REFORMATIONS TO DEVELOPMENTAL MATHEMATICS EDUCATION: A MIXED-METHODS ANALYSIS OF PROGRAMMATIC CHANGES

by

Gabrielle M. Castro

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ABSTRACT

A mixed methods study was conducted to determine the effectiveness of a newly implemented developmental mathematics education program at an institution of higher education. Under the old program (Program 1), at the most, students would take two developmental mathematics courses; a beginning algebra course, and an intermediate algebra course, after which students would then be able to enroll in a credit-bearing mathematics course. Under the new program (Program 2), this is shortened to only one beginning algebra course, after which students can then enroll in a credit-bearing mathematics course. A Regression Discontinuity Design (RDD) was utilized to find differences in retention of students who have taken either of the mathematics pathways provided at the institution. The experiment also looked for qualitative differences in student and faculty experiences in these courses through the lens of a developmental education theory proposed by Wambach, Brothen, and Dikel (2000). Implications from this research extend to determine factors that could hinder student success, generate program improvement, and provide additional literature on reforms in developmental mathematics education.

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Approved:

[Chairman, Thesis Committee] [Date]

[Member, Thesis Committee] [Date]

[Member, Thesis Committee] [Date]

[Department Head/Direct Supervisor] [Date]

[Dean, Academic College] [Date]

[Dean, Graduate School] [Date]

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I. INTRODUCTION

Recent changes in state policy have required institutions of higher education in Texas to reform their developmental mathematics education programs. However, with 42.6% of first-time students entering higher education deemed unprepared for college (Texas Higher Education Coordinating Board Almanac, 2018), one might wonder if policymakers considered those who are most affected by their policy changes. It is clear that institutions of higher education in Texas have a plethora of reasons to restructure developmental mathematics programs. However, the focus of these institutions should prioritize the quality of their students' education. To optimally serve these students, institutions should strive to make use of the best practices available in such a complex area of education.

This study viewed one Texas institution's transformation of a developmental mathematics program, through the lens of an emerging theory specifically designed for developmental education. Wambach, Brothen, and Dikel (2000) proposed that developmental education must include three major aspects: self-regulation, responsiveness, and demandingness. Through defining the developmental mathematics program using this theory, the hypothesis is that students will experience successful learning of mathematics. The following research question guided the investigation in analyzing the success of student learning;

- What impact, if any, have changes to developmental mathematics course offerings had on students' successful learning of mathematics, in regards to overall experience and outcome?

II. LITERATURE REVIEW

What is "developmental education"?

Currently, "developmental education" is the preferred terminology widely used to describe the interventions in place at institutions of higher education, designed for students deemed unprepared for college-level courses in subjects such as reading, writing, and mathematics (Lundell & Collins, 1999). Throughout history, the name of this area of education continues to change and has not yet been clearly defined. However tedious, it is important that researchers and educators alike have an accurate, agreed upon name, which clearly matches the definition of their work, not the students. It should recognize diversity and complexity, but not bring about labels/stereotypes of the students who happen to participate in these courses. One could argue that the current terminology used is still not quite accurate. If the goal is to *develop* skills – "to bring into being, as if for the first time" – then, it is also assumed that "what is already "in being" about the student is to be devalued as unfit for the new environment" (Lundell & Collins, 1999, p. 6).

After a review of the literature in developmental education, Lundell and Collins (1999) found five patterns in the literature or assumptions that researchers and educators operate in when dealing with developmental education. First, disciplinary-specific models and definitions emphasize practical, pedagogical issues. Educators and

researchers in this area of education are dealing with students' behavioral and skills-based needs and issues. Research claims to address diverse or non-traditional students, but focuses instead on individual deficit and its remediation. Broader research on national and historical issues focus more on assessment tools, emphasizing the gap between students deemed college-ready and those who are not. Finally, few programs share their developmental education models to a broader audience, specifically the theories they are based on and how they relate to the current definitions of developmental education. (Lundell & Collins, 1999). This particular study, along with any further research in this area of education should strive to challenge these patterns and assumptions in order to move forward in the struggle to improve post-secondary education.

Compliance with Developmental Education Regulations in Texas

In June 2017, the State of Texas passed House Bill 2223, requiring changes to developmental education (Texas Higher Education Coordinating Board, 2018).
It stated that institutions of higher education in Texas must develop and implement a "corequisite model" for developmental education. A corequisite model applies to developmental courses in which a student is enrolled for their respective area of need. This model states that the student will concurrently enroll in a college-level course and a developmental education course over one semester (Schudde & Meiselman, 2019). The goal is to supply the "underprepared" student with the additional instruction/resources they need, as well as granting these students the required college-level credit, all in the same semester. The bill also states that by academic year 2020-2021, 75% of all students enrolled in developmental education must be enrolled in the institution's corequisite program (Texas Higher Education Coordinating Board, 2018).

Another concern to the State of Texas, similarly concerning to the individual, is cost of tuition through this developmental process. At the institution of this study, before reformation, at a minimum, students starting their track in a beginning or basic adult education algebra course had to pay full tuition for three semesters worth of math coursework before they were able to receive any college-level mathematics credit, as shown in Table 1 (below). Students placed in an intermediate algebra course were required to pay for two semesters worth of mathematics coursework before receiving college credit. It is worth noting that this is defined as the minimum with the assumption that the student will pass every course and continuously enroll in the next course of their respective sequence. In a 2010 study of developmental education programs in nine states including Texas, 67% of students either did not finish their sequence or took longer than six years to do so (Bailey, Jeong & Cho, 2010).

According to Pittendrigh et al. (2020), Texas legislators passed HB 2223 in order to gradually get rid of developmental education courses because "they are not working, they do not count for credit, they waste students' time and money, and they make it more likely that students will not complete their degrees" (p. 11). One of the major issues with this policy is that it may have been prematurely implemented based on inaccurate data. At face value, "85% of students that enroll in remedial math do not pass a single college-level math course" (Pittendrigh, et al., 2020, p. 11). However, the fact is "overall attrition is always highest after a student's first semester," for various reasons, some not related to education (Goudas, 2018, p. 49). It is also well-known by educators in the area of developmental education that the courses in question are part of a tiered system or sequence.

Legislators may have been misled by comparing these students' pass rates incorrectly. Goudas (2018) explains that when comparing students in a two-course sequence, for example, the students who are placed in the second course but given twice the time in class to complete it, will almost always show higher pass rates than those who had to take both courses in a traditional two-semester time period. This is due to the fact that the pass rates for the second group includes the students who did not enroll in the second course at all. "The theory here is that if students do not have an opportunity to stop out, they will be more likely to persist and pass a class" (Goudas, 2018, p. 48).

Another reason educators may disagree with HB 2223 is that the legislators are "confusing causation with correlation and assuming that remedial English and math courses are *causing* high fail rates or attrition" (Goudas, 2018, p. 49).While it is true that most students requiring developmental education enroll in such courses during their first semester of college, first-semester courses have the highest fail rates, regardless of the type of course (Goudas, 2018).

Texas Success Initiative Assessment

The Texas Success Initiative (TSI) Program was enacted in 2003 to better help high school students transition to post-secondary education (Texas Success Initiative FAQ, 2004). This was accomplished by providing all Texas institutions of higher education with an assessment tool, to help incoming freshman students decide which courses are best suited to their needs in the areas of reading, writing, and mathematics. Students may be exempt from the TSI Assessment for a number of reasons. For example, student scores on the SAT and ACT are taken into consideration. Before reformations at the institution of this study, the ACCUPLACER exam was also considered, and served as

an aid in advising student placement in the mathematics program. In 2017, Texas officially adopted the TSI Assessment, or exemption thereof, as the sole means in advising student placement in developmental mathematics education. All students enrolling at an institution of higher education must take the TSI Assessment or be deemed exempt at the university level by one of the following reasons.

- ACT composite score of 23 or higher, with at least a 19 on the Mathematics section.[1]
- (Before March 5, 2016) SAT combined Critical Reading (formerly "Verbal") and Mathematics score of 1070, with a minimum score of 500 on the Mathematics test (see Footnote 1).
- (After March 5, 2016) SAT minimum score of 530 on the Mathematics test (see Footnote 1).
- Eleventh grade exit-level Texas Assessment of Knowledge and Skills (TAKS) minimum scale score of 2200 on the Math section (see Footnote 1).
- STAAR end-of-course (EOC) Algebra II minimum Level 2 score of 4000 (see Footnote 1).
- Texas Assessment of Knowledge and Skills (TAAS) minimum Texas Learning Index (TLI) of 86 on the mathematics test.[2]

[1] Scores only valid 5 years from the testing date.
[2] Scores only valid 3 years from the testing date.

- Student has graduated with an associate or baccalaureate degree from an institution of higher education.
- Student has already completed transferrable college-level coursework at another institution.
- Student has already been deemed "college-ready" by another institution.
- Student is serving on active duty as a member of the armed forces of the United States.
- (On or before August 1, 1990), student was honorably discharged, retired, or released from active duty as a member of the armed forces of the United States.
- Student has completed a college-preparatory course in mathematics, under the institution of enrollment.[3] (Texas Administrative Code, 2018)

Due to these changes, at the institution of this study, the developmental mathematics program changed from the placement policy described in Table 1 to the placement policy shown in Table 2, below.

Table 1 Student Placement Before Reformations (Program 1)

TSI SCORE	**0-335**	**336-350**	**351 or Higher**
Placement	Beginning algebra course	Intermediate algebra course	College-level mathematics course

[3] Student is only exempt for 24 months and must enroll in their first college-level course within their first year of enrollment.

Table 2 Student Placement After Reformations (Program 2)

TSI SCORE	0-335	336-350	351 or Higher
Placement	Beginning algebra course	College-level mathematics course with an NCBO	College-level mathematics course

Analyzing Developmental Mathematics Education

A common occurrence in newly reformed developmental mathematics education are mathematics pathways. "Pathways" in developmental mathematics education refer to major-specific courses, rather than one core algebra course required for all degrees/programs. In Bickerstaff, Chavarin, and Raufman's (2018) project for the Community College Research Center, they state the mathematics pathways have helped students receive college-level credit faster, as well as improved student retention and other long-term outcomes. Mathematical pathways offer a more organized approach which allows students to see the benefit and significance of their respective math course sequence.

The Charles A. Dana Center

One example of mathematics pathways, followed by the Community College Research Center, has gained a lot of interest in developmental mathematics education (Bickerstaff, Chavarin & Raufman 2018; Schudde & Meiselman, 2019; Moussa & Bickerstaff 2019). Created at the University of Texas (UT) at Austin in 2012, the Dana Center Mathematics Pathways to Completion (DCMP) approach is highly praised for its

early success and ongoing evaluation, and mentioned by name in the Texas HB 2223 Frequently Asked Questions (2018), under Question 14 "What type of can institutions expect from THECB to help them implement HB 2223?" The DCMP utilizes a "compression" approach in the pathways, where two or more developmental mathematics courses are compressed into one shorter, accelerated prerequisite course that is meant to feed into the students' respective college-level mathematics courses. The DCMP at UT, Austin offers professional development opportunities for educators experiencing reformations, such as conferences and workshops, and upkeep an online informational website on the Pathways, including how to implement them (Charles A. Dana Center, 2020).

Theories in Developmental Education

There is a great deal of literature on the research studies conducted, attempting to explain the complexity and seemingly futile attempts at developmental education, in general. However, many of the studies analyzing the effectiveness of a developmental program seem to lack any theoretical framework or are very subtle in stating a theory of which to base their program on. It is assumed that when any issue is addressed, there is a well-thought-out reason, or structure upon which a resolution is brought about. For developmental mathematics programs, there seems to be a lack of this structure. There are many fingers pointing to reasons why issues might exist, but researchers are now asking for a more grounded practice (Middleton & Spanias, 1999; Brothen & Wambach, 2004; Chung & Higbee, 2005). A short search into The Scholarship of Teaching and Learning (a community of researchers, scholars namely, who explore the relationship between teaching and learning, the way students learn, how teachers teach) provides even

more researchers demanding a better coherence of practice and theory (Dewar & Bennett, 2010; Kanuka, 2011; Miller-Young & Yeo, 2015).

Chung and Higbee (2005) explore the "theory crisis" in developmental education, concluding that while a few theories do exist, little research has been done implementing them. Most importantly, "everyday developmental educators and learning assistance practitioners seem to have thoughtful and valuable insights and ideas to share regarding the state of theory in our field", not just researchers (Chung & Higbee, 2005, p. 14). Other major literature within developmental education theories include Casazza and Silverman's (1996) book entitled *Learning Assistance and Developmental Education* that summarizes the work of many learning theories into one framework, tailored to the needs of students within the developmental education realm. Lundell & Collins (1999) draw upon Gee's (1996) "Discourses" as a lens through which to view students in the developmental education environment; people who merely have a different way of "being" in the world. Wambach, Brothen, and Dikel's (2000) idea that developmental education should be focused on the development of self-regulation is based on providing students with adequately demanding and responsive courses. While these theories exist, there is still much needed research to be done utilizing them, not only by researchers in the field, but practitioners as well. As Chung and Higbee (2005) state,

> The work has been carried out by leaders of the field or by individuals at research universities… But it is not clear whether the conversation regarding theory adequately represents the experiences, perspectives, and needs of those 'in the trenches,' the front-line practitioners working in the classroom, learning center, or advising or counseling office. (p. 6)

There is currently no consensus on a unifying theory of developmental education (Chung & Higbee, 2005; Kanuka, 2011; Miller-Young & Yeo, 2015), with many general theories or discipline specific frameworks being utilized. Therefore, this study employs Wambach, Brothen, and Dikel's (2000) proposed theory based on self-regulation, demandingness, and responsiveness as its framework.

Context of the Study

Until Fall 2019, the developmental mathematics courses at the institution in this study included a beginning algebra course and an intermediate algebra course, as shown in Table 1 (above). Depending on a student's score (assuming they are non-exempt) on the TSI Assessment, they would be placed in beginning algebra (scoring 335 or less), or intermediate algebra (scores of 336 to 350). After completion of intermediate algebra, students were able to enroll in their mathematics core curriculum requirement for college-level credit hours a full semester after they first entered the institution. Under the new corequisite model, this institution is incorporating the use of Non-Credit Bearing Option (NCBO) courses. Within these courses, students normally placed at the intermediate algebra level were allowed to enroll in their respective core curriculum mathematics course requirement, so long as they also enroll in the supplemental NCBO counterpart. Using this method, students are able to gain the college-level credit they need within one semester. If a student is placed in beginning algebra, the time in which it should take to receive college credit is accelerated from 3 semesters in the old format, to just 2 semesters using the new NCBO courses.

Theoretical Framework

Wambach, Brothen, and Dikel (2000) posed that "the conscious development of self-regulation is the task that might distinguish developmental education from other postsecondary education programs" (p. 3). Therefore, the main component of this theory is to "[think] about developmental education as a process that facilitates the development of self-regulation" (Wambach, Brothen & Dikel, 2000, p. 7). Self-regulation has been defined as self-generated thoughts, feelings, and actions that are directed toward the attainment of one's educational goals (Zimmerman, Bonner & Kovach, 1996). According to this theory of developmental education, this self-regulation is developed in social contexts which are demanding and responsive (Wambach, Brothen & Dikel, 2000). The desired solution then, is that by placing students in this type of environment, successful learning can occur.

Successful learning in this paper will be defined using two aspects of the student perspective; positive experience and positive outcome, after having participated in a course. Howard and Whitaker (2011) claimed that students' perceptions of success capability are highly influential to students' performance. There is much support for students' perceptions of oneself and one's feelings affecting the occurrence of learning (Middleton & Spanias, 1999; Kesici & Erdogan, 2009; Howard & Whitaker, 2011). It is important to include these internal qualities in our definition of success. While quantitative data measuring student outcomes gives helpful information, the student perspective is one in which the mathematics education community seems to have overlooked; "Little is known about how students specifically view their mathematics learning experiences" (Howard & Whitaker, 2011, p. 3).

Application of the Theory

The Developmental Mathematics Program

In order to foster self-regulation among students, the program must incorporate the aspects of demandingness and responsiveness. Wambach, Brothen & Dikel, (2000) give each aspect specific characteristics which can be applied to the program as described in the tables below. The developmental mathematics program before reformations is referred to as Program 1, after reformations, Program 2. Row one of each of the tables lists the characteristics of demandingness (Tables 3 and 4), and responsiveness (Table 5), as given by Wombach, Brothen, and Dikel (2000). It is worth noting that instructors play a large role in developmental courses. According to the theory proposed, themes also apply to instructors and their specific role in the classroom, as given in Tables 6 and 7. Characteristics displayed for Program 1 and Program 2 in these tables must be the "norm" at the university, but more characteristics of these themes may be present. Without individually evaluating each professor specifically on this theory, it is uncertain exactly how much or how little of the theory is being applied in the classroom

Table 3 Demanding Characteristics of the Developmental Program

In demanding classes…	Standards for excellence and expectations for appropriate behavior must be clearly stated and enforced.	Skills courses are challenging and clearly connected to the rest of the curriculum.
Program 1	• Courses provide all students access to course syllabi on or before the first class day, which clearly state required texts, prerequisites, objectives/student learning outcomes and program learning outcomes. The same syllabus is used for all course sections for consistency between multiple course instructors. • Expectations for missing homework or exams is clearly stated within the syllabi for all courses and is the same regardless of difference in instructor. • Attendance is required four days every week, rather than the traditional two. • Behavior expectations stated in the syllabi explain all students are expected to attend class, take notes, and participate in classroom discussions. • Other course policies ask that students log on to the institution's online course management system for announcements and updates	• Beginning and intermediate algebra courses were designed to follow a smooth progression through arithmetic and algebra, purposefully leading students into college-level mathematics courses. • There is a committee designated to devise and assess the curriculum every semester, solely for the improvement of the developmental mathematics program at the university.
Program 2	• Courses provide all students access to course syllabi on or before the first class day, which clearly state required texts, prerequisites, objectives/student learning outcomes and program learning outcomes. The same syllabus is used for all course sections for consistency between multiple course instructors. • Expectations for missing homework or exams is clearly stated within the syllabi for all courses and is the same regardless of difference in instructor. • Attendance is required four days every week, rather than the traditional two. • Behavior expectations stated in the syllabi explain all students are expected to attend class, take notes, and participate in classroom discussions. • Other course policies ask that students log on to the institution's online course management system for announcements and updates to the course.	• Beginning algebra courses often use short, 1-5 item quizzes in class to assess conceptual and procedural knowledge. Students are able to work in pairs or groups or ask the instructor for assistance. • NCBO courses were designed to incorporate the recently removed material required to understand the new material of the college-level course. • There is a committee designated to devise and assess the curriculum every semester, solely for the improvement of the developmental mathematics program at the university. • Often, the material is presented in a " just-in-time" approach, while students have access to teaching assistants in class. This way, students are still getting the material that picks up where beginning algebra course left off, while sitting in a more challenging college-level course.

Table 4 More Demanding Characteristics of the Developmental Program

In demanding classes…	Students are required to read, write, speak, compute and generally demonstrate competence.	Curriculum should be content-based and worth credit toward degrees.
Program 1	• Students are expected to be engaged in the lab activities during every lab day of beginning algebra and intermediate algebra courses. Students are allowed to work with each other and teaching assistants during this period, as there is no lecture on these days.	• Curriculum is reviewed at the beginning and end of every semester to ensure it is content-based, and to allow for smooth transition into consecutive mathematics courses by the designated developmental committee at the institution.
Program 2	• Students are expected to be engaged in the lab activities during every lab day of beginning algebra. Students are allowed to work with each other and teaching assistants during this period, as there is no lecture on these days. • NCBO courses often encourage students to work collaboratively on example exercises throughout lecture periods. The instructor will often have a teaching assistant available, so that during these exercises both the instructor and teaching assistant may walk around the room to provide assistance and encouragement.	• Curriculum is reviewed at the beginning and end of every semester to ensure it is content-based, and to allow for smooth transition into consecutive mathematics courses by the designated developmental committee at the institution. • Incorporating the NCBO courses allows for students to receive mathematics credits towards their degrees

Table 5 Responsive Characteristics of the Developmental Program

In responsive classes…	Courses should be small enough to allow students and teachers to come to know one another.	A wide variety of learners are accommodated.
Program 1	• Class sizes remain on average, between 10-25 students. • All instructors encourage students to contact them through a variety of means; office hours, email, phone, all of which are given to students on the first day of class and remain accessible throughout the semester on the provided syllabi for each course. • In beginning algebra students are encouraged to work collaboratively during the lab periods, giving the teaching assistants, who do not lecture, the chance to walk around the room and provide one-on-one as well as small-group aid. • Teaching assistants often also hold office hours, making themselves available to students outside of class.	• Students of all mathematic abilities are accepted at the institution upon meeting basic, initial admission requirements. If students are not declared exempt from taking the TSI Assessment, they must partake in the assessment tool which determines the student' s placement in an appropriate mathematics course at the institution. Even if students score a 0 on the mathematics portion of the exam, they are still accepted into the program. • Students registered with the institution' s Disability Services receive the necessary accommodations, on a case-by-case basis. Instructors are notified of these students every semester and are required to sign a form for each individual student ensuring they are aware of each individual' s situation, which includes the accommodations to which they are entitled.
Program 2	• Class sizes remain on average, between 10-25 students. • All instructors encourage students to contact them through a variety of means; office hours, email, phone, all of which are given to students on the first day of class and remain accessible throughout the semester on the provided syllabi for each course. • In beginning algebra students are encouraged to work collaboratively during the lab periods, giving the teaching assistants, who do not lecture, the chance to walk around the room and provide one-on-one as well as small-group aid. • Teaching assistants often also hold office hours, making themselves available to students outside of class. • Many of the NCBO courses are taught in collaborative environments on a daily basis, providing the TA' s (and instructors) time to walk around the room and provide students with more personalized instruction.	• Students of all mathematic abilities are accepted at the institution upon meeting basic, initial admission requirements. If students are not declared exempt from taking the TSI Assessment, they must partake in the assessment tool which determines the student' s placement in an appropriate mathematics course at the institution. Even if students score a 0 on the mathematics portion of the exam, they are still accepted into the program. • Students registered with the institution' s Disability Services receive the necessary accommodations, on a case-by-case basis. Instructors are notified of these students every semester and are required to sign a form for each individual student ensuring they are aware of each individual' s situation, which includes the accommodations to which they are entitled.

Table 6 Instructor Roles in Providing Demandingness

In demanding classes…	**Instructors create courses where, in order to succeed, students must read, think critically, and complete numerous assignments.**	**Instructors need support: appropriate workloads, performance evaluations based on more than popularity with students, training in designing demanding courses, access to technology for both the educators and their students.**
Program 1	• Textbooks are required in all classes. • Students are required to complete multiple homework assignments each week. • Exams include both numerical assessments as well as word problems.	• Instructors are encouraged to attend conferences and other events for Professional Development • Calculators, for appropriate courses, are available for students to rent out during exams as part of the math lab services
Program 2	• Textbooks are required in all classes, and often suggested as a source for extra help outside of class. • Students are required to complete multiple homework assignments each week. • Exams include both numerical assessments as well as word problems.	• Instructors are encouraged to attend conferences and other events for Professional Development • Calculators, for appropriate courses, are available for students to rent out during exams as part of the math lab services • Instructors are encouraged to make use of technology updates to classrooms (e.g. Apple TV' s installed in every classroom, instructor-issued iPads).

In responsive classes…	Instructors deliver timely and useful feedback, early and often.	Students are encouraged to record their progress and identify strategies for improving performance.
Program 1	• Initial feedback is given to students through in-class lecture. • Students may also receive feedback in the classroom by asking questions during lecture periods. • Outside of classes, all instructors hold office hours available to the students. • Other resources, at no additional cost include: two on-campus mathematics tutoring centers, one-on-one tutoring, scheduled with a personal tutor, offered through two of the institution's educational services, a Virtual Math Lab available 24/7 which provides tutorials specific to each lesson covered in all developmental mathematics courses, and Smarthinking: a 24/7 live online tutoring service. • All courses give students online access through the course management system to view their grades on all assignments. Gradebooks are updated regularly, and graded assignments and exams are handed back in class in a timely manner.	• In all courses, students may view their grades and academic progress throughout the semester. • Students are notified by instructors of important deadlines, such as the institution's last day to drop/withdraw from a class. It is left up to the responsibility of the student to evaluate their progress at this time in the semester and to be aware of their personal abilities.
Program 2	• Initial feedback is given to students through in-class lecture. • Students may also receive feedback in the classroom by asking questions during lecture periods. • Outside of classes, all instructors hold office hours available to the students. • Other resources, at no additional cost include: two on-campus mathematics tutoring centers, one-on-one tutoring, scheduled with a personal tutor, offered through two of the institution's educational services, a Virtual Math Lab available 24/7 which provides tutorials specific to each lesson covered in all developmental mathematics courses, and Smarthinking: a 24/7 live online tutoring service. • All courses give students online access through the course management system to view their grades on all assignments. Gradebooks are updated regularly, and graded assignments and exams are handed back in class in a timely manner. • Instructors are encouraged to use the institution's advising alert system. The notification sent to the student's advisor contains instructor-provided information alerting advisors to any situation needing attention including academic progress, changes in student attendance, or behavior.	• In all courses, students may view their grades and academic progress throughout the semester. • Students are notified by instructors of important deadlines, such as the institution's last day to drop/withdraw from a class. It is left up to the responsibility of the student to evaluate their progress at this time in the semester and to be aware of their personal abilities.

In the theme of responsiveness, it is said instructors and staff working with the students must also have good listening and conflict resolution skills. It is difficult to determine whether having these traits are the "norm" in any educational setting. It is the hope of this study to reveal the instructors of developmental education courses in the mathematics department at the university in question do possess these qualities through student responses, as would anyone evaluating an educational setting.

According to the theory, providing students with this type of social environment leads to the successful learning of mathematics. While each program displayed the characteristics of self-regulation through demandingness and responsiveness, the way they are being implemented has changed from Program 1 to Program 2. This is due to the new program's responsibility in essentially providing students with two semesters worth of knowledge in half the time, therefore it is more demanding while providing more feedback to aid in monitoring student progress (responsiveness). Program 2 is demanding students to be more self-regulating, hence demanding more successful learning of mathematics. The researcher hypothesizes then, that Program 2 will show more successful outcomes than Program 1.

III. METHODOLOGY

The aim of this study was to determine the successfulness of students' learning in the developmental mathematics track at the post-secondary level. Other implications of the study extend to generate program improvement and provide additional literature on reforms in developmental mathematics education.

As previously stated, the guiding research question to be explored is the following;

- What impact, if any, has changes to developmental mathematics course offerings had on students' successful learning of mathematics, in regards to overall experience and outcome?

To address the importance of both internal (qualitative) and quantifiable outcomes of the program, this study utilized a mixed-methods research approach, using a convergent parallel design. A convergent parallel design is one in which both qualitative and quantitative data is collected concurrently. According to Creswell and Clark (2011), the purposes of using a convergent parallel design include providing both sets of data equal importance, the ability to directly compare and contrast the separate data sets for corroboration and validation, and eventually, "to develop a more complete understanding of a phenomenon," (p. 77) the phenomenon of this study, being the students' learning of mathematics.

Quantitative Data. In order to view student outcomes, data was collected on student retention from the first Fall semester in which they were accepted at the university, to the following Spring semester for each of the two programs in question, Program 1 and Program 2. Under Program 1, at the most, students would take two developmental mathematics courses; a beginning algebra course and an intermediate algebra course, after which students would then be able to enroll in a credit-bearing mathematics course. Under Program 2, this is shortened to only one beginning algebra course, after which students can then enroll in a credit-bearing mathematics course. Student Math TSI scores were also collected, in order to differentiate which students were placed into the corresponding developmental mathematics course. Any personally identifying information was expelled from this database. This data was viewed using discontinuity regression, using the students' TSI scores as a control.

The goal of this study is to analyze the developmental education program in mathematics at the university level. The use of the Regression Discontinuity Design (RDD) was chosen due to its' rising popularity in education research (Lee & Lemieux, 2010; Matthews, Peters & Housand, 2012; Dyson, Solity, Best & Hulme, 2018; Jacob & Lefgren, 2004). Within the developmental educational setting, it is impossible to randomize which students will take developmental coursework, and those which will not. For the institution of this study, it should also be noted that it was impossible to control which students were assigned to Program 1 and Program 2, since the programs were not concurrently running at the same time. The major factor that determines whether a student should take developmental mathematics courses (in Texas) is the TSI Assessment. Unless the university chooses to randomly place students in developmental

courses, there is currently no ethical way to compare students with similar TSI scores (Matthews, Peters & Housand, 2012; Trochim, 2020), other than using RDD. The goal of RDD is to analyze a discontinuity at a certain pre-specified "cutoff" score or measure among a certain group of observations. A treatment effect is shown when there is a discontinuity in the regression line at the cutoff point for group assignment. In this case, a math TSI score of 335 is the cutoff score for requiring the developmental courses analyzed in this study and any errors are accounted for since this is a university policy (Matthews, Peters & Housand, 2012).

Qualitative Data. In order to view student perspectives after taking at least one of the courses offered in the developmental mathematics program, students were asked to participate in a survey. The survey (Appendix A) first collected information about the student, such as gender, race/ethnicity, major, and asked which developmental mathematics course(s) the student had taken. At the end of the survey, students were asked two short-answer questions, including, "As a student from a developmental course at [the institution], do you have any suggestions about the course, in general?" The final section of the survey asked if the student was willing to participate in an interview to further discuss their experiences from their developmental mathematics course(s). The students had the option to decline and if not, they indicated their preferred method of contact and how to reach them. If they so wished, students were contacted and participated in a short interview (see Appendix B for Tentative Student Interview Protocol), discussing their experience and outlook on the developmental course(s). Interview transcripts were then coded, using thematic coding analysis in conjunction with the theory for developmental education, proposed by Wambach, Brothen, and Dikel

(2000). Both results from the survey and the interviews helped understand the students' feelings towards mathematics after having experienced at least one of the courses offered through the developmental mathematics program at the university.

Data Collection

Students. The first database collected, with the help of the institution's research center, included undergraduate students 18 years of age or older, from all classifications (freshmen, sophomore, junior, or senior) at the institution, who are or were previously enrolled in a developmental mathematics course in the Fall semesters of 2017 and 2019. Mathematics course offerings under the "developmental" designation include the beginning algebra course, intermediate algebra course, and any core-level mathematics courses paired with the Non-Credit Bearing Option. Two cohorts of students were analyzed: students first entering the developmental mathematics program in the Fall of 2017 served as the population before reformations at the institution (Program 1), students first entering the developmental mathematics program in the Fall of 2019 served as the population after reformations (Program 2).

A second database, separate from the first, was retrieved, only to include email addresses of undergraduate students, 18 years of age or older who are or were previously enrolled in a developmental mathematics course. The student survey as mentioned above was sent to these students as an anonymous link in an email, clearly stating the goal of the research and the option to decline participation. Students who chose to further discuss their experiences in the developmental mathematics program at the institution were contacted for an interview with the researcher. According to institutional review board

policy, students and any named professors were given pseudonyms. Students were asked to sign consent forms stating the nature of the questions asked, optional participation/stopping the interview, and where to go for any other information or questions regarding the study once the interview concluded.

Instructors. Instructors are an integral part of providing a classroom environment which is demanding and responsive, as previously stated in Tables 3 through 7. Instructors who currently are or have previously taught any of the developmental mathematics course offerings mentioned above at the institution also served as participants in this study. After acquiring permission from the institution's Associate Dean of the mathematics department, the appropriate instructors were asked to participate in an interview (see Appendix C for Tentative Instructor Interview Protocol). Similar to student interviews, instructors were asked to sign consent forms stating the nature of the questions asked, optional participation/stopping the interview, and where to go for any other information or questions regarding the study once the interview concluded.

IV. RESULTS

Demographics

The population of students participating in developmental courses in the Fall of 2017 and Fall of 2019 included 468 total students. Table 8 gives the demographics of the students included in the database used for the RDD analysis. Both programs contained mostly female students. Program 1 was mostly White students, while Program had nearly an even distribution of White and Hispanic students. Greater numbers of African American students were enrolled in Program 2, while Other races/ethnicities remained similar throughout both programs, which included Asian American, Pacific Islander, multiple races reported, etc.

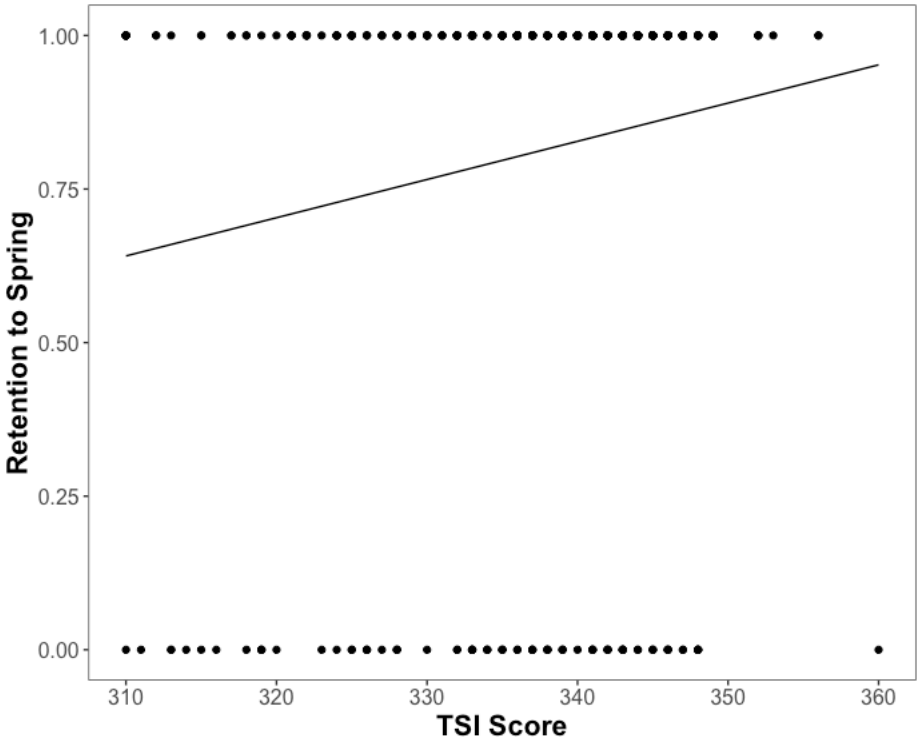
Table 8 Demographic Data of Students in Regression Analysis

	Program 1		**Program 2**	
	n	%	n	%
Gender				
Female	115	55.0	158	61.0
Male	94	45.0	101	39.0
Race/Ethnicity				
White	98	46.9	97	37.5
Hispanic	73	34.9	102	39.4
African American	22	10.5	39	15.1
Other	16	7.7	21	8.0

Regression Discontinuity Design

All regression analysis was completed using R-Studio. To begin with the RDD model, an overall regression was run on the entire dataset, both 2017 and 2019 cohorts.

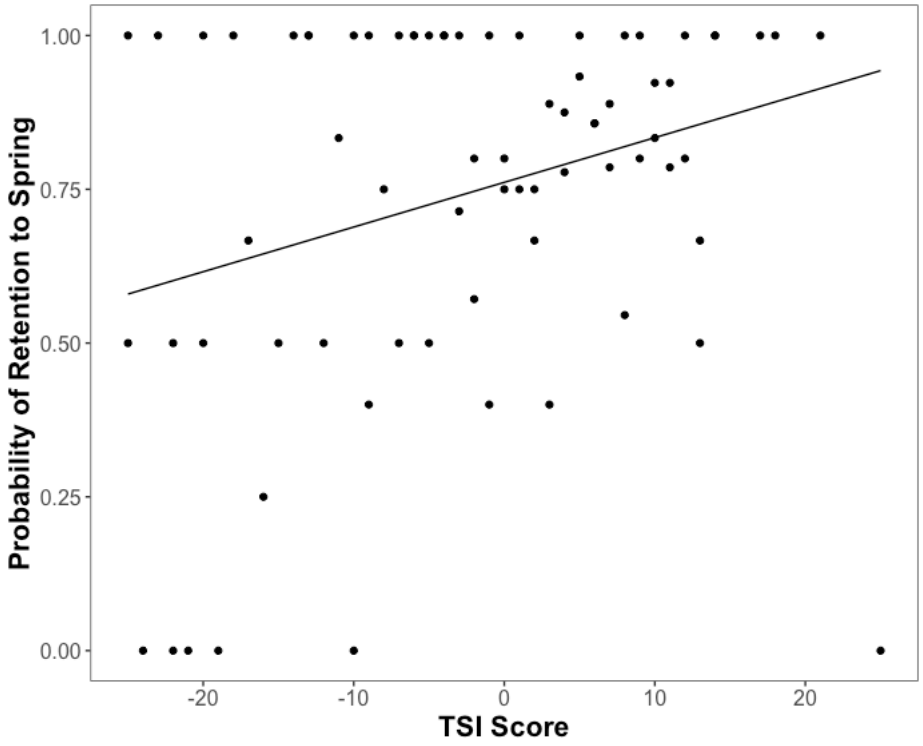
Figure 1 Overall Regression Line of Retention



In this RD model, the estimate for the coefficient of the math TSI score is positive, and math TSI scores had a *significant* positive impact on retention rates at the 95% significance level ($p = 0.002, CI: (0.002, 0.010)$). However, all data points are either zero's or one's. This is due to the dependent variable of this regression analysis being "retention from first fall semester to first spring semester", being either Yes or No. To conduct a more pleasing RDD, these data points were transformed into the probability of retention given a certain TSI math score, using a Bayesian (empirical) distribution. TSI math scores were transformed in order to center the x-axis at zero. The cutoff point (zero)

in this graph is the TSI math score which would have determined placement into the two classes, 335. The resulting dataset, including the regression line is shown in Figure 2.

Figure 2 Overall Regression for Probability of Retention

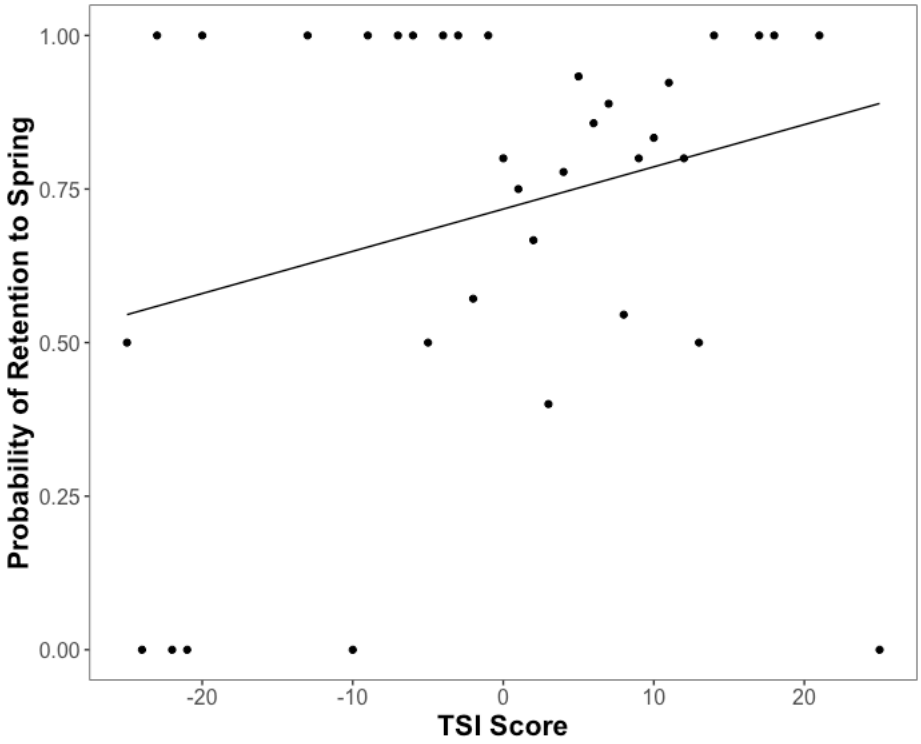


Using the probability now gives a little less significance of TSI math score on the probability of retention, but still significant, and positively affecting retention ($p = 0.011, CI: (0.001, 0.013)$). After separating the data into the respective cohorts, a new regression analysis was run on each.

Program 1: 2017 Cohort

Figure 5 shows the regression line for the 2017 cohort. This group of students were either placed in beginning algebra (to the left of zero), or in an intermediate algebra course (to the right of zero). In other words, students scoring a 335 or less were placed in the beginning algebra course (to the left of zero), and students scoring a 336 or above were placed in the intermediate algebra course (to the right of zero). Retention to the spring semester is recorded on the y-axis.

Figure 3 Program 1 Probability of Retention



According to the summary of this regression, given in Figure 6, TSI math scores do have a positive impact on retention rates, but it is no longer a significant factor ($p = 0.119, CI: (-0.001, 0.015)$). Zero is within the confidence interval, meaning there may be no relation between TSI math scores and retention rates among students who were in Program 1.

Application of the Model

The RDD in this study will follow the basic model:

$$Y = b_0 + b_1X + b_2T + e$$

where Y is the outcome, or the predicted probability of the student being retained, assuming they made a certain TSI math score; b_0 is the intercept for the line representing the group of students below the cutoff score, students in the beginning algebra course; $b_0 + b_2$ is the intercept for the line representing students above the cutoff score, students taking intermediate algebra; b_1 is the

marginal effect of scoring one point higher on the TSI math portion (X) on the outcome variable Y; $b_2$is the estimated treatment effect; T denotes which side of the cutoff score the student is (left or right); e is the error in this prediction (Matthews, Peters & Housand, 2012).

Using this model, one can easily derive that T will always be either 0 or 1, for being in beginning algebra or intermediate algebra, respectively. In the case that a student is placed in beginning algebra, $T = 0$, and

$$Y = b_0 + b_1X + e$$

Given some error, this gives us a linear model. It is the linear regression which appears on the left of the cutoff score: TSI scores are the independent variable, X, while b_0 is the intercept of the y-axis, and b_1 is the slope, the description of how Y changes as X changes.

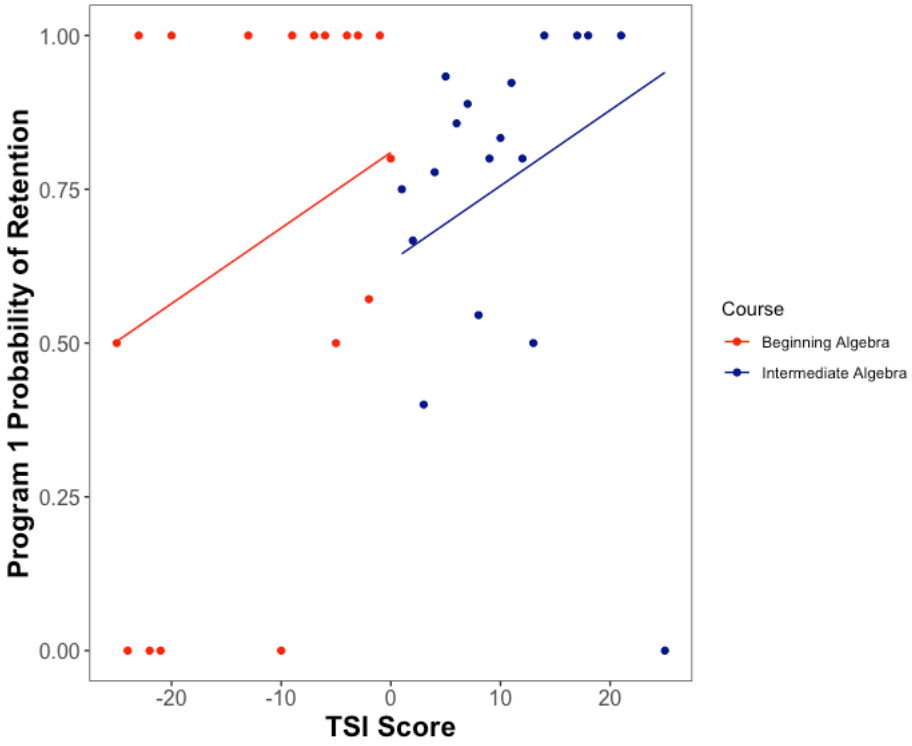
In the case that $T = 1$

$$Y = b_0 + b_1X + b_2 + e$$

Given some error, again this gives us the linear regression which appears on the right. Since b_0 and b_2 are both constants, their sum gives us a new y-intercept, but we still have the same slope as before. Therefore, the two lines on either side of the RDD are parallel, giving us the same slope for the relationship between the independent and dependent variables. The main idea of RDD is to analyze the difference between these two lines; the difference in the y-intercepts. In other words, the size of this discontinuity gives an estimate of the effect TSI scores have on retention (Dyson, Solity, Best & Hulme, 2018).

Incorporating the RDD model to the entire 2017 cohort, we get Figure 4.

Figure 4 Program 1 Full Regression Discontinuity

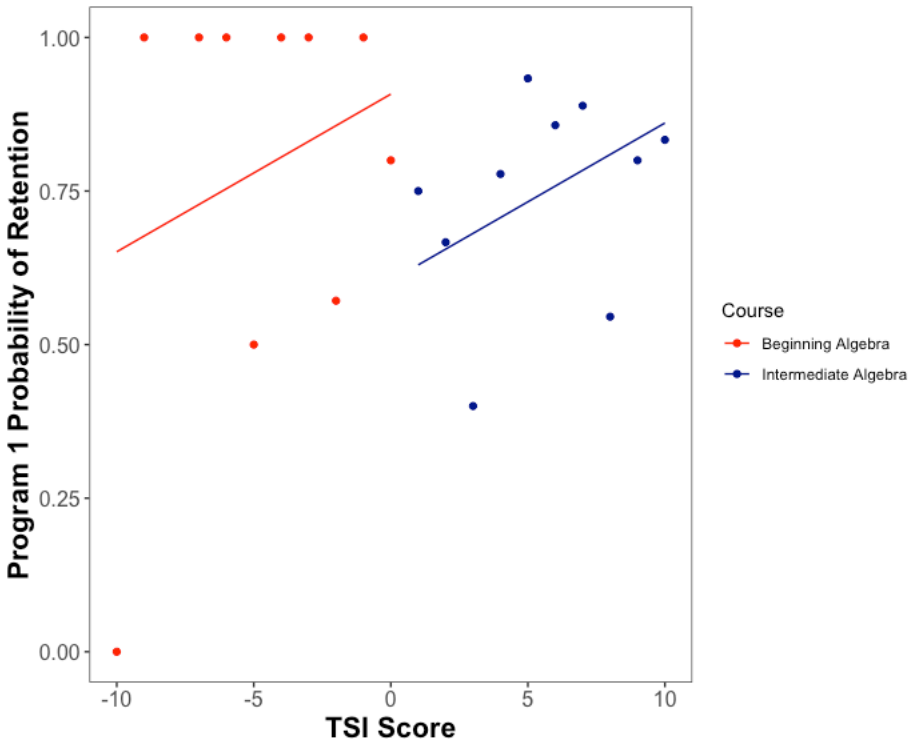


Neither TSI math scores, nor the intermediate algebra course have a significant effect on retention rates ($p = 0.109, CI: (-0.002, 0.026)$ for TSI score, and $p = 0.381, CI: (-0.575, 0.221)$ for intermediate algebra). The discontinuity in Figure 4 shows that the intercept of the line to the right of the cutoff score is actually below the intercept of the line to the left of the cutoff. This implies students placed in the intermediate class are somewhat negatively affected by the placement system. But again, zero remains within the confidence interval and there may be no effect at all.

This is for the entire 2017 cohort. It is safe to assume there could be differences in students 20 points away from the cutoff score, which this RDD is not concerned with. Students 20 points above (or below) the cutoff score are not as affected by what happens at the cutoff

score as much as students 10 points above (or below) the cutoff score, or even 5 points above (or below). To show this, a new RDD is calculated at 10 points above and below the cutoff score, given in Figure 5, and summarized in Table 9.

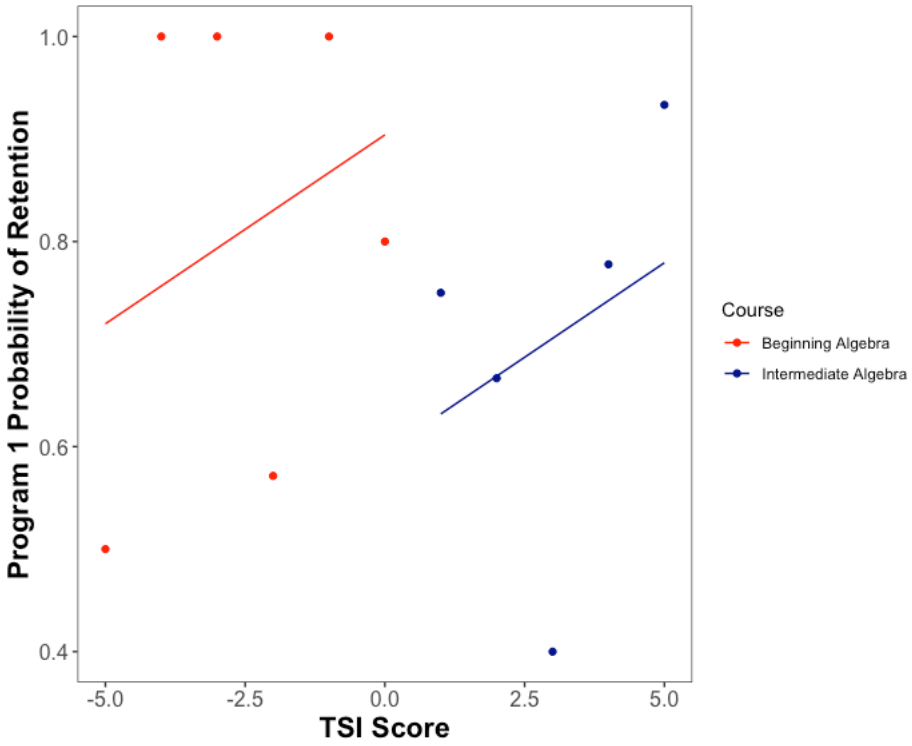
Figure 5 Program 1 Regression Discontinuity +/- 10 TSI Points



This graph continues to show a positive trend, but with students being negatively affected by the intermediate algebra course, closer to the cutoff TSI math score. For TSI scores, $p = 0.199$, CI: $(-0.012, 0.064)$, meaning it is still not significant enough to say this is truly what is happening. For the intermediate algebra course, $p = 0.200$, and the confidence interval, $(-0.760, 0.152)$. Again, both confidence intervals include zero.

A new RDD is calculated at 5 points above and below the cutoff score in Figure 6, summarized in Table 9.

Figure 6 Program 1 Regression Discontinuity +/- 5 TSI Points



The data from this final RDD gives us no new information.

Table 9 Summary for Program 1 RD Models in Figures 4-6

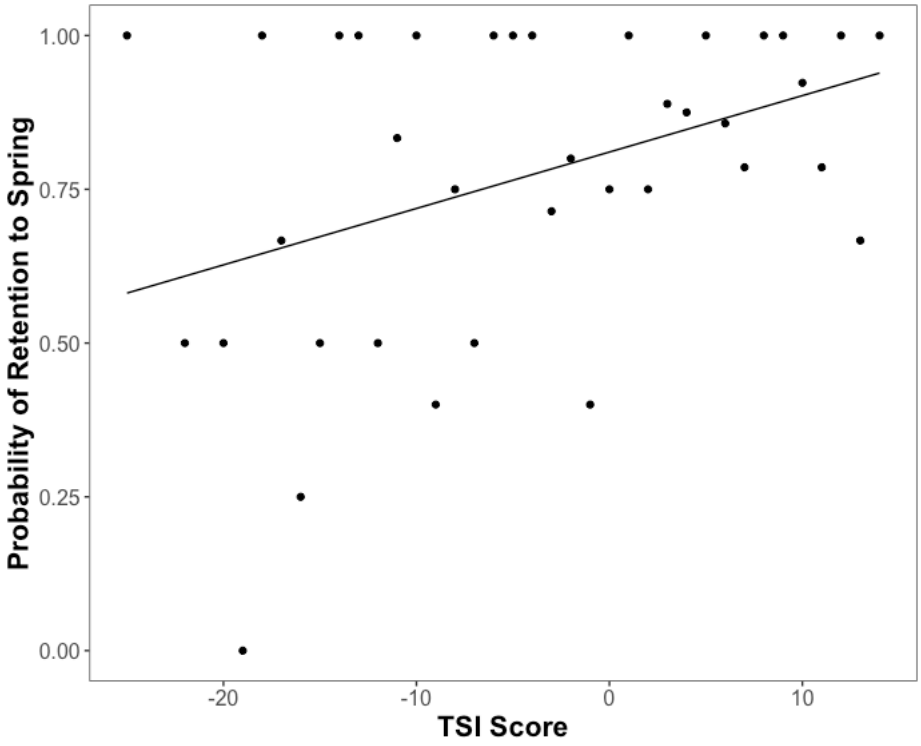
Variable	*B*	SE	T	p	95% CI
Full RD Model (Figure 4)					
b_0	0.810	0.119	6.818	1.04E-07	[0.572, 1.048]
TSI Score	0.012	0.007	1.648	0.109	[-0.002, 0.026]
Intermediate Algebra	-0.177	0.199	-0.889	0.381	[-0.575, 0.221]
RD +/- 10 Points (Figure 5)					
b_0	0.908	0.122	7.438	9.7E-07	[0.664, 1.152]
TSI Score	0.026	0.019	1.336	0.199	[-0.012, 0.064]
Intermediate Algebra	-0.304	0.228	-1.333	0.200	[-0.759, 0.152]
RD +/- 5 Points (Figure 6)					
b_0	0.904	0.136	6.626	0.000165	[0.632, 1.176]
TSI Score	0.037	0.041	0.889	0.399	[-0.045, 0.119]
Intermediate Algebra	0.309	0.263	-1.174	0.274	[-0.836, 0.217]

Program 2: 2019 Cohort

Figure 7 shows the overall regression line for the entire 2019 cohort. This group of students were either placed in beginning algebra (to the left of zero), or in a corequisite course (to the right of zero). TSI math scores were transformed in order to center the x-axis at zero. The cutoff point (zero) in this graph is the TSI math score which would have determined placement into the two classes, 335. In other words, students scoring a 335 or less were placed in the beginning algebra

course (to the left of zero), and students scoring a 336 or above were placed in the corequisite course (to the right of zero). Retention to the spring semester is recorded on the y-axis.

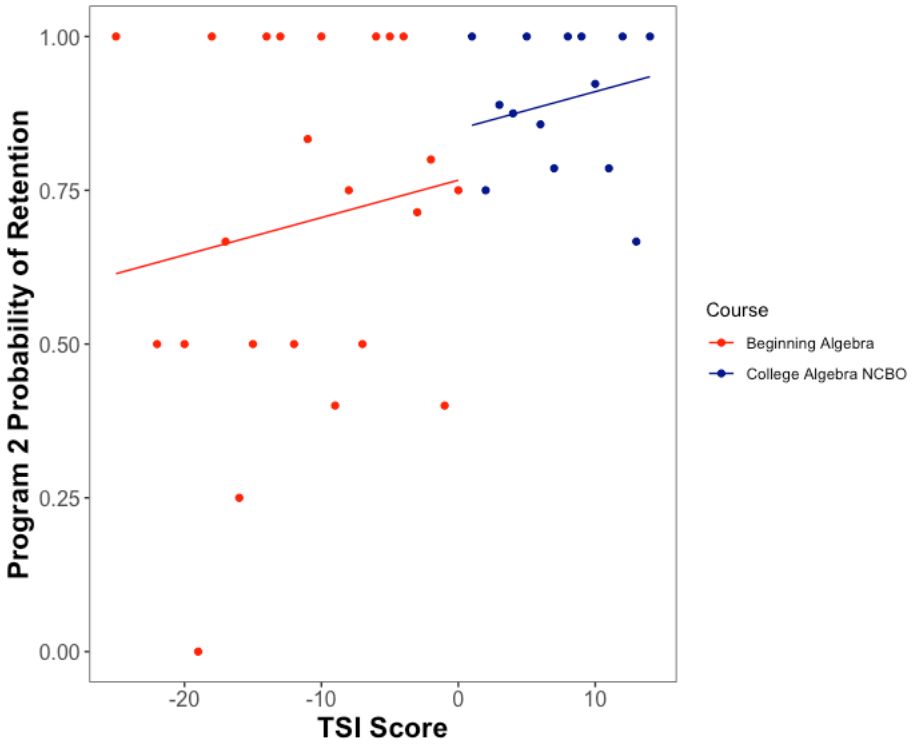
Figure 7 Program 2 Probability of Retention



The summary given Figure 7 gives TSI math scores as a significant factor at the $p = 0.015$ level, (CI: $(0.001, 0.017)$). This implies that for Program 2, TSI scores might play a bigger role in predicting retention than they did in Program 1.

The only difference in RDD models between 2017 and 2019 is that the regression line to the right of the cutoff score is now representing the appropriate corequisite course. Incorporating the RDD model for the 2019 cohort gives us Figure 8, summarized in Table 8.

Figure 8 Program 2 Full Regression Discontinuity

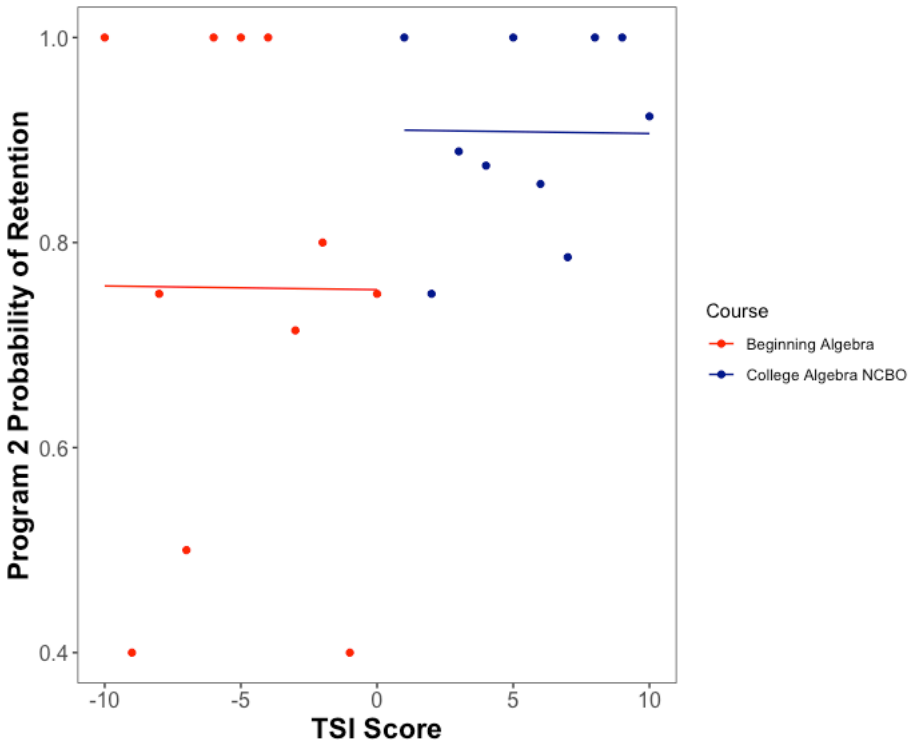


Incorporating the discontinuity into the model now tells us that TSI math scores are not significant ($p = 0.359$). In Figure 8, the intercept for the line to the right of the cutoff score is now above the intercept for the line to the left of the cutoff score, unlike Program 1. This, in turn implies that the corequisite course had a positive effect on students nearest the cutoff score.

Just as for the 2017 cohort, it is important to consider the probabilities as they get closer and closer to the cutoff score. These are the populations most affected by the cutoff score.

Figure 9 gives the 2019 cohort at 10 points below and above the cutoff score.

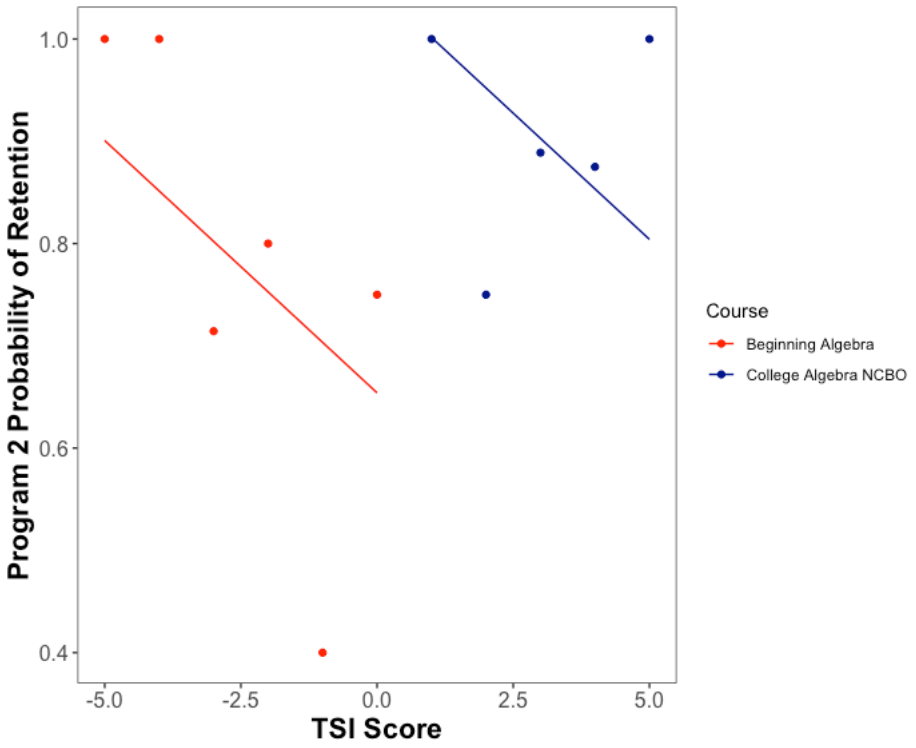
Figure 9 Program 2 Regression Discontinuity +/- 10 TSI Points



The graph of the retention rates now looks as though there may be no slope at all, (no relationship between TSI math scores and retention rates). A look at the summary in Table 8 tells us TSI math scores may have a *negative* effect on retention rates. But we must keep in mind, the data also says these are not significant; for the NCBO course, $p = 0.356, CI: (-0.174, 0.486)$ and for TSI scores, $p = .979$, with $CI: (-0.028, 0.028)$. With the confidence interval so centered around zero, there very well may be no effect at all.

Figure 10 gives the 2019 cohort at 5 points below and above the cutoff score.

Figure 10 Program 2 Regression Discontinuity +/- 5 TSI Points



This graph is now drastically different than before, claiming a negative effect of TSI scores. In other words, the higher a student scores on the TSI math portion, the less they are likely to be retained to the next semester. Although the corequisite course does have a positive impact on students nearest the cutoff score, the trend remains negative. According to the summary table, these factors are not significant: for TSI scores, $p = 0.160, CI: (-0.113, 0.015)$, and for the NCBO course, $p = 0.085, CI: (-0.007, 0.801)$. However interesting the graph may seem, the truth is, there may be no relationship at all.

Table 10 Summary for RD Models in Figures 8-10

Variable	B	SE	t	p	95% CI
Full RD Model (Figure 8)					
b_0	0.766	0.088	8.661	4.05E-10	[0.590, 0.942]
TSI Score	0.006	0.007	0.929	0.359	[-0.008, 0.020]
College Algebra NCBO	0.083	0.147	0.567	0.574	[-0.211, 0.377]
RD +/- 10 Points (Figure 9)					
b_0	0.754	0.089	8.518	9.92E-08	[0.576, 0.932]
TSI Score	-0.0003	0.014	-0.027	0.979	[-0.028, 0.028]
College Algebra NCBO	0.156	0.165	0.947	0.356	[-0.174, 0.486]
RD +/- 5 Points (Figure 10)					
b_0	0.654	0.105	6.241	0.000248	[0.444, 0.864]
TSI Score	-0.049	0.032	-1.550	0.160	[-0.113, 0.015]
College Algebra NCBO	0.397	0.202	1.963	0.085	[-0.007, 0.801]

Thematic Coding Analysis

In partnership with the quantitative data, survey and interview responses were analyzed according to themes of the theory proposed by Wambach, Brothen, and Dikel (2000): self-regulation, demandingness, and responsiveness. In the design of these questions, it was important not to directly bias the responses by asking specifically about the themes of the theory, or the effectiveness of the program(s). Instead of leading questions, the researcher asked students and instructors to describe their experience and/or give suggestions for the courses in question.

Survey Results

Out of 102 survey responses coded, Program 1 accounted for 29 of the responses, and program 2 accounted for 73. While there are much more participants from Program 2, the demographics of these two populations of students are very comparable, as shown in Table 11.

Table 11 Demographics of Student Survey Participants

	Program 1		**Program 2**	
	n	%	N	%
Gender				
Female	22	75.9	53	72.6
Male	7	24.1	20	27.4
Race/Ethnicity				
White	16	55.2	37	50.7
Hispanic	10	34.5	22	30.1
African American	2	6.9	8	11.0
Other	1	3.4	6	8.2

The following tables give the three main themes of the theory used in this study, as defined by Wambach, Brothen, and Dikel (2000), according to how the survey responses were coded.

Table 12 Coding Student Survey Responses According to Main Themes[4]

A student showed evidence of…	If the survey response talked about…
Self-Regulation	Any self-generated thoughts, feelings, or actions directed at the attainment of one's educational goals.
Course Demandingness	Standards for excellence and expectations for appropriate behavior clearly stated and enforced. Skills courses are challenging and clearly connected to the rest of the curriculum. Students are required to read, write, speak, and generally demonstrate competence. Curriculum/course material is content-based and worth credit toward degrees. Students are asked to read, think critically, and complete numerous assignments.
Course Responsiveness	Small class sizes, or evidence of students and teachers getting to know one another. Student services being proactive or anticipating what students will need. Instructors/staff have good listening and conflict-resolution skills. Instructors/staff respect cultural and racial differences and acknowledge diversity in the classroom. Instructors/staff deliver timely and useful feedback, early and often. Instructors/staff encourage students to record their progress and identify strategies for improving performance.

[4] Themes adapted from Wambach, Brothen, & Dikel (2000).

The two short-answer questions on the student survey were the following.

- Short Answer Question 1: As a student from a developmental mathematics course at [the institution], do you have any suggestions about course materials, such as homework assignments, labs, textbook?
- Short Answer Question 2: As a student from a developmental mathematics course at [the institution], do you have any suggestions about the course, in general?

The coded responses were separated into two categories for each of the main themes from the theory, whether a survey response showed *evidence of* the student applying that certain theme or *opposition to* the theme, along with the frequency of such an occurrence. It is important to note that some responses showed an opposition to certain themes. For example, one response stated, "I believe some of the course material can be disregarded in relation to the many types of business majors". This response was recorded as demandingness of the course, but in *opposition to* demandingness. According to the developmental education theory proposed by Wambach, Brothen, and Dikel (2000), curriculum should be *content based*. This response is an example of course material that is regarded as not needed, does not apply, or rather, *not content based.*

First, the 2017 cohort was coded, summarized by Tables 13 and 14, using the two short answer questions on the student survey.

Survey Results

Table 13 Program 1 Themes in Short Answer Questions

Program 1 (2017)	**Evidence/Opposition**	**Frequency**	
		n	%
Self- Regulation	Evidence	18	31.0
	Opposition	1	1.7
Demandingness	Evidence	11	19.0
	Opposition	6	10.3
Responsiveness	Evidence	2	3.4
	Opposition	6	10.3

Table 14 Program 2 Themes in Short Answer Questions

Program 2 (2019)	**Evidence/Opposition**	**Frequency**	
		n	%
Self- Regulation	Evidence	38	26.0
	Opposition	1	0.7
Demandingness	Evidence	10	6.8
	Opposition	5	3.4
Responsiveness	Evidence	8	5.5
	Opposition	8	5.5

Self-regulation is the most apparent theme overall, both because the students showed evidence of this theme most often and their opposition to this theme the least often. Program 1 has been shown to be more demanding within these survey responses, while both programs are less responsive than expected.

Interview Results

13 students agreed to participate in an interview. Two had to be excluded for technical issues in the recordings. The remaining 11 were separated into two groups, 3 students from Program 1 and 8 students from Program 2. Tables 15 and 16, similar to Tables 13 and 14, give the main themes of the theory again, and the frequency for which they occurred. Unlike the survey responses, the themes do not belong to a certain question from the interview protocol. Interviews followed a tentative protocol (see Appendix B Tentative Student Interview Protocol). Questions included on the interview protocol included the following.

- Can you describe your experience in this course?
- Do you see this as a worthwhile course?
- Do you understand the significance of the course to your program of study?
- (For students from Program 1) Under our new program, students who received a 336 or above on the TSI test are able to enroll in a college algebra course, along with a Non-Credit Based Option course. This allows those students who may not have been ready for college algebra to get the extra help they need in order to pass college algebra in one semester. They get to cover all the same material and even take the same Final Exam at the end of the semester so that they receive that college algebra credit. The main difference is that these students will be meeting with instructors and Teaching Assistants 4 days a week, rather than 2 days a week in the regular college algebra class. Is this option something you would have preferred?

Every student had the opportunity to respond to each of the questions however, each student responded differently, and various topics were explored in each interview, based on the students' responses. Multiple questions and topics were raised that are not included in the interview

protocol. Any occurrence of the themes defined by the theory of this study were recorded according to Table 12 Any secondary themes are summarized by Tables 17 and 18, for Program 1 and Program 2, respectively.

Main Themes

Table 15 Program 1 Themes in Interview Responses[5]

Program 1 (2017) Themes in Interview Responses	**Evidence/Opposition**	**Frequency**
Self- Regulation	Evidence	11
	Opposition	0
Demandingness	Evidence	7
	Opposition	6
Responsiveness	Evidence	2
	Opposition	8

Table 16 Program 2 Themes in Interview Responses

Program 2 (2019) Themes in Interview Responses	**Evidence/Opposition**	**Frequency**
Self- Regulation	Evidence	34
	Opposition	0
Demandingness	Evidence	9
	Opposition	6
Responsiveness	Evidence	24
	Opposition	7

Unlike survey responses, during the interviews, students were allowed more than one short response per question asked. If a student showed more interest in expanding on their response to one of the questions asked, the researcher allowed for this exploration on the topic. Therefore, it

[5] Table 16: 16 of the total occurrences recorded originated from one student (Jim)

would be unwise to calculate percentages based on the number of responses given, since interviews were so tentative. Based on the numbers alone, self-regulation remains the most prominent theme overall. However, within these interviews, students seemed to express more of a responsiveness in Program 2 than Program 1.

Secondary Themes

A few underlying themes were recorded during the analysis. These secondary themes help give meaning to the main themes of the theory. For example, any student response which was directed at the attainment of educational goals was coded as self-regulation, whether it was positive or negative. The secondary theme of "It helped me", when referring to a developmental math course tells a strictly positive story.

Table 17 Secondary Themes in Program 1 Interviews

Program 1 (2017) Themes in Interview Responses	**Subcategory**	**Frequency**
It helped me	True	3
	False (the course "did not help")	9[6]
Faculty/Staff	Positive	3
	Negative	10[7]

Table 18 Secondary Themes in Program 2 Interviews

Program 2 (2019) Themes in Interview Responses	**Subcategory**	**Frequency**
It helped me	True	25
	False (the course "did not help")	4
Faculty/Staff	Positive mention	25
	Negative mention	10

[6] Table 17: Under responses coded as "the course did not help", all 9 occurrences originated from one student (Jim)
[7] Table 17: Under responses coded as Negative mentions towards Faculty/Staff, 8 occurrences originated from one student (Jim)

Instructor Interviews

Four instructors from the university also participated in an interview. Three of these instructors have experienced teaching under both programs. The fourth was asked to compare the developmental courses to the equivalent college-level courses (e.g. a college algebra course paired with an NCBO corequisite course compared to a stand-alone college algebra course). The goal of this study is to analyze the students participating in developmental courses at the institution, and their success in these courses. For this reason, themes from the instructor interviews do not match up perfectly with the theory of this study, but they will be used to provide insight on the results of the student responses and RDD analysis. The themes which appeared 75% of the time or more, (3 or more instructors spoke about this topic) are given in Table 19.

Table 19 Themes from Instructor Interviews

Instructor Themes from Interviews	Example
Some students need an intermediate algebra course/not ready for NCBO	"For those half a dozen people that were blown away, because they just didn't feel like they could do it at all, We still need an [intermediate algebra] section and I don't know how you could do that with the enrollment stipulations we have." (Mr. Edward)
NCBOs do benefit some students	"I've only done this once the NCBO thing. Okay, the one time I did it, I think it helped more than it drove away." (Mr. Edward)
Developmental program still needs work	"It's hard to say what's better for each kid. And even if we could offer both methods [of intermediate algebra and NCBO courses], I don't know that we would have a true way to get the right kids in the right spot." (Mr. Umbridge)
TSI scoring system negatively affects students	"One of the problems we had to address with both systems was the TSI." (Mr. Edward)
Students feel overwhelmed in NCBOs	"the NCBOs are detrimental [to some students] because the four days a week becomes overwhelming, they get behind and they just quit. They either quit coming, [or] they drop." (Mr. Umbridge)
Continuous improvement	"I've learned so much of this. The way I teach even basic things, is so different than the way I started teaching… in high school, 16 years ago." (Mr. Umbridge)
Students have lack of confidence/motivation	"The first difference that comes to mind [between students in the NCBO's and stand-alone college algebra course] is not academic. Surprisingly, it's their social skills or lack thereof, their confidence level, their defense mechanisms." (Mrs. Tatum)
Not much of a difference in programs	"With the grades, I don't see very much difference [between programs]." (Mrs. Tatum)
Negative student history with math (before the university)	"I think some of them have been so lost in math for such a long time." (Mrs. Singer)
Negative student attitude towards math	**"**I know some students who have the attitude of I've never got this. So, I never will. Somehow the attitude of I don't need math." (Mrs. Singer)

V. DISCUSSION

The question set out to be explored through this study is the following;

- What impact, if any, has changes to developmental mathematics course offerings had on students' successful learning of mathematics, in regards to overall experience and outcome?

In regards to overall experience, student surveys and interviews were collected. To analyze the course offerings, students were assigned to either Program 1 or Program 2, according to the change in course offerings. In regards to student outcomes, retention data was obtained and analyzed through Regression Discontinuity Design (RDD) methods for the two programs. To get a fully-formed response to the research question, these two methods were combined to form the following generalizations about the developmental mathematics education program at the university.

Connecting Results to Responses

At the university of this study, the developmental mathematics program is still under reformations. Incorporating Non-Credit Based Option courses only began in the Fall of 2018. Such rapid changes in course offerings affect both students and educators alike. In a student interview, Callie described her feelings after her instructor revealed to the class that it was being taught under a new program,

> So, it was better, like, for trying to figure out how to, like, making it to where the program was run smoothly. I feel like that was kind of what it was, like, she was very frustrated with that. And she kind of took it out on us. I'm not… it happens, like, we're all human and everything, so I'm not mad, but it was just kind of… it was really hard.

As stated in many of the graphs from the RDD analysis, TSI scores seemed to not have much effect in the retention of students to the next semester. TSI scores were significant for both Programs, before the RDD model was used. TSI scores commonly do give educators a good idea of how well students will succeed in math courses. However, once we consider the specific courses in developmental education, the TSI scores may or may not give any such indication. With almost all the confidence intervals including zero, we cannot be sure. This is most apparent in one instructor's comparison of his classes' passing rates throughout his developmental teaching experience.

> So, from the original enrollment, we're going to end up with probably about a 25 to 30% passing rate, which is really sad. However, if you go back to the old system with [beginning algebra], and [intermediate algebra] and [college algebra], generally, we had somewhere around 60% passing rates. Well, if you get 60% that pass [beginning algebra] and then 60% of those pass [intermediate algebra], now you're already down to 36%. And if only 60% pass those, you're down to around 20% anyway, by the time they get through all three semesters. So, if we can get 25 to 30%, to pass one semester, it's almost a victory, which is a sad way to think about it. (Mr. Umbridge)

The graphs of Program 1 and Program 2 differed in the arrangement of the discontinuity. For Program 1, all the RDD graphs showed a negative effect of the intermediate algebra course on students nearest the cutoff score, while Program 2 showed more of a positive effect. In the themes of the theory, instructors play a big role in *responsiveness* towards the students and this effect is clearly shown in Tables 15 and 16. In Program 2, students talked about the responsiveness of their instructors in 12 times as many occurrences as in Program 1. When taking the appropriate ratio of students from each program into account, that is 4.5 times as often. In the theory proposed by Wambach, Brothen, and Dikel (2000), instructors have the most responsibility within the theme of responsiveness.

As an educator in the field of developmental mathematics, instructors were asked what they believe to be some "best practices" for this group of students. All four were able to come to an agreement that the most important practices are to build proper relationships, and to make students aware of the shared goal: success in the course. Instructors believe it is most important for students to feel comfortable enough to speak up in class, to approach the instructor or TA's outside of class, and to have meaningful conversations with the students.

- "Create relationships with those willing to create relationships." (Mrs. Singer)
- "The number one thing is the rapport the teacher establishes with those students. Period. That's how strongly I feel about it." (Mrs. Tatum)

- "It does help to remind them of the fact that this is a different process. We're still trying to make it better. Your feedback is always welcome." (Mr. Edward)
- "I always tell the kids who come to me and say, I hate math. Like, I don't have to get you to love math, but I want to at least get the two of you on speaking terms." (Mr. Umbridge)

Other practices upon which three out of four of the instructors agreed were the following:

- Make good use of the extra time given in the NCBO courses.
- Informally assess student understanding often.
- Stay positive.
- Continuously improve teaching practices.

One of the most interesting responses in the instructor interviews was one which could explain many of the aspects of the radical graphs given in this study. Pertaining to the very unusual negative effect on students nearest the cutoff in Program 1, Mr. Edward explains,

> Oftentimes in the previous [program], we'd have someone just barely missing the cutoff and they would be a capable student, capable of probably doing well in [college algebra], but they were stuck back in [intermediate algebra] and I could tell they were resentful of that.

Then, in Figure 10, from Program 2, we see a dramatic, negative slope across TSI scores after zooming in to the scores 5 points above and below the cutoff score, in complete opposition to the simple regression, which showed a positive slope;

> Then, the new system, it addressed that population of people that barely missed. Okay, but then, there were some students that could not do the [college algebra] stuff.
>
> [Interviewer: The ones who wouldn't have just barely missed?]
>
> Right. They were more challenged, they felt like they were overwhelmed. Some were able to really apply themselves and make it, but I had a half a dozen that just quit because it was way beyond their capabilities, they thought. They wouldn't come by and visit. They were just… felt overwhelmed. (Mr. Edward)

Limitations

Any hinderances to the RDD model must be avoided as much as possible, due to the pre-existing power level of the RDD. Although RDD models are just as good as a randomized control/trial (RCT) model, there must be at least 2.75 times as many observations as the RCT approach in order to achieve the same power (Dyson, et al., 2018; Matthews, Peters, & Housand, 2012; Trochim, 2020).

The only outcome variable tested in this study was retention from the first fall semester to the first spring semester. This variable was chosen due to time constraints of the experiment. Since Fall 2019 is currently the only semester in which the intermediate algebra course was not available, this was the only clear choice to represent Program 2. Therefore, other data on these students such as final grade in the course, GPA, Overall Math GPA, or number of semesters until college-level mathematics credit awarded were considered, but simply, were not available. Once retention was transformed into the probability of being retained, given a certain TSI score, there was only one data point for

each TSI score. To improve this drawback, more semesters' worth of data needs to be collected for further study into the results shown here.

The timing of the study may have been detrimental to much of the results, both quantitative and qualitative. On the quantitative side, the data collected on students had to be shortened to two non-consecutive semesters, Fall 2017 and Fall 2019. The semester which falls in between the two semesters chosen in this study, Fall 2018 had to be removed. Both intermediate algebra courses and NCBO courses existed in this semester, and placement into either course was not regulated: students scoring between a 335 and 350 on the Math TSI Assessment had the option to choose either the intermediate algebra course, or the corequisite courses. This would have made the RDD models invalid since there were multiple courses using the same criteria for "treatment", which the researchers did not have any control over at the time of enrollment. On the qualitative side, the survey and interview data were collected at the end of the Fall 2019 semester. The time in which students take their final exams and receive final grades for their courses could be a vulnerable and trying time for students and instructors alike. The reader is reminded that surveys and interviews were optional. The students who responded were those willing to give up their time and energy to openly speak their mind about their mathematical courses. The students were reassured no negative consequences would come about through their responses. Students who may have just completed their developmental course were interviewed and asked to talk about their experience in this class. Responses may have been emotionally skewed by final exams, or any uncertainty students had about passing (or failing) the overall course.

Limitations also existed within the survey instrument. Student surveys were sent out using one anonymous link through email, which could not be traced. For this reason, some students may have completed the survey multiple times. Any apparent duplicates were deleted from the results.

Jim: A Case to be Studied

Paying close attention to the footnotes under the section covering thematic coding analysis in this study, one would notice a particularly popular student's pseudonym. Jim accounted for the majority of responses recorded for Program 1. Not only did Jim have a lot to say, but it was all very negatively expressed. Jim's view of the developmental mathematics program in general is the following quote from his interview:

> Developmental math classes is a huge failure and a joke. It is a rigid attempt, or should I say, a scare tactic by the Texas higher education system to manipulate and to scare people into passing the requirement needing to get their degree.

Jim took multiple developmental courses at the institution, some had to be repeated. He asked every person he knew working at the institution for help: his instructors, TA's, the institution's math lab, educational services, and disability services. He gave negative commentary on all of them, some were mentioned specifically by name. Jim often felt as though his needs were being dismissed and was told that "college isn't for everybody."

> Those who tried to prepare us for life in the real world, fail to remember that we have labor laws and disability laws that protect those who encounter abuse from management. And what happens to those who do not do their jobs like they're supposed to, like management abuse. People have been fired from jobs and people have been taken to court for violating disability rights, which they need to

> remember that when they make that comment, well, you're in college and we're getting you ready for the real world. (Jim)

While many educators at the university level may know that the college environment may not “be for everybody”, the comment can become quite tiring and degrading for a student continuously seeing failure, but still seeking help. Jim became so aggravated with his experience, he contacted legal authorities.

> I attempted to contact the American Civil Liberties Union and LULAC to see if I needed to consider taking legal action against [the university] or the state of Texas for their rigidness of the remedial classes. (Jim)

No legal action has taken place, but the statement expresses the severity of his negative experience. Jim may have been a very unlucky student, and very unique in his experience in the developmental mathematics program. It is not clear where the blame can be placed, whether every aspect of the program failed this one student, or whether this one student refuses to take responsibility over his learning. In either case, Jim is one character which stands out in this study and further investigation into this phenomenon is needed, not only for research purposes, but for the sake of educators everywhere.

Other Implications

While many of the responses are able to tell a story on their own, including the future implications of continuing the RDD with more outcome variables as they become available, much of the data collected through this study has not been fully illuminated in this paper. Indeed, several papers can feasibly be written using this data. The narrative given here should be regarded as merely one vein of a much larger story, to be told at a later time.

For this study, the Dana Center Mathematics Pathways show promise in relating the major themes of the theory proposed by Wambach, Brothen, and Dikel (2000). Since the university of this study has taken the DCMP into consideration while designing the developmental mathematics program, it is wise to take into account the full model, which also includes a reflection aspect in which full responsibility belongs to the faculty and staff who work within any aspect of developmental education courses.

Continuous Improvement

As many as 20 states are now implementing the Dana Center Mathematics Pathways (DCMP) model (Hughes & Saxon, 2020). While the DCMP model agrees with much of the developmental education theory proposed by Wambach, Brothen, and Dikel (2000), the DCMP model gives more than suggestions on designing courses. The Charles A. Dana Center claims for success using this model, the math department must work to achieve cohesive cooperation throughout all university services affecting developmental mathematics students, including advising services and institutional research. Not only should educators within the classroom strive to create demanding and responsive environments, but in order for the program to succeed the continuous improvement of the program must be taken into account (Hughes & Saxon, 2020).

There are three main aspects of the Dana Center's idea of Continuous Improvement:

1. "Continuous improvement is data-driven, but not compliance-oriented." (p. 12)[8]

Educators in the developmental programs are encouraged to view data of previous student classes, in order to help inform knowledge on practices within the classroom.

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[8] Taken from Hughes & Saxon, 2020.

This should include any student feedback or student evaluations. Instructors in the interviews expressed many accounts of personal improvement, upon reflection of course materials and lectures:

- "Always, looking for ways I can improve, yes." (Mr. Edward)
- "I try to be a lifelong learner and constantly have my teaching evolve and get better in every semester. Even in the class like college algebra that I've taught literally 20 times." (Mr. Umbridge)

Institutional research staff are asked to give educators access to quantitative student outcomes, and educators should be given professional development on how to interpret this data.

2. "Continuous improvement is collaborative." (p. 12)[9]

Many of the instructors teaching the new NCBO courses often share ideas about teaching practices and try to maintain a uniform schedule across equivalent courses. At the university of this study, collaboration is highly maintained, especially for the courses in which a Graduate Assistant is assigned. In preparation of a course, Mr. Umbridge explains,

> I'm co-teaching the NCBO with [Mr. Simms] and so, at the beginning of the semester we got together and looked at just… all the lessons and said, okay, what do we feel like we need more days on, what do we not?

Not only should the developmental mathematics faculty and staff meet often within the department, but other organizations at the university should be involved. Students often

[9] Taken from Hughes & Saxon, 2020.

go to educational services, disability services, and advisors for help outside of the math department. All of these staff members should be on the same page when it comes to the students. For example, all advisors should be aware of the appropriate core-level mathematics courses according to students' degree programs.

3. "Continuous improvement thrives where there is a culture of professional learning." (p. 12)[10]

Faculty and staff involved in the continuous improvement process should maintain a sense of group-learning, such as *we're all in this together*. It should be understood that continuous improvement is a process, always changing, where feedback is encouraged and will be taken into account when considering these changes. As previously stated in the interviews with instructors, it may help to let the students know how new the program is and that we are willing to change.

> I don't have all the answers. And even day to day, I feel like I'm lost. I don't know what's going on. But it's a process. I keep reminding myself it's a process. And with the students, I remind them, it's a process. (Mr. Edward)

In a similar instance, once Callie learned this information from her instructor, she expressed discontent with her situation, but later explained how understanding she was:

> I think every… like, everything is going to improve. Like, as they… as everyone figures out, like, what's going to, like, how was the best… like, just with time. I feel like, because when everybody was, like, whenever you get on the same page, I feel like it'll be a little smoother and everything. And so, I think just as time goes

[10] Taken from Hughes & Saxon, 2020.

on, it will get a little bit better and everything. And like, for students, I just think, like, be patient with yourselves and with the instructors, because everyone's trying to… everybody's trying to figure everything out. (Callie)

Conclusion

The goal of this study was to analyze the developmental mathematics education program at the university level, through the lens of a theoretical framework to help identify and understand differences in the program before and after reformations took place. One prominent conclusion is that there is currently insufficient evidence to show any significant differences in the program before and after reformations. The program has changed the way in which courses are presented, but retention rates, one of the main data points which influences the policy changes such as Texas HB 2223, which started the corequisite reform, have not proven to be any better than before the policy was implemented. To strengthen these results and the models given in this study, more observations must be included, more semesters worth of retention rates for this population of students. Moreover, to obtain a complete picture of the new corequisites, studies should include variables such as GPA and time until college-credit is awarded.

This study also adds to the literature in support of a theoretical framework for which to base decisions on regarding developmental education reforms. Incorporating theory into research allows for discussion with reason, ethics, and humanization; qualities in which the area of mathematics seems to be lacking. Utilizing the theory proposed by Wambach, Brothen, and Dikel (2000) called for inquiry into the classroom and in the minds of the instructors. Surveys and interviews of the students and instructors only seemed reasonable. “If we involve students in the conversation about what developmental

[education] is and should do, then students have buy-in, and we have become a field that is truly student-centered" (Threadgill, 2018, p.22).

In response to new developmental education policies, institutions across Texas all experience struggle with reformations. The first step in addressing any issue is the admittance that issues exist at all, both within developmental education and policy making. "The goal should be to increase success rates throughout college for at-risk students by addressing the actual causes of fail rates and attrition instead of eliminating helpful courses" (Goudas, 2018, p. 50).

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APPENDIX A

Math Anxiety/Self-Efficacy Survey

Start of Block: Default Question Block

The following survey will take approximately 10 minutes to complete. Data collected from this survey will aid in Gabrielle Castro's research which aims to measure the effectiveness of developmental mathematics courses at [the institution]. With your feedback, we can better determine the student experience within these courses, and help make mathematics education at [the institution] a better learning environment for everyone. You may stop the survey at any time, close the survey window, or choose not to answer any questions for which you feel uncomfortable answering, with no negative consequences brought to you, including any impact to your grade in mathematics courses at [the institution]. All answers are completely anonymous and cannot be traced. We thank you in advance for your time.

Do you understand what you are agreeing to do *and* consent to participate in this survey?

- ○ Yes
- ○ No

Skip To: End of Survey If The following survey will take approximately 10 minutes to complete. Data collected from this sur... = No

Page Break

Please answer the questions to the best of your ability. In order to better understand how you think and feel about your college mathematics courses, please respond to the following statements. If there are any questions you do not wish to answer, please select "No Response".

Section I

What is your gender?

- ○ Male
- ○ Female
- ○ Other
- ○ No Response

What is your age?

_____

What is your ethnicity? (Please indicate all that apply)

- ☐ Caucasian/Non-Hispanic
- ☐ Hispanic/Latino(a)
- ☐ African American/Black
- ☐ Asian American/Asian
- ☐ Native American/American Indian
- ☐ Other (please specify)

_____

Are you a first-generation student?

- ○ Yes
- ○ No
- ○ No Response

What was your high school senior GPA?

- ○ No Response
- ○ 1.0 - 1.49
- ○ 1.50 - 1.99
- ○ 2.0 - 2.49
- ○ 2.5 - 2.99
- ○ 3.0 - 3.49
- ○ 3.5 - 3.99
- ○ 4.0

What is your current overall GPA?

- ○ No Response
- ○ 1.0 - 1.49
- ○ 1.50 - 1.99
- ○ 2.0 - 2.49
- ○ 2.5 - 2.99
- ○ 3.0 - 3.49
- ○ 3.5 - 3.99
- ○ 4.0

What is your major?

_____

What was your average grade in your mathematics classes in high school?

- ○ No Response
- ○ _____

Did you take a mathematics course in high school for college credit?

- ○ No Response
- ○ No
- ○ Yes
- ○ I don't know

Which developmental mathematics course(s) at [the institution] are you currently enrolled in, or have already taken?

- ☐ MATH 0302
- ☐ MATH 0303
- ☐ MATH 1314 NCBO option
- ☐ MATH 1324 NCBO option
- ☐ MATH 1332 NCBO option
- ☐ MATH 1342 NCBO option

Page Break

Section II

For each of the following statements, please indicate how well each applies to you. Please respond as honestly as you can according to the following scale.

Working on mathematics homework is stressful for me.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I believe I can learn well in a mathematics course.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I worry that I do not know enough mathematics to do well in future mathematics courses.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I worry that I will not be able to complete every assignment.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I feel confident when taking a mathematics test.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I believe I am the type of person who can do mathematics.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I feel that I will be able to do well in future mathematics courses.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I worry I will not be able to understand the mathematics.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I believe I can do the mathematics in a mathematics course.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I worry that I will not be able to get an “A” in my mathematics course.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I worry that I will not be able to learn well in my mathematics course.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I get nervous when taking a mathematics test.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I am afraid to give an incorrect answer during my mathematics class.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I believe I can think like a mathematician.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I feel confident when using mathematics outside of school.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

Page Break

For each of the following statements, please indicate how well each applies to you. Please respond as honestly as you can according to the following scale.

I feel confident enough to ask questions in my mathematics class.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I get tense when I prepare for a mathematics test.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I get nervous when I have to use mathematics outside of school.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I believe I can do well on a mathematics test.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I worry that I will not be able to use mathematics in my future career when needed.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I worry that I will not be able to get a good grade in my mathematics course.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I believe I can complete all of the assignments in a mathematics course.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I worry that I will not be able to do well on mathematics tests.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I believe that I am the kind of person who is good at mathematics.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I believe that I will be able to use mathematics in my future career when needed.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I feel stressed when listening to mathematics instructors in class.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I believe I can understand the content in a mathematics course.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I believe I can get an "A" when I am in a mathematics course.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

I get nervous when asking questions in class.

- ○ No Response
- ○ Never
- ○ Seldom
- ○ Sometimes
- ○ Often
- ○ Usually

Page Break

Section III

Please respond to the following short answer questions to the best of your ability.

As a student from a developmental mathematics course at [the institution], do you have any suggestions about course materials, such as homework assignments, labs, textbook?

_____

_____

_____

_____

_____

As a student from a developmental mathematics course at [the institution], do you have any suggestions about the course, in general?

_____

_____

_____

Page Break

Section IV

Would you be willing to be interviewed to further discuss your experiences through your developmental mathematics course(s)?

- ○ Yes
- ○ No

Skip To: End of Survey If Would you be willing to be interviewed to further discuss your experiences through your developme... = No

End of Block: Default Question Block

Start of Block: Default Question Block

Thank you for your interest in being an interview participant! Please let us know how you would like to be contacted below by filling in your choice of contact information.

- ○ Call; _____
- ○ Text; _____
- ○ Email; _____
- ○ Other (please specify); _____

End of Block: Default Question Block

APPENDIX B

Tentative Interview Protocol for Student Interviews

I am a graduate student in the Mathematics Master's program at [university]. I am conducting research on the developmental mathematics programs, due to recent changes in course offerings.

The purpose of this interview is to ask for your assistance in answering questions related to my study. This will take about 30 minutes of your time. You will be compensated for your participation in this study by having $5 deposited to your [student] Account. Do you have any questions before we begin? Do you fully understand what you are agreeing to do? May I audio record this interview?

As we conduct the interview, please feel free to ask any questions that you have about participating in this project. I want you to have the information you need to make a decision that is best for you. Please understand that you can end the interview at any time without any penalty including any impact to your grades in courses at [the university], or loss of benefits to which you are otherwise entitled, including the $5 deposit to your [student] account.

(Additional questions will be identified through the open-ended questions from the online survey.)

Current Developmental Students;
- Can you describe your experience in this course?
- Do you see this as a worthwhile course?
- Do you understand the significance of the course to your program of study?

Students previously enrolled in developmental courses;
- Can you describe your experience from this course?
- Do you see this as a worthwhile course?
- Do you understand the significance of the course to your program of study?

- Under our new program, students who received a 336 or above on the TSI test are able to enroll in a college algebra course, along with a Non-Credit Based Option course. This allows those students who may not have been ready for college algebra to get the extra help they need in order to pass college algebra in one semester. They get to cover all the same material and even take the same Final Exam at the end of the semester so that they receive that college algebra credit. The main difference is that these students will be meeting with instructors and Teaching Assistants 4 days a week, rather than 2 days a week in the regular college algebra class. Is this option something you would have preferred?

APPENDIX C

Tentative Interview Protocol for Instructor Interviews

I am a graduate student in the Mathematics Master's program at [university]. I am conducting research on the developmental mathematics programs, due to recent changes in course offerings.

The purpose of this interview is to ask for your assistance in answering questions related to my study. This will take about 30 minutes of your time. Do you have any questions before we begin? Do you fully understand what you are agreeing to do? May I audio record this interview?

As we conduct the interview, please feel free to ask any questions that you have about participating in this project. I want you to have the information you need to make a decision that is best for you. Please understand that you can end the interview at any time.

(Additional questions may be identified as interviews progress.)

• Do you notice any differences between developmental students from the previous track and developmental students in the new NCBO courses?

• Now that you have the experience of teaching both under the old program, and our new NCBO option, do you prefer one method to the other?