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Just-in-time Pedagogical Support in Co-requisite Remedial Models in terms of Student Learning, Mathematics Self-efficacy, and Achievement

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Abstract: *Higher institutions in the U.S. have focused on transforming remedial education because of increasing the number of remedial students and low success rates of traditional pre-requisite remedial designs. Co-requisite remedial models have been considered as an alternative model. The aims of this study are to examine student achievement and mathematics self-efficacy, to explore student learning and perspectives on Co-requisite remedial models, and to find the relationships between student mathematics self-efficacy, and achievement in Co-requisite remedial classes. Pre-and post-tests, questionnaires, and semi-structured interviews were collected from 252 participants in 6 Co-requisite and 5 traditional College Algebra courses during 3 semesters. The results of this study reveal that Co-requisite remedial models significantly improved student mathematics self-efficacy and achievement. In addition, the findings of this study show the vital relationships among student learning, mathematics self-efficacy, and achievement. This study contributes to evidence of reforming remedial education and encourages math departments to adopt Co-requisite designs in remedial education.*

Keywords*: Co-requisite remedial models, transforming remedial education, mathematics-self-efficacy, achievement*

I. Introduction

Universities and colleges in America admit students who have substantial mathematical deficiencies, which will prevent them from successfully completing gateway courses. Unprepared students are required to enroll in a sequence of remedial courses before enrolling in gateway courses. Over the past several years, researchers and institutions in higher education have been interested in moderation of remediation because of the increased number of remedial students and the lack of roles for supporting them. In the past several decades, the percentage of remedial students in higher institutions did not change, even if enrollment of colleges and universities increased (Merisotis & Phipps, 2000).In addition, Complete College America (2012) reported that over 50% and nearly 20% of entering freshmen in 2-year colleges and 4-year universities enroll in at least one remedial course.

Remedial education provides unprepared students an opportunity to improve their college readiness. However, prerequisite gateway courses have been "gatekeeper" courses (Complete College American, 2012; Bryk & Treisman 2010). Remedial students' success and degree completion depend on successful remedial and gateway courses. For example, mathematics in remedial education is an important measure of remedial students' degree completion (Attwell et al., 2006; Bailey, Jeong, & Cho, 2010). Although passing rates of writing and reading in remedial education were 68% and 71%, passing rates of mathematics were only 30% (Attwell et al. 2006). In prerequisite designs in remediation, remedial students have taken year-long math in order to pass gateway math courses. If they fail at least one remedial math course, they are easily discouraged to retake the remedial math course because of increased time and tuition (Bailey, Jeong, & Cho, 2010). The mandate prerequisite pathways significantly decrease the graduation rates of remedial students. The current college completion rates in postsecondary education could not fit the industrial demand. In a transforming remediation system, researchers and higher institutions have suggested Co-requisite course models instead of traditional prerequisite remedial designs. Dana Center at the University of Texas recommends a one-year Co-requisite model for transforming remediation (Inside Higher ED, 2016). Several colleges and universities in the University System of Georgia have joined moderation of remediation and have started to offer Co-requisite courses for the past several years. Researchers and institutions have studied the implications of Co-requisite remediation. The Tennessee Board of Regents revealed that success rates of remedial students have increased. The Community College Research Center at Columbia University's Teachers College found the cost-effectiveness of Co-requisite remediation (Inside Higher ED, 2016). Even if students' mathematics self-efficacy beliefs are an important component to improve student achievement (Bandura, 1977; Hicks, 1997; Kim, 2016), there is little literature on the relationships between students' mathematics self-efficacy beliefs and their achievement in Co-requisite remedial models.

The purposes of this study are to examine student achievement and mathematics self-efficacy in Co-requisite classes, to find the relationships among student learning, achievement, and mathematics self-efficacy, and to understand student learning and perspectives on Co-requisite remedial classes. Research questions are classified by two qualitative questions and a quantitative question: 1) How do Co-requisite remedial courses affect student achievement and learning?; 2) What are the relationships between student mathematics self-efficacy, achievement, and learning in Co-requisite remedial classes?; 3)What are students' perspectives on Co-requisite models in terms of their learning? For question 1, independent variables are students who are in a remedial program and students who are not in a remedial program. Dependent variables are the scores of pretests, posttests, and mathematics self-efficacy. The null hypothesis is "Are there differences on student achievement and mathematics self-efficacy between Co-requisite College Algebra and traditional College Algebra?"

II. Literature review

Colleges and universities in the U.S. have offered remedial education to provide additional academic support for underprepared students and meet the demands of society in quality human resources. In 1849, students started to enroll in the remedial education programs in reading, writing, and arithmetic at the University of Wisconsin (Breneman & Haarlow, 1998). Land-grant colleges in 1862 were offered preparation programs for students who needed academic assistance in reading, writing, and arithmetic (Payne & Lyman, 1998). Due to the passage of the Civil Rights Act, open admissions of 1964 and the Higher Education Act of 1965, which opened admissions policies and provided government funding, the number of unprepared students in institutions dramatically increased (Payne & Lyman, 1998). For example, over 40% of first-year college students registered preparatory programs in the 19th century (Ignash, 1997).

Remediation programs are considered to be an academic bridge for unprepared students to improve their college readiness and have opportunities to receive a college degree (complete college America 2012). Remedial courses are English, reading, writing, and mathematics (NCES, 2014). Over 90% of colleges and universities used standardized placement tests in order to determine which students were underprepared students and provide placements for the students in the appropriate mandatory level of remediation (Bettinger, Boatman, & Long, 2013). According to a report by the Southern Regional Education Board (SREB, 2000), remedial students were traditional students who immediately graduated from high school, non-traditional students, and all levels of undergraduate programs. In addition, 42.5% and 35.5% of students who were 25 years of age or older in 2- and 4-year public colleges were in remediation (College Complete America, 2012).

Researchers and higher institutions have reformed remediation education due to the increased number of remedial students, and the very low success rates of remedial and gateway courses. College Complete America (2012) reported that 51.7 % and 19.9% of the entering first-year students at 2- and 4-year public institutions were in remediation. Even if 62% and 74.4% of remedial students at 2- and 4-year colleges passed remedial courses, only 22.3% and 36.8% of those students completed gateway courses (DOE, NCES, 2014). In addition, 9.5% and 35.1% of those students at 2-and 4-year colleges graduated within 3 years and 6 years (DOE, NCES, 2014). Over 90% of institutions used a standard placement test in order to determine remedial students (Bettinger, Boatman, & Long, 2013). Although a placement test was a common method in remedial education, around 30% of students were misplaced (Scott-Clayton, Crosta, & Belfield, 2014). Calcagno and Long (2008) revealed that traditional prerequisite remedial mathematics and reading courses helped students obtain college credits. However, the courses did not affect the students' degree completion. Students who took a few remedial courses had better college completion than students who took three or more remedial courses (Adelman, 1998). In addition, traditional prerequisite remedial designs did not promote students' academic completion (Baile, Jeong, & Cho, 2010). Researchers found that endless remediation sequences were the main reasons which decreased students' retention and college completion (Complete College America, 2012). According to Complete College America (2012), institutions utilize multiple methods such as placement scores, high school GPA, high school transcripts, and non-cognitive measures for selecting remedial students. Co-requisite designs should be affordable solutions in order for remedial students to improve completion of gateway math and English courses, and to support on-time graduation (Complete College America, 2013).

Researchers have been interested in students' self-efficacy beliefs because these are an important tool to predict students' behavior, persistence, and achievement in education (Bandura, 1977; Bandura, 1986; Pajares, 1996b). Researchers reported that student self-efficacy beliefs significantly influenced students' performance and engagement (Bandura, 1977; Patrick & Hicks 1997). Collins (1982) described that students who had high ability had stronger self-efficacy and persistence than students who had low self-efficacy. Though there is little literature on mathematics self-efficacy in remedial education, Martin, Goldwasser, and Harris (2015) reported that the number of remedial courses was a factor in decreasing students' self-efficacy beliefs.

III. Methods

The appropriative design of this study was a mixed methods design. The findings of student perspectives, engagement, and learning in Co-requisite College Algebra could interpret or support the statistical results of student achievement and mathematics self-efficacy in more depth (Creswell 2007). The number of participants was 252 students in Co-requisite and traditional College Algebra courses during three semesters in an academic year at an educational university with about 16,000 students in the Southeast (Table 1). The participants registered to their own courses. Two math instructors taught six Co-requisite College Algebra (the treatment groups) and five traditional College Algebra (the control groups) courses. Co-requisite College Algebra designs of this study were 3-hour lectures and 3-hour labs each week with the same instructors. Instructors in the Co-requisite classes often used short review sessions, WebAssign (an online homework system), and group work in labs. Traditional College Algebra consisted of only 3-hour lectures each week. The number of participants in 5 traditional College Algebra sections was 127, with 11% withdraw rates. 125 participants were in 6 Co-requisite Algebra sections, with 5% withdraw rates (Table 1).

Table 1. Number of Participants

	The number of students (Withdrawer)	The actual number of participants (Withdraw Rates)
5 Traditional College Algebra Sections	142 (15)	127 (11%)
6 Co-requisite College Algebra Sections	132 (7)	125 (5%)
Total number	274 (22)	252 (12.5%)

This study employed three different data sources: questionnaires, semi-structured interviews with 24 students in Co-requisite College Algebra, and student achievement, measured by the pre-and post-tests. All participants answered two questionnaires at the beginning and the end of the semesters. To find the improvement in the participants' Mathematics Self-Efficacy, the two questionnaires included the Mathematics Self-Efficacy scale, developed by Betz and Hackett (1993). The first 20-minute questionnaires asked students' background information and Mathematics Self-Efficacy scale at the beginning of a semester. The second 20-minute questionnaires consisted of student learning, perspectives, engagement, and student Mathematics Self-Efficacy scale. For example, the question number 10 on the second questionnaire was: "How often did you read class material before your next class." The questions from 1 to 13 were a frequency scale, and the other questions were on a 5-point likert scale. To understand student learning, engagement, and perspectives on Co-requisite classes, 24volunteers for 30-minute interviews with a digital voice recorder were interviewed at the end of the semester. The interviews were 4 open-ended questions about student learning, engagement, and perspectives. The first and final exams consisted of pre- and post-tests respectively. The first and the final exams were collected at the beginning and end of the semesters. Although two instructors wrote different exams, the exams covered the same materials and had similar patterns of problems.

The quantitative data were analyzed with NVIVO (a Statistical Software). Two-sample t-tests with the significant level 0.05were used to find the differences in the student achievement and mathematics self-efficacy between Co-requisite College Algebra and traditional College Algebra. To measure the improvement of student mathematics self-efficacy in both groups, paired t-tests were employed. In addition, descriptive statistics were used to analyze student learning and perspectives on Co-requisite classrooms. For qualitative data, an author read and re-read the interviewers' transcripts to find and develop tentative codes. Based on the codes, categories with codes were constructed. Finally, the categories derived critical themes.

IV. Results

To answer research questions, employed three data sources, pre-and post-tests, questionnaires, and semi-structured interviews were analyzed by three sections: student achievement, student mathematics self-efficacy, and student learning and perspectives on Co-requisite remedial classes. By two-sample t-tests, the results indicated that remedial student achievement was improved (Table 2). There was the significant difference on the means of the first exams between students in Co-requisite College Algebra classes and traditional College Algebra classes ($p = 0.009 < 0.105$). On the other hand, the mean of the final exams in Co-requisite classes was not statistically different from the mean of the final exam in traditional College Algebra ($\mu_{\text{corequisite}} = 69.31, \mu_{\text{tradition}} = 69.34, \text{p} = 0.988 > 0.05$).

Table 2. Mean differences for student achievement

	Co-requisite class	Traditional class	*p*-value
Pre-tests (First exam)	73.97 (15.18)	78.65 (13.12)	0.009*
Post-tests (Final exam)	69.31 (16.22)	69.34 (22.64)	0.988

Note. Standard deviations are in parentheses. The level of significance is 0.05. *$p < .05$

From the questionnaires, the data were analyzed by two sections: lectures and labs (Table 3). The first section was classified by three categories: student preparation, engagement, and learning. There were significant differences on preview and attendance between two groups. By two-sample t-tests, students in traditional classes were more prepared in the next classes than students in Co-requisite classes were ($p = 0.001 < 0.05$). The attendance rates of students in Co-requisite courses were significantly higher than the attendance rates of students in traditional courses ($p = 0.003 < 0.05$). In addition, students in both groups were not significantly different in terms of engagement and learning in lectures ($p_E = .322 > 0.05$ *and* $p_L = 0.390 > 0.05$). The second section was analyzed by descriptive statistics in terms of student engagement, learning, and perspectives on labs. The findings of the second section for labs showed that the activities in the labs were to help students understand concepts and content and enhanced student engagement ($\mu_{E(lab)} = 4.06$ *and* $\mu_{L(lab)} = 4.10$). For students' perspectives on Co-requisite courses, students were strongly satisfied with Co-requisite College Algebra classes ($\mu_v = 4.34$ *and* $\mu_s = 4.24$). Therefore, labs were important aids for remedial students in order to support their learning and engagement.

Table 3. Mean Differences in Preparation, Engagement, and Learning in Lectures

		Co-requisite classes	Traditional classes	*p*-values
Preparation for class in both groups	Preview	3.22 (0.85)	3.71 (0.93)	0.001*
	Review	3.82 (0.86)	3.88 (0.93)	0.774
	Attendance	4.62 (0.61)	4.02 (1.11)	0.003*
Lectures in both groups	Engagement	3.59 (0.97)	3.81 (1.01)	0.322
	Learning	3.27 (1.01)	3.44 (0.84)	0.390
Labs in only Co-requisite classes	Engagement	4.06 (0.91) / 5		
	Learning	4.10 (1.00) / 5		
Perspectives on Co-requisite classes	Valuation	4.34 (0.73) / 5		
	Satisfaction	4.24 (1.04) / 5		

Note. Standard deviations are in parentheses. The level of significance is 0.05. *$p < .05$

The findings of student mathematics self-efficacy scores (MSES) were analyzed by three categories; 1) two groups' MSES at the beginning of semesters, 2) two groups' MSES at the end of semesters, 3) differences between the beginning and end of semesters for each group's MSES (Table 4).

Table 4. Mean Differences in MSES

	Co-requisite courses	Traditional courses	*p*-value for two groups
Beginning	5.56 (1.27)	5.52 (1.66)	0.923
End	6.25 (1.14)	5.89 (1.93)	0.274
p-value for each group	0.019*	0.363	

Note. Standard deviations are in parentheses. The level of significance is 0.05. *$p < .05$

Table 4 shows that the means of two groups' MSES at the beginning and end of semesters were not significantly different according to two-sample t-tests. Although the students' MSES in traditional courses at the beginning and end of semesters were not significantly different, the mean of their' MSES at the end of semesters slightly increased. In addition, the mean of the students' MSES in Co-requisite courses at the end of semester was slightly higher than the mean of the students' MSES in traditional courses. The mean of the students' MSES at the end of semester in Co-requisite courses was significantly different from the mean of their MSES at the beginning of semester ($p = 0.019 < 0.05$). Two themes, pedagogical and emotional influences, emerged from the five categories (Table 4). Lab hours in Co-requisite classes were the main factor of pedagogical and emotional effects on student learning and perspectives.

Table 5. Themes and Categories

Themes	Categories	Documentary analysis
Pedagogical influence	One-to-one instruction	• Detailed explanations • Review • Increasing retention • Increasing ease • Interaction with instructors
	Group work	• Closer relationships • Sharing information about problem solving and better methods to understand materials • Watching peers' problem-solving • Engaging in worksheets
	Web-based learning	• Individual work on online • Instant feedback

		• Watching supplemental videos
Emotional influence	Less anxiety & stress	• One-to-one instruction • Professor cares • Feels free ask questions • Closer relationships with peers • Completing all work in class • Extra time • Relaxed & comfortable
	Confidence	• Understanding of more materials • Being ready for the next math class • Increasing math abilities to do better in a future math class

Pedagogical Influence

Lab hours provided more opportunities for remedial students to make time to study. Even if students could arrange their schedule to study outside of classroom, they believed that appointed time at school helped their learning: If I did not have to go the lab, the amount of time is much less, only one or two hours to study instead of five or six. For only lectures, I could not do that. I have to have constant practice. If this class is only lectures, I would fail this class. Without something being due by a certain time, I would not do it. After the lab, I got it. I mean it is just easier. I had more time to work on it, so when I went home I knew the materials. It helps you. I think it is great. Labs in Co-requisite classes affected instructors' pedagogical methods and promoted interactions between instructors and students and between students. In labs, instructors could provide a wide range of pedagogical methods, such as one-to-one instruction, web-based learning through WebAssign (an online homework system), and group work. Students improved their attention and understanding of problems that they asked about because one-to-one instruction in labs provided appropriate explanations of concepts, properties, or theorems based on students' math abilities: "She always does everything and shows everything. She breaks everything down into little pieces. It is easy to learn." In addition, students developed their individual learning abilities through WebAssign. Students worked on assigned problems individually and watched supplemental videos. Students believed that working on worksheets as group work in lab made them be active learners and evoke peer tutoring. Students could deeply understand material that they need to know because they shared information about problem solving and understanding because of peer tutoring: It is group work, so you can see the other people do it. That really helped us learn. Sometimes the way a peer dose it is the best or fastest. Group environment is easier to learn, participate in work, and ask questions. Especially since everyone can understand the same page. I got this one and he got that one. We are kind of engaged that way. It really helped. Even outside class we did WebAssign together. Like "Hey how do you do this one. Write down how he is doing. I still could not get it and watch it." It helped you engage multiple resources and information.

Emotional Influence

Students reduced their anxiety about learning new math materials, stress to learn new topics, and felt comfortable due to interactions with their instructors in lab and more time to work on materials: Instead of briefly going over it and moving on, you have chances to go over it and actually learn. The professor made it easier and made me learn one-on-one, which is really hard to learn. One-on-one instruction by a professor in lab setting gives you confidence that even if you don't pick it up in the main classroom, you are not stuck with your book at home because you have another opportunity to get it. If you don't get something, you always know that you are allowed to be there. You know you are at school to get all the time to work on it and then you feel comfortable. Because of just-in-time pedagogical support in labs, students could improve their confidence that they were ready for the next math class: "I did more practice problems and more classwork. So I got to understand more stuff and better, and I feel like it helped me in the long run with everything that I needed for my major." "I think it is a great program to help. I was one point behind from passing math. This is a good opportunity for me to be able to go on to the higher level math class instead of having to be behind."

V. Conclusion and Discussion

The findings of this study answer three research questions. First, the results of comparisons of student achievement in both groups found that students in Co-requisite classes received just-in-time support on learning mathematics. The means' differences on the means of pre-tests between two groups indicated that students in Co-requisite classes needed appropriate remedial support ($p_{pretests} = .009 < 0.05$). Although students in Co-requisite classes were not ready for learning College Algebra at the beginning of semesters, they improved their math learning abilities and caught up materials of College Algebra during lab hours. This is illustrated by no difference on the means of the final exam between two groups ($p_{posttests} = 0.988 > 0.05$). The findings from the questionnaires and interviews helped us understand the results of students' improvement on their achievement in Co-requisite classes. Even though the number of students who previewed materials in traditional classes were

more than the number of students who previewed in Co-requisite classes ($p_{\text{preview}} = 0.001 < 0.05$), previews before class did not strongly affect student achievement illustrated by no differences on the means of posttests of students in both groups. This result supports that there was no relationship between student preview before class and student achievement (Kim, 2016).Students in Co-requisite classes were strongly motivated to attend lectures and labs because the policies of Co-requisite classes allowed students to obtain college credits and to exit a remedial math program in the same semester ($p_{attendance} = 0.03 < 0.05, \text{drop rate} = 5\%$).

Extended learning time as lab hours also promoted remedial students to learn materials with a variety of pedagogical methods based on the high rates of student attendance in Co-requisite classes. During lab hours, students had more opportunities to recall and review learned materials and interact with peers. Through group work in labs, students actively shared their information about how they understood new materials or their methods for problem solving. Because the lab hours helped students make regular time to study in class, students could complete their work in class instead finishing it at home. During one-to-one instruction and individual learning through an online homework system in labs, students often asked any questions to instructors, and instructors provided the appropriate explanations depending on students' math abilities.

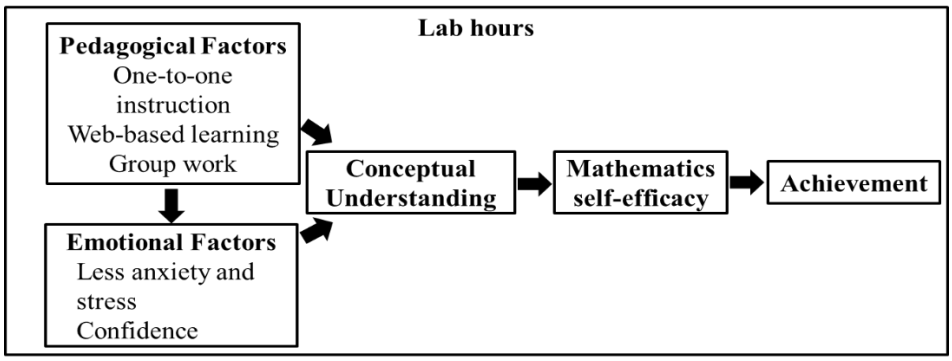

Figure 1. Relationships among student learning, mathematics self-efficacy, and achievement in Co-requisite classes

The findings of this study show that there are the close relationships between student mathematics self-efficacy and achievement, and mathematics self-efficacy is a vital tool of predicting student achievement (Bandura, 1977; Patrick & Hicks, 1997). Pajares and Graham (1999) and Andeman and Maehr (1994) reported that student mathematics self-efficacy decreased at the end of semesters because students had several challenges for difficult concepts or problem solving and stress on learning new materials. However, this study revealed that both groups' mathematics self-efficacy did not decrease at the end of semesters. In addition, student mathematics self-efficacy in Co-requisite classes significantly increased because of just-in-time pedagogical support ($\mu_{\text{Begin(MSE)}} = 5.56, \mu_{End(MSE)} = 6.25, p = 0.019 < 0.05$). Just-in-time pedagogical support, such as one-to-one instruction, group work, and web-based learning in labs enhanced remedial students' learning and understanding and then reduced their anxiety about learning new materials in College Algebra. In addition, the pedagogical and emotional effects in Co-requisite classes stimulated students to increase student mathematics self-efficacy. The significantly increased student mathematics self-efficacy influenced student mathematical achievement in this study (Figure. 1). Therefore, the results of this study support that mathematics self-efficacy is a vital factor to improve student achievement (Bandura, 1977; Bandura, 1986)

The limitations of this study were the number of interviewers and the period of collecting data. This study would have over 24 interviewers and collect data during even numbers of semesters, for example, two fall and two spring semesters. Although there were limitations, three data resources through triangulation improved validity of the findings of this study. The results of this study describe that Co-requisite classes significantly promoted student achievement and mathematics self-efficacy. In addition, this study shows the close relationships among just-in-time pedagogical support, mathematics self-efficacy, and mathematics achievement. The findings of this study support that the Co-requisite remedial designs are appropriate models for transforming remedial education. Therefore, this study contributes to understanding of student achievement in Co-requisite classes and evidence of successful Co-requisite models in reforming remedial education. Furthermore, this study promotes math departments to adopt Co-requisite remedial models. Further research would be the effects of the number of instructors in Co-requisite courses in terms of student achievement, mathematics self-efficacy, and learning: one instructor teaches both a remedial section and a gateway section, while two instructors teach a remedial section and a gateway section separately in a Co-requisite course.

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