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Instructional Format and Differences in Remedial Mathematics Performance for Community College Students: A Multiyear Investigation

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I. Introduction

Instructional Format and Differences in Remedial Mathematics Performance for Community College Students: A Multiyear Investigation Students entering community colleges should have the opportunity to succeed and complete a degree or certificate. Students who are not college ready are spending extended time in college remediating subject areas, in which they are not college ready (Scott-Clayton & Rodriguez, 2012). Undergraduate students beginning their academic careers at 4-year institutions are more likely to complete their college degree when compared to undergraduate students who begin their academic careers at a 2-year institution (Brock, 2010). According to the Texas Higher Education Coordinating Board (2008), 16% of community college students in Texas earn college level mathematics credit within twoyears. Policy might be enacted to increase success rates in mathematics remediation programs in Texas community colleges to assist students with completing their college degrees.

The literature reviewed may be categorized into four primary subjects related to the research: (a) technology in remedial mathematics courses, (b) retention, (c) developmental mathematics education, and (d) remedial mathematics courses. The fusion of technology with the traditional lecture format provides additional opportunities for students of various learning styles to engage in the learning process in developmental mathematics (Moore, 1973). Incorporating technology into developmental mathematics has shown great benefits for some students who are required to remediate in the areas of mathematics (Wladis, Offenholley, & George, 2014). Retention and completion rates of students in various instructional formats could help researchers and policymakers further understand students who enroll in developmental education.

Taylor (2008) examined differences in completion rates of students enrolled in a computer assisted remedial mathematics course compared to students enrolled in a traditional lecture format. Both groups for this study showed improvement throughout the term; however, students enrolled in a traditional lecture format had statistically significantly greater improvement. Students who completed a computer-assisted course had more confidence and lower anxiety compared with students in a traditional format. Taylor (2008) further reported that ethnicity, gender, age, and number of previous mathematics course taken were not statistically significant factors in student success in either instructional format.

Instructional methods for mathematics continues to be an area of interest for researchers. Vilardi and Rice (2014) analyzed performance levels of students who enrolled in three different variations of course delivery: (a) online, (b) web-enhanced, and (c) traditional. Students enrolled in a traditional course had greater achievements in mathematics, as determined by end of course GPA averages. Those students enrolled in a traditional mathematics course earned more A's and fewer F's than students enrolled in online and web-enhanced course sections (Vilardi & Rice, 2014).

Utilizing technology in a traditional classroom setting to help increase student success rates in remedial mathematics is another area of importance for increasing success rates in remedial mathematics. Wladis et al. (2014) analyzed methods for improving

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outcomes of students enrolled in traditional remedial mathematics classes. After each student was given a departmental mid-term, a computer-assisted intervention component was available as a resource to increase student success rates. During the initial semester of implementation, students experienced a 50% increase in passing rate for remedial courses. Each semester thereafter the passing rate continued to increase due to computer-assisted interventions (Wladis et al., 2014).

Spradlin and Ackerman (2007) explored differences in the academic performance of developmental mathematics students in a traditional lecture format compared to students enrolled in a traditional lecture format with a computer-assisted instruction component. Participants learned equally in both the traditional format and computer-assisted format; however, females outperformed males regardless of instructional method used. Spradlin and Ackerman (2007) further suggested females gain more knowledge from developmental mathematics courses than males. Moreover, students were receptive to utilizing technology for educational purposes.

Zavarella and Ignash (2009) explored withdrawal and completion rates of students enrolled in developmental mathematics courses with regard to instructional formats. Withdrawal rates were higher for participants enrolled in either the hybrid and/or distant learning formats. Of note was that student learning style had no effect on completion or withdrawal from a developmental mathematics course. Students who deemed themselves face-to-face learners were also more inclined to withdraw from their developmental mathematics course. In addition, placement exam scores did not correlate with a student's ability to complete a developmental mathematics course (Zavarella & Ignash, 2009).

Additional research studies were completed by Zhu and Polianskaia (2007) regarding traditional lecture and computer-assisted mathematics. Students were more likely to enroll in a computer-mediated developmental mathematics course when compared with other instructional formats. However, students who enrolled in a traditional lecture format had higher success rates in developmental mathematics than did students enrolled in a computer-assisted mathematics course. Moreover, males had higher pass rates in traditional lecture format courses. Females had similar success rates to males with lecture formatted developmental mathematics courses (Zhu &Polianskaia, 2007).

Student persistence rates in remedial mathematics is an additional area of importance for researchers. Davidson and Petrosko (2015) examined how factors such as demographics, enrollment status, and family background affected student persistence into a second semester after enrolling in basic algebra. Gender was statistically significant with increasing persistence rates in four cohorts. Family and work obligations affected persistence rates of independent students but had no effect on dependent students. Further, a statistically significant difference was determined with regard to enrollment status for students who completed a remedial mathematics course from Spring 2008 to Fall 2008. Further determined was statistically significant difference with regard to enrollment status for dependent students who completed a remedial mathematics course from Spring 2009 to Fall 2009.Female students had higher persistence rates than their male counterparts (Davidson & Petrosko, 2015).

Ashby, Sadera, and McNary (2011) completed a study in which they compared student success based on the following instructional formats: (a) online, (b) blended, and (c) face-to-face. Student success was based on students earning a grade of 70 or higher, which would then allow the student to enroll in a college-level math course. Ashby et al. (2011) used a convenience sample of 167 students who previously completed remedial math coursework or placed directly into intermediate math based on placement exam scores. Learning environments were determined to play a key role in the success of students in this study with face-to-face students having the highest completion rate at 93%, followed by online students with a 76% completion rate, and blended courses with a 70% completion rate (Ashby et al., 2011).

Incorporating technology into remedial mathematics courses may effectively create opportunities for some students to navigate the remedial mathematics pathway. Colleges and universities are experiencing an increase in non-traditional students who are returning to school to continue their education. The National Center for Education Statistics (1993) defined nontraditional undergraduate students as, "a student over the age of 24, who often has family and work responsibilities as well as other life circumstances that can interfere with successful completion of educational objectives" (para 1). According to the National Council of State Legislatures (2015), computer-assisted classes could benefit the nontraditional student who is unable to access additional campus support due to life circumstances and responsibilities. Various interactive models such as the Assessment and Learning in Knowledge Spaces (ALEKS) are available for education institutions to utilize. Instructional Technology such as ALEKS provides computer based tutoring and adaptive based questioning to best assist a student with learning mathematics (McGraw-Hill, 2014). Nontraditional students can receive academic support through programs, such as ALEKS, that offers tutorials for students as they complete assignments. Students unable to receive academic assistance can utilize computer-assisted software to receive the necessary guidance to complete their respective classes.

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Computer-assisted classes provide traditional and nontraditional students with an option to complete their coursework without physically being in a classroom, while also receiving automatic feedback (Shute & Zapata-Rivera, 2007). Students who have sociocultural limitations, have an additional option to complete classes and receive convenient academic support (Shute & Zapata-Rivera, 2007). Computer-assisted classes allow students to work at their own pace and receive assistance as needed based on the learner, which is not always possible in a traditional classroom setting (Shute & Zapata-Rivera, 2007).

Nationally, community colleges are educating students with fewer resources (Mullin, 2010). Computer-assisted learning technology provides institutions with an alternative for instructing more students by allowing faculty to shift their role from a teacher to student advocate in the learning process. Community colleges play an important role in preparing students for college level coursework, with over one half of all community college students enrolling in a remedial class at some point while pursuing their college education (Bailey et al., 2010). Understanding the completion rates for students enrolled in a computer-assisted class compared to traditional classroom setting is important for policymakers and institutional leaders who are faced with retention issues and with educating a population of students who have life situations that prevent them from engaging in the assisted learning services offered within the college.

a) Purpose of the Study

The purpose of this study was to examine the extent to which differences were present in remedial mathematics performance as a function of student enrollment in either a computer-assisted remedial mathematics course or a traditional remedial mathematics course. The following areas were addressed in this study: (a) mathematics success rates of students enrolled in computer-assisted remedial mathematics courses, (b) mathematics success rates of students enrolled in traditional lecture remedial mathematics courses, and (c) changes, if any, that occurred in remedial mathematics performance inthe 2012-2013through the 2014-2015 academic years.

b) Significance of the Study

This research investigation could be used to determine which groups of students are being successful in remedial mathematics courses by instructional method. Students begin the remedial mathematics process, but often fail to complete the sequence (Bahr, 2013). Instructional formats could help policymakers determine if certain groups of students would benefit from a specific instructional format. From this study, future researchers might also investigate learning styles of students required to remediate in mathematics. Additionally, policymakers could develop policies for placement into remedial mathematics courses based on instructional format based on the outcome of this study. Stakeholders and policymakers could also create structural changes to technology assisted courses and traditional remedial mathematics courses to increase student success rates.

c) Research Questions

The following research questions were addressed in this investigation: (a) What is the difference in remedial mathematics success rates as a function of instructional format (i.e., computer-assisted and traditional classroom lecture) of students enrolled in a Texas community college? and (b) What trend, if any, exists in remedial mathematics successrates as a function of instructional format for the 2012-2013 through the 2014-2015 academic years? The first research question was repeated for each of the 3academic years of data analyzed herein.

II. Method

a) Research Design

Research where the independent variable is not manipulated and random assignments are not utilized is classified as no experimental research (Johnson &Christensen, 2010). In this investigation, data for students who had been enrolled in remedial mathematics courses over a 3-year period were examined. When the independent variable is a categorical variable and the dependent variables have already occurred, this research design is regarded as being causal-comparative in nature (Johnson & Christensen, 2010). In this study, the independent variable wasthe instructional format (i.e., computer-assisted course or a traditional classroom lecture) course. The dependent variables were grades that students earned in a remedial mathematics course.

b) Participants and Instrumentation

Participants were current or former students of a Texas community college and were 18 to 21 years of age. Data examined for this study were from students who completed the following remedial mathematics courses: (a) Math 0404, (b) Math 0406, (c) Math 0407, (d) Math 0408, (e) Math 0410, (f) Math 0411, and (g) Math 0412. Students must have earned a grade of C or better to pass the specified remedial math course.

III. Results

Remedial mathematics success rates as a function of instructional method was investigated in this study. Instructional methods explored were traditional classroom lecture and computer-assisted instruction. Three academic years of data (i.e., 2012-2013, 2013-2014, and 2014-2015) were analyzed with regard to instructional delivery methods. Results will now be

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presented by academic year. Because the independent and dependent variables were categorical, Pearson chi-square inferential statistical procedures were used to answer the research questions.

For the 2012-2013 academic year, the Pearson chi-square test resulted in a statistically significant difference, $\chi^2(1) = 11.79$, $p = .001$, with a Cramer's V of .11, in remedial mathematics success rates as a function of the instructional format. Using Cohen's (1988) criteria, a small effect size was present. A higher success rate in remedial mathematics courses was present for students who completed the traditional classroom lecture format, 70.5%, than for students who completed the computer-assisted instructional method, 58.1%. Delineated in Table 1 are the descriptive statistics for the 2012-2013 academic year.

Table 1: Success Rates in Remedial Mathematics Courses by Instructional Method for the 2012-2013 Through the 2014-2015 Academic Years

Year and Instructional Method	Success Rate	Non-Success Rate
2012-2013		
Traditional	70.5%	29.5%
Computer-Assisted	58.1%	41.9%
2013-2014		
Traditional	62.6%	37.4%
Computer-Assisted	41.2%	58.8%
2014-2015		
Traditional	67.2%	32.8%
Computer-Assisted	57.3%	42.7%

Concerning the 2013-2014 academic year, the Pearson chi-square test yielded a statistically significant difference, $\chi^2(1) = 37.80$, $p < .001$, with a Cramer's V of .20, in remedial mathematics success rates as a function of instructional method. Using Cohen's (1988) criteria, a small effect size was present. Similar to the previous academic year results, a higher success rate was present for students who completed the traditional instructional method, 62.6%, than for students who completed the computer-assisted format, 41.2%. Revealed in Table 1 are the descriptive statistics for the 2013-2014 academic year.

With respect to the 2013-2014 academic year, a statistically significant difference was present, $\chi^2(1) = 4.31$, $p = .04$, with a Cramer's V of .07, in remedial mathematics success rates as a function of instructional format. Using Cohen's (1988) criteria, a trivial effect size was present. Congruent with the previous two academic years of results, a higher success rate was present for students who completed the traditional instructional method, 67.2%, than for students who completed the computer-assisted course, 57.3%. Descriptive statistics for this analysis are included on Table 1.

With respect to the 2012-2013, 2013-2014, and 2014-2015 academic years, statistically significant differences were present, albeit with trivial and small effect sizes. In all three academic years, the highest success rates were documented for students who completed remedial mathematics courses in the traditional classroom format than for students who completed remedial mathematics courses in a computer-assisted format. Depicted in Figure 1 are the success rates in remedial mathematics courses in both instructional formats for the 2012-2013 through the 2014-2015 academic years. Completion rates for computer-assisted instruction decreased from the 2012-2013 to 2013-2014 academic year, but increased sharply from the 2013-2014 to 2014-2015 academic year.

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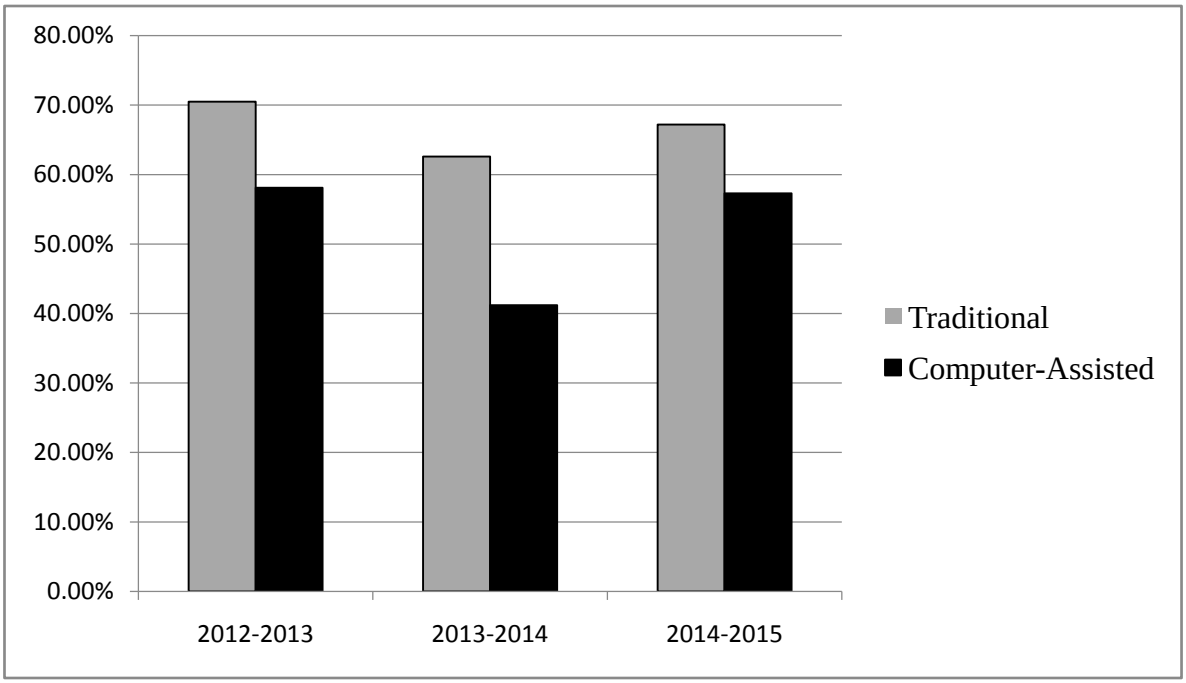


Figure 1: Trends for success rates in remedial mathematics courses by instructional method for the 2012-2013 through the 2014-2015 academic years.

IV. Discussion

For this study, the degree to which success rates in remedial mathematics courses differed as a function of instructional format were analyzed. The two instructional formats of interest were the traditional classroom lecture format and computer-assisted instruction. In analyzing three years of data, students who completed remedial mathematics courses in a traditional instructional method course had higher success rates than students who completed remedial mathematics courses in computer-assisted courses.

a) Connection to the Related Literature

Students in a remedial mathematics course with a traditional instructional format had a higher success rate than students in a computer assisted course (Ashby, Sadera, & McNary; Vilardi& Rice, 2014; Zhu & Polianskaia, 2007). Computer-assisted remedial mathematics course seems to be a developing model of instruction for some schools. Results from this study were similar to outcomes in previous studies; however, computer-assisted instruction requires more research for an adequate assessment for increasing success rates. Students enrolled in traditional format courses earned higher grades and had higher GPAs (Vilardi & Rice, 2014). For this study, students who completed their remedial mathematics courses in a traditional classroom instructional format had higher success rates than students who completed their remedial mathematics courses in a computer-assisted format. A traditional instructional format is a pedagogical model to which students are more familiar. Most high school mathematics courses are not technology infused. Additional research is need to explore success rates of students in traditional and computer-assisted instruction. Technology is an increasing part of everyday life. Computer-assisted instruction is not a new phenomenon, however, more research investigations are needed to increase success rates for students who enroll in these classes.

b) Implications for Policy and Practice

Providing alternative instructional methods is beneficial for ensuring that all students have an opportunity to learn (Shute & Zapata, 2007). Students who are unable to attend a face-to-face course need an alternative method to learn, which is where computer-assisted instruction becomes beneficial. Computer-assisted courses have been endorsed by the National Council of State Legislatures (2015) as a means to provide support for students unable to access traditional support as needed. Students who completed a computer-assisted course were reported to have a higher level math competency in mathematics (Trenholm, 2006). However, in the current study, results were not congruent with Trenholm (2006).

Understanding the types of students who enroll in traditional and computer-assisted courses is important for policymakers. Traditional students, ages 18-21, may not require the same level of support for computer assisted instruction. Nontraditional students may require additional support compared to the nontraditional student. Perhaps, a targeted approach to the support provided for both traditional and nontraditional instruction could help increase success

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rates in remedial mathematics. Nevertheless, more research is needed to explore the differences and the needs of traditional and nontraditional students in terms of computer assisted instruction.

c) Suggestions for Future Research

Course instruction is a vital role in the learning process. Today's student encounters additional challenges that make it difficult for the student to learn in a traditional format. Computer-assisted classes provide students with the opportunity to learn at their own pace and receive the support necessary for student success (Shute & Zapata, 2007). More research is needed to determine which students (i.e., traditional or nontraditional) are enrolling in computer-assisted courses and how these students are performing.

Data for this study pertained to traditional age college students. More research should be focused on nontraditional students who enroll in computer-assisted courses. Nontraditional students are more likely to have work and family responsibilities and may choose to enroll in computer-assisted courses. Investigating success rates as a function of age is an area for future researchers to pursue. Another problem to investigate is the advisement available for students who must enroll in remedial mathematics. Because some students are able to complete a computer-assisted remedial mathematics course and other students struggle, investigating this phenomenon would be important for future research regarding how students are advised to select remedial courses. Future researchers should also compare computer-assisted software programs (i.e., ALEKS and My Math Lab) to determine which program has the higher success rate for students enrolled in remedial mathematics.

V. Conclusion

In this investigation, three years of data on success rates in remedial mathematics courses for students enrolled at a Texas community college were analyzed. Statistically significant differences in remedial mathematics success rates were established in each of the 3 academic years. Students who were enrolled in a traditional lecture format in their remedial mathematics courses had higher success rates than their peers who were enrolled in a computer-assisted format in each of the 3 years of data analyzed here.

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