: Students take the departmental exam 1 during week 4 of classes.

Step 2: Students, in each section, were divided into two groups based on their performance on the exam. Students who scored below 70% were placed in basic group (group 1) and those who scored above 70% were placed in the more advance group (group 2)

Step 3: Investigators designed a practice-problem worksheet for each group based on topics where students under performed

Step 4: Instructors and teacher assistants each ran a 4-hour intervention during week 7. For group 1, instructors conducted the intervention by giving a mini lecture of each of the topics needed, followed by a practice of the designed worksheet. Teacher assistants led the 4-hour intervention for group 2 in a separate room by just working on the designed worksheet.

Step 5: Students were given the second attempt to take the departmental exam 1 at the end of week 7

The same process was repeated for second departmental exam.

Participants

This study was conducted at LaGuardia Community College located in New York City, where the principal investigators worked as full-time faculty. The target population is made up of students who are enrolled in fundamentals algebra course. This course is a remedial mathematics course which consist of 9 sections during the 12-week session of Fall 2018. The average enrolment per section is 30 students.

Sampling and Sampling Procedure: The sampling strategy used in this quantitative research study was a cluster sampling. Out of 9 fundamental algebra sections offered in Fall 2018, two were randomly selected to form the samples of this research. In this study, the two fundamental Algebra sections were made up of 58 students. After withdrawals and drops, 44 students took all exams and participated in all research activities. The two sections were taught by adjuncts who had the same level of experience (7 years on average) teaching the course. A teacher assistant was assigned to each section to help students in and outside of the classroom. The fundamental algebra course meets seven hours per week: 4 hours lecture, 2 hours computer lab, and one tutoring lab hour led by the teacher assistant (TA). Students used a mathematics platform, OHM Lumen, a free Open Educational Resource (OER) software to complete their assignments including homeworks, quizzes and departmental exams.

Data Collection Tools

The instruments used in this study includes students' scores on departmental exam 1(1st and 2nd attempts), departmental exam 2 (1st and 2nd attempts) and final exam. The investigators designed four worksheets for the group interventions. Each group (group 1 and group 2) used two worksheets, one for the first intervention and one for the second intervention.

Data Analysis

The average scores on departmental exams and final exam for the basic group (group 1) and the advance group (group 2) were calculated to compare the groups' performances. The difference between the first and second attempt of departmental exam 1 and departmental exam 2 were calculated to evaluate students' improvements after the interventions. Finally, the correlations between the second attempt of each of the departmental exams (departmental exam 1 and departmental exam 2) and the final exam scores were performed to measure the strength of the relationship between each of the departmental exams and the final exam scores.

Results

Departmental Exam 1 Intervention

The first attempt of departmental exam1 was given during the fourth week of classes. Of the 44 students from both fundamental algebra sections that fully participated in this study, 22 students scored below 70 out of 100 points and were placed in group 1 and the remaining 22 students who scored at least 70 points were in group 2. The two instructors for both sections, each ran a 4-hour intervention for group 1 and their teacher assistants led the 4-hour intervention for group 2. The average scores of the first attempt of departmental exam 1 for both groups are summarized in Table 1. The exam report showed that students in group 1 had an average score of 54 out of 100 points, and struggled on questions related to algebraic sentences, linear inequality, rational equations, and linear equations. During the intervention, instructors focused on these topics by reviewing key formulas or concepts as well as practicing more related problems using the prepared worksheet.

Table 1.

Departmental Exam 1 Scores (First and Second Attempts Each Out of 100 Points)

	Departmental Exam 1		
Group	1st attempt average score	2nd attempt average score	Difference = 2nd attempt – 1st attempt
1 (n = 22)	54	69	15
2 (n = 22)	83	93	10

Students in group 2 averaged 83 out of 100 points on the first attempt of departmental exam 1 and generally struggled on questions related to algebraic expressions and linear inequality. The teacher assistants for both classes helped students in group 2 practice related problems using the prepared worksheet.

At the end of the interventions, students took the second chance of departmental exam 1 which had the same format but was a different version. Students in both groups performed better on the second attempt as compared to the first attempt (see table 1). The average score for students in group 1 went up by 15 points on the second attempt as compared to 10 points for students in group 2.

Departmental Exam 2 Intervention

For the first trial of departmental exam 2, given during the 8th week of classes, 16 out of 44 students scored below 70 out of 100 points and were placed in group 1. The remaining 28 students who scored 70 points or more, were placed in group 2. The average score on the first attempt for group 1 was 57/100 compared to 86/100 for group 2. Following the same procedure used in the departmental exam intervention, instructors ran a 4-hour intervention on slope and

equation of a line, system of equations, and factoring for group 1. In group 2, the teacher assistants focused their intervention on equation of a line and factoring.

Table 2.
Departmental Exam 2 scores (first and second attempts each out of 100 points)

Departmental Exam 2			
Group	1st attempt average score	2nd attempt average score	Difference = 2nd attempt – 1st attempt
1 (n = 16)	57	78	21
2 (n = 28)	86	94	8

After the interventions, students took the 2nd attempt of departmental exam 2. Students in group 1 averaged 78 out of 100 points, 21 points higher than the first attempt as compared to group 2 average which went up by 8 points (Table 2).

Summary of Exams by Group
For the intervention of departmental exam 1, students in group 1 scored on average 81 out of 100 points on the final exam as compared to 86 points for students placed in group 2 (Table 3).

Table 3.
Departmental Exam 1 vs Final Exam Scores (Each Out of 100 Points)

Departmental Exam 1 vs Final Exam Scores			
Group	1st attempt average score	2nd attempt average score	Final exam score
1 (n = 22)	54	69	81
2 (n = 22)	83	93	86

In the second intervention of departmental exam 2, students in group 1 averaged 79 points on the final exam as compared to 94 points for those placed in group 2 (Table 4).

Table 4.
Departmental Exam 2 vs Final Exam Scores (Each Out of 100 Points)

Departmental Exam 2 vs Final Exam Scores			
Group	1st attempt average score	2nd attempt average score	Final exam score
1 (n = 16)	57	78	79
2 (n = 28)	86	94	94

Correlations: The correlation between the 2nd attempt of departmental exam 1 and the final exam score was investigated

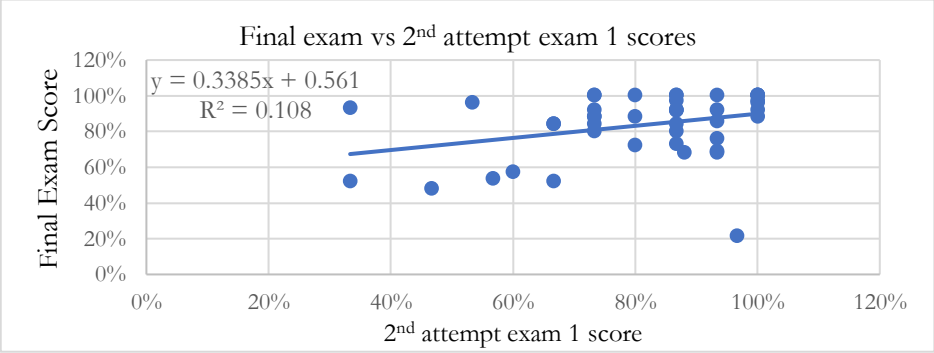


Figure 1.
Final Exam vs 2nd Attempt of Exam 1 Scores

The coefficient of determination, R^2 is 0.1080 indicating about 10.8% of the variability in the final exam scores is explained by the second attempt of departmental Exam 1 scores (figure 1). The corresponding correlation coefficient is equivalent to 0.3286 which indicates a weak positive relationship between the 2nd attempt of departmental exam 1 and the final exam scores

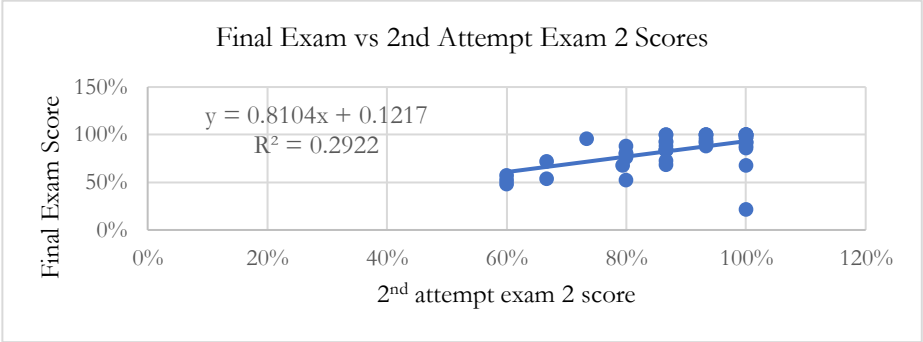


Figure 2.
Final Exam vs 2nd Attempt Exam 2 Scores

The correlation between the 2nd attempt of departmental exam 2 and the final exam score revealed a coefficient of determination, $R^2 = 0.2922$ (figure 2). Thus, about 29.2% of the variability in the final exam scores is explained by the scores of the second attempt of departmental exam 2. The correlation coefficient between these two variables is equivalent to 0.5406. This implies the two variables have a moderate positive relationship.

Discussion and Conclusion

The main goal for this study was to find a new way to help students improve their exam scores during the second chance as well as nurture their ability to apply procedures accurately, efficiently, and flexibly in mathematics. Based on the results previously shown (Table 1 and Table 2), the interventions helped students improve their exams scores. After 4 hours of intervention, the average scores for students in group 1 increased by 15 points and 21 points respectively for departmental exam 1 and departmental exam 2, while the average for group 2 increased by 10 points and 8 points, respectively. These findings align with the results of a previous study that found students who are exposed to interventions programs will show growth in their mathematics achievements (Hines, 2016). As a result, the classroom interventions had a positive effect on students' pass rates in these two fundamental algebra sections. The three major exams (the two departmental exams and the final exam) constitute 65% of students' grade: 15% for each departmental exam and 35% for the final exam. The final exam was given three weeks after the second departmental exam and contains nearly 80% of questions related to topics covered in departmental exam 2. This explains the moderate relationship between departmental exam 2 and the final exam scores has compared to the relationship between departmental exam 1 and the final scores (figure 1 and figure 2). Thus, the second intervention helped students on the 2nd attempt of the departmental exam 2 and the final exam. In addition, students' average scores for both groups, were nearly the same for the 2nd attempt of the second departmental exam and the final exam (Table 4). Of the 44 participants, 34 (77%) passed the class. This pass rate is higher than the average pass rate for fundamental mathematics (61%) course according to the college Institutional research.

Departmental exam 2 was cumulative, therefore contains questions related to topics covered in the first exam. However, students did better on the second departmental exam compared to the first departmental exam. This shows that the first intervention improved students' procedural flexibility which might explain their high performance on the first attempt of departmental exam 2.

The interventions were integrated during the classrooms hours and showed huge impact on students' mathematics achievements. As revealed in a previous research, intervention programs are effective when integrated with the regular classroom (Balfanz, Mac Iver, & Byrnes, 2006). How about individual intervention (online intervention) outside of the classroom? Future research must explore the effect of individual intervention outside of the classroom as compared to in-class group intervention.

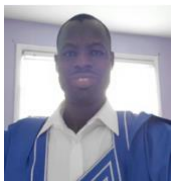
The intervention strategy used in this study, identifying students' weaknesses through exams results, contributed to the positive outcomes. As recommended in previous research, instructors must first identify students' weaknesses then address them through classroom interventions that focused just on those issues (Gersten et al. 2009). A key component to the success of any intervention is matching the student with the appropriate supports (Danielson, 2009).

Recommendations

The outcomes of this study revealed the positive effects of classroom interventions on students' procedural flexibility but does not justify students gain of conceptual understanding which is the mental connections among mathematical

facts, procedures, and ideas (Hiebert & Carpenter, 1992). Research have shown that conceptual knowledge has had a stronger influence on procedural knowledge than vice versa (Hecht & Vagi, 2010; Matthews & Rittle-Johnson, 2009). In addition, with a strong conceptual understanding, students can better generalize skills and understand algorithms (Gersten et al., 2009; Jones, Inglis, Gilmore, & Evans, 2013; Miller & Hudson, 2007). Thus, a further research is needed that focused on the effects of classroom interventions on students 'conceptual knowledge. Furthermore, this may require monitoring students' progress in learning and comprehension of the subject by assessing each intervention effectiveness throughout the semester.

Biodata of the Authors



Dr. Alioune Khoule is an Assoc. Professor in the Department of Mathematics and Computer Science at LaGuardia Community College in the City of New York, USA. His research interests are in mathematics modeling and mathematics education. His current research focuses on the impact of teaching-based concepts in developmental courses. **Affiliation:** Department of Mathematics, Engineering and Computer Sciences at LaGuardia Community College, New York, USA. **Email:** akhoule@lagcc.cuny.edu **Office:** E 218 G **Phone:** 001 718 482 6194

Dr. Nana Osei Mensa Bonsu, Assoc. Professor in Mathematics and Statistics. His research interest is in the area of statistical modeling. His current research is in mathematics education at the community college level. **Affiliation:** Department of Mathematics, Engineering and Computer Science, LaGuardia Community College, Long Island City, New York, USA. **Email:** nbonsu@lagcc.cuny.edu **Phone:** +17183494034

Dr. Hassan Elhouari is an Assoc. Professor of Mathematics at City University of New York. He received his doctorate in Mathematic from Cadi Ayyad University in Morocco. His current research focuses on mathematics education at the community college. **Affiliation:** Department of Mathematics, Engineering and Computer Sciences at LaGuardia Community College, New York, USA. **Email:** helhouari@lagcc.cuny.edu **Office:** E 235-I **Phone:** (+1)718 482 5710.

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