An Activity Theory Approach to Examining the Implications of Developmental Mathematics Reform at an Urban Community College

Jennifer Ruth Zakotnik-Gutierrez

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AN ACTIVITY THEORY APPROACH TO EXAMINING THE IMPLICATIONS OF DEVELOPMENTAL MATHEMATICS REFORM AT AN URBAN COMMUNITY COLLEGE

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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has been approved as meeting the requirements for the Degree of Doctor of Philosophy in College of Natural and Health Sciences in School of Mathematical Sciences, Program of Educational Mathematics

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ABSTRACT


Developmental mathematics courses, designed to provide remediation for students who are identified as having skills below the college level, have long been a mainstay in community colleges. These courses fill a need and effectively prepare some students for college level math courses, providing access to mathematics courses and college programs they otherwise would not have had. However, a large majority of students experience developmental mathematics as a gatekeeper, rather than a gateway, to higher courses. As such, the status quo of traditional developmental mathematics programs is inequitable, denying access to college-level courses. Recognizing this equity issue as necessitating institutional change, many community colleges have begun reform of their developmental programs and courses.

Much of the research regarding developmental mathematics reform is focused on student outcomes measures such as course completion and degree attainment, and the data is largely quantitative in nature. Although instructors and administrators are integral to any reform efforts, their voices are reasonably silent in the existing literature. In my qualitative study, I sought to explain the experiences of various stakeholders involved with one such reform at an urban community college, in particular administrators, instructors and students. I gathered these experiences through surveys, individual
interviews, and classroom observations and employed activity theory as both a theoretical and analytical framework for this study. The novel use of activity theory provided a means to operationalize course reform as an activity, allowing me to identify a number of tensions and contradictions arising from the reform process which both illuminate conflicts as a result of reform and act as drivers of change within the reform process. The way in which activity theory facilitated recognition of these tensions highlights the utility of the framework for future studies of course and program reform.

The identified contradictions underscore the importance of stakeholder buy in and communication, as well as the need for proactive and ongoing professional development for instructors. Furthermore, the implications for administrators and policymakers indicate the necessity to fully consider the downstream effects of policy and program changes.
ACKNOWLEDGEMENTS

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Many thanks to my advisors Dr. Gulden Karakok and Dr. Spencer Bagley, who believed in me from the beginning and have encouraged, challenged, and trusted me through courses and the dissertation process. You entered the world of developmental mathematics with me and have believed in the value of my work as much as I do. Your countless suggestions and edits helped me to learn the benefit of rough drafts, and I hope that my final work makes you proud. I have learned so much from both of you and your dedication to students, research, and social justice. I am forever grateful.
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This dissertation is dedicated to my parents, Bob and Mary Kay Zakotnik. And to Brian, who is missed every day.
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CHAPTER I

INTRODUCTION

Developmental mathematics courses represent the graveyard of dreams and aspirations.

—Anthony S. Bryk, President

Carnegie Foundation for the Advancement of Teaching President (Merseth, 2011)

Community colleges are commonplace in the United States. According to the American Association of Community Colleges (AACC), there are nearly 1,200 community colleges in the U.S. educating close to 12 million students—almost half of all undergraduates (American Association of Community Colleges, 2018). Many of these students upon enrolling at community colleges are told that they are underprepared for college-level mathematics and must complete some number of pre-college level courses before they can fulfill their college mathematics requirement (Bailey et al., 2015; Scott-Clayton, 2012). As a result, developmental mathematics programs have become a staple at community colleges in order to remediate students to the college level. Unfortunately, many of these students never do make it into, let alone through, the college-level mathematics courses required for their academic major. In fact, roughly half of all students required to begin college in developmental mathematics do not successfully make it into the first relevant college-level course (Bailey et al., 2010; Snyder et al.,
Based on these facts, it is evident that developmental mathematics is simply not working for most of the students required to take it.

Decades of open enrollment policies have ensured that community colleges bear the responsibility of developmental education (Bailey et al., 2015; Brint & Karabel, 1989; Makowski, 2017; Mesa, Wladis, & Watkins, 2014) for nearly 44% of all incoming undergraduates who are deemed unprepared for college-level mathematics (Blair et al., 2018). While open enrollment has indeed opened access to higher education for many students, as Engstrom and Tinto (2008) note: “access without support is not opportunity” (p. 46). Instead, many students referred to developmental mathematics courses encounter the same traditional instructional methods that have failed them in the past (Makowski, 2017). Rather than progressing through the developmental sequence as intended and gaining the preparation for college-level courses that they are perceived to be lacking, students become discouraged and caught up in a cycle of enrollment and failure in non-credit courses (Larnell, 2017). Over 60% of students who take developmental mathematics do not succeed in college-level mathematics, either through failure of that course or through never reaching it in the first place, necessitating changes of major or abandonment of college aspirations (Bailey et al., 2010; Larnell, 2017).

Given the student population at community colleges is predominantly underrepresented groups (Mesa, Wladis, & Watkins, 2014; Snyder et al., 2018), and these same populations are referred disproportionately to developmental education (Bailey et al., 2015; Engstrom & Tinto, 2008; Mesa, Wladis, & Watkins, 2014) not only is the current state of developmental mathematics a disservice to students, it is inequitable.
Students who are female, Black\(^1\), Hispanic, or part-time all tend to be placed into a greater number of developmental mathematics courses (Bailey, et al., 2010) than those who are male, White or full-time. Further, students who are male, Black, or part-time have a lower probability of successfully progressing through the sequence of developmental courses than do those who are female, White or full-time (Bailey, et al., 2010). Even more, Black students who are placed three or more levels below college-level are at particularly high risk of exiting the sequence before completion (Bailey et al., 2010). Inequities such as these in educational outcomes are a problem of institutional performance calling for remediation of practices (Felix et al., 2015).

In light of the many identified issues with developmental mathematics, a number of institutions have begun program changes and redesigns in an effort to better serve all students. These reform efforts range from accelerated sequences, in which three or more developmental courses are condensed into one or two (Cafarella, 2016a; Cafarella, 2016b) to complete program redesign (Charles A. Dana Center, 2018; Huang & Yamada, 2017; Yamada et al., 2016) utilizing pathways models in which students are advised into mathematics courses designed to be most applicable to students’ academic majors of study. Many of the reform efforts take into account not only student success measured as completion of the developmental sequence and college-level mathematics courses, but also students’ persistence in future semesters of college work (Huang & Yamada, 2017; Yamada et al., 2016; Zachry Rutschow et al., 2017). Although these reform efforts approach the inequities of developmental mathematics through different processes, the

\(^1\) In this dissertation I intentionally capitalize B in Black and W in White as the “name of a culture, ethnicity, or group of people” https://www.nytimes.com/2014/11/19/opinion/the-case-for-black-with-a-capital-b.html
research on all of the efforts mentioned has shown positive results in student success (Cafarella, 2016a; Cafarella, 2016b; Huang & Yamada, 2017; Yamada et al., 2016; Zachry Rutschow, 2019).

**Statement of the Problem**

Through an institutional equity initiative in 2013, Lowry Community College (LCC, a pseudonym) discovered that their Black students had a much lower rate of degree completion or transfer within three years of their first enrollment than all other groups at the college. Furthermore, Blacks were disproportionately represented in developmental mathematics, not succeeding in developmental mathematics, and underrepresented in college algebra. With this information in hand, the college set an equity goal for Black students to reach the same 3-year graduation/transfer rate of White students, which was the highest rate of all subgroups and the college average.

As a result of the equity initiative LCC also noticed that many students continued to struggle in developmental mathematics similarly to the results found in research studies (e.g., Bailey et al., 2015). Following the recommendations of Bailey et al. (2015) and Complete College America, LCC began the process of developmental mathematics reform. During the Fall 2018 semester, LCC implemented a newly designed college algebra course incorporating a corequisite model of support to replace the existing sequence of developmental mathematics courses for students intending to take calculus. Replacing two prior developmental mathematics courses, developmental content is now taught in service to the college algebra content, at first in an intensive 5-week on-

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2 This information comes from published internal research which is not cited in order to maintain confidentiality in data collection.
boarding class, and then as a separate, mandatory corequisite course that meets for one hour either directly before or directly after the college algebra class during the remaining 10 weeks of the semester.

Although LCC is not the first community college to undertake this type of redesign, they are at the forefront of reform in their state. As such, they desire to be a leader in reform and anticipate that they will be a model for other colleges considering such a program change. LCC’s story of reform calls for attention, and the research study presented in this dissertation was designed and conducted to capture the initial stages of reform efforts from various participants’ perspectives.

This study sought to contribute to the small body of qualitative research regarding developmental mathematics reform. Although there exist many quantitative studies that detail the success and failure of developmental mathematics students in both traditional (e.g. Bailey et al., 2010; Engstrom & Tinto, 2008; Larnell, 2017; Scott-Clayton, 2012) and reform programs (e.g., Charles A. Dana Center, 2018; Huang & Yamada, 2017; Yamada et al., 2016), there is a definite lack of research detailing the experiences of those involved in the process of change, especially from the instructor and administrator viewpoints.

**Purpose and Research Question**

The purpose of this qualitative case study was to contribute to the research on developmental mathematics reform by providing a multi-perspective account of a community college’s developmental mathematics program redesign. According to Merriam and Tisdell (2016), case study research is used to investigate a contemporary phenomenon, or case, within its natural context. This method is especially suited to
situations in which the case is impossible to separate from its context (Merriam & Tisdell, 2016). The case for this study is defined as the activity system of developmental mathematics reform at Lowry Community College. This case comprises administrators and instructors involved with the reform process and students taking the reformed courses. The case does not include other college administrators, instructors not involved in teaching developmental mathematics, or students not enrolled in the reform developmental or college algebra courses, as these individuals do not necessarily have the same object, thus excluding them from the activity system which is explained in the next paragraph. This case study method is appropriate because the case is an academic situation in which individuals’ experiences are a direct result of the context of this situation. This study aims to address the following research questions:

Q1  What are the experiences of administrators, instructors, and students during a redesign of the developmental mathematics program at an urban community college?

Q1a  What tensions and contradictions exist within and between the experiences of these three distinct groups?

Q1b  In what ways are these tensions and contradictions related to the constructs of equity?

To address these research questions, I collected data from instructors, administrators, and students through surveys, video-taped interviews, classroom observations and artifacts. I used activity theory as a theoretical framework to provide an account of the experiences resulting from the course redesign. The unit of analysis in activity theory is the goal-directed activity system which characterizes individual and collective experiences through the interpretation of interactions between and within systems (Engeström, 2015). Through the influence of mediating tools, implicit and
explicit rules, community, and a defined division of labor, activity produces an outcome (Engeström, 2015). These components of the activity system are kept in constant tension, and disagreements (contradictions) within components or between activity systems act as catalysts for change (Engeström, 2015). The experiences that result from the college’s course and program redesign are also impacted by the available resources (tools), procedures for implementation (rules), other individuals (community), and specified roles (division of labor) which are present during everyday academic activity and as a result of the redesign. Thus, the constructs of activity theory provided a theoretical basis to design this case study and further analyze and interpret the various experiences, allowing me to “make sense of the systemic factors behind seemingly individual and accidental disturbances” that occur as a result of the interaction within and between these different experiences (Engeström, 1998, p. 78). Details of the constructs of this framework, as well as how it informed this case study design are discussed further in Chapter III.

In addition to activity theory, it was natural to undertake this study through equity and persistence lenses because increasing and improving retention and graduation rates of underrepresented students were a major impetus for LCC’s developmental mathematics reform and course redesign. Gutiérrez’s (2009) equity framework emphasizes the importance of both the dominant axis of mathematics equity, in which attention is paid to students’ access and achievement in regard to the current dominant culture of mathematics education, and the critical axis of equity, which pertains to roles of students’ identity and power in order to effect change in the future of mathematics education. Tinto’s (1975) persistence framework focuses on the importance of students’ academic and social involvement as major influences on decisions to persist in education.
I used this equity lens primarily to analyze the relevant literature in order to make a general case for developmental mathematics reform and to motivate the necessity of my study. In addition, I used the constructs of equity and persistence during data analysis to illuminate instances of tension within the components of the activity systems to denote necessary change. Details of the use of constructs and themes from these lenses in data analysis are further discussed in Chapter III.

**Significance of the Research**

Developmental mathematics reform is an important topic to explore right now for several reasons. Most of the research to date is focused on student success in both traditional and reform developmental mathematics, with results from primarily quantitative data analysis. By investigating the research questions, I was able to provide a qualitative examination of the experiences of the individuals involved in developmental mathematics reform. More specifically, this dissertation centers attention on administrators and instructors whose perspectives are notably absent in previous research despite their crucial roles in reform. Although the research question included the perspectives of students in addition to instructors’ and administrators’ perspectives as part of the proposed investigation, there were not enough students who completed surveys or volunteered for interviews in order to answer the question in regard to the student perspective. This limitation of the study is discussed in more detail in Chapter VI.

As described in Chapter IV, activity theory analysis allowed me to elucidate the experiences of instructors and administrators and to illuminate the tensions and contradictions resulting from the reform, answering Q1a. One tension arose between the subjects in the same activity system: developmental and college-level mathematics.
instructors. Due to the elimination of all developmental courses other than the 5-week onboarding and the corequisite courses, instructors who had previously been able to teach multiple classes each semester were relegated to somewhat of a teaching assistant position and struggled financially due to teaching fewer credits. This also led them to feel undervalued as professionals.

Another significant contradiction occurred between instructors’ and administrators’ goals for the reform and their beliefs about students placed into developmental mathematics. One goal of the reform was to improve student success in college algebra by allowing them to complete developmental requirements in the same semester as college algebra through the onboarding and corequisite courses. However, instructors were concerned students would be overwhelmed and unsuccessful in college algebra without the opportunity to learn the basics in full developmental courses first. Administrators echoed similar concerns, although theirs were more in relation to what they called a ‘full corequisite model’ in which the developmental content is taught only during the corequisite course. Fearing students were not ready for this model ‘yet,’ this reform was designed with the intensive 5-week developmental onboarding. Both of these views of subjects indicate a lack of confidence in students’ abilities.

I also detected contradictions between instructors and administrators regarding the expectations of the reform courses and their actual implementation. The onboarding course had been designed as a sequence of developmental content modules for students to work through at their own pace. Instructors were expected to individually conference with each student during class time to provide course status updates and action plans, in addition to answering questions on the material. Many of the instructors were
uncomfortable in the role as facilitator rather than lecturer, and felt they were not allowed ‘to teach’ when the class was run this way.

A similar issue arose in the implementation of the corequisite course. The course was intended to be a review of developmental content applicable to the corresponding college algebra content, with the explicit intent that it not be treated as a ‘glorified study hall.’ Although instructors attempted at first to adhere to this restriction, many noted the large quantity of college algebra homework problems as a deciding factor in choosing to instead use the course as extra time for students to do the homework and ask for help.

Although these tensions and contradictions initially appear as negative outcomes of the reform, through the activity theory lens they are viewed as drivers of change within the activity system of course reform and implicate a number of recommendations for administrators, researchers, and policy makers. As detailed in Chapter V, three main areas of focus arose for administrators: recruitment, retention, and development. Obviously, departments want to recruit the best instructors and retain them, and quality professional development is one way to successfully do this. At minimum, instructors must have access to development in the new and different areas of pedagogy they are being asked to employ, the notable absence of which in LCC’s reform implementation caused tension between instructors and administrators. In addition, professional development can act as a means for instructors to earn credentials or teaching qualification.

The implications for mathematics education researchers are twofold: activity theory as a methodology for studying course reform and a renewed call to investigate community college instruction. The activity theory methodology proved particularly
useful in operationalizing the reform process as an activity, allowing the identification and interpretation of contradictions between stakeholders. In addition, the study revitalizes the necessity for researchers to understand the instruction at community colleges as different from what is known about K-12 and university level instruction.

A final recommendation concerns policymakers with consideration toward credentialing and qualifying instructors. Before implementing well-meaning policies, it is necessary to consider the downstream effects such policies will have on departments.

The research question Q1b highlights the dual role of equity in this study, as both a goal of the activity system and as a framework to interpret the data. The overall goal of the activity system was to increase student success in college algebra, particularly for those students who have traditionally been underrepresented and unsuccessful in that class. Using equity as an analytical framework, I was able to evaluate all other aspects of this study in regard to the constructs of access, achievement, identity and power, and that analysis is woven throughout this dissertation.

**Definitions**

Throughout this study, certain words and phrases were used that have meanings particular to this research. In order to minimize the possibility of misunderstanding, these phrases are now defined in the manner that they were used in this study.

**Community College**

Community colleges are two-year public institutions providing lower-level post-secondary education and granting diplomas, certificates, and associate degrees (AACC, 2018; Cohen et al., 2013). Community colleges are regionally accredited, locally supported, and may partner with four-year institutions to offer baccalaureate degrees.
This definition of community colleges includes technical institutions, but consistent with the National Center for Educational Statistics policy, excludes any schools that offer their own baccalaureate degrees (Cohen et al., 2013).

**Developmental Mathematics Courses**

Often referred to as ‘remedial education,’ developmental courses are pre-college courses that teach primary and secondary level content to students who demonstrate deficits in the knowledge required to enroll in credit-bearing college-level courses such as college algebra (Bailey et al., 2015; Makowski, 2017). Most developmental mathematics programs incorporate a sequence of courses which includes basic arithmetic, introductory algebra, and intermediate algebra, and students are placed into the sequence based upon a predetermined performance level on a standardized placement exam (Travers, 2017). Once students have successfully completed all of the courses within their developmental sequence they may enroll in credit-bearing college-level mathematics courses.

**Equity**

The definition of equity is dependent upon the specific context and research paradigms being used by scholars (Myers, 2014). For the purposes of this research, I first note that equity must not be confused for equality. Equality refers to sameness, in which inequities are addressed by treating all students the same, regardless of their backgrounds (Gutiérrez, 2002). Rather, equity focuses on justice, which takes into consideration the roles that students’ identities and background play in their educational experiences (Gutiérrez, 2002).
I also rely on Gutiérrez’s (2002, 2007) 3-part definition of equity in mathematics, which forms the equity framework I briefly mentioned previously in this chapter and will explain further in Chapters II and III. According to Gutiérrez (2007), equity is “being unable to predict students’ mathematics achievement and participation based solely upon characteristics such as race, class, ethnicity, gender, beliefs, and proficiency in the dominant language” (p. 41, emphasis in original). This part of the definition refers to the existing dominant culture of mathematics, including who is allowed access and how achievement is measured (Gutiérrez, 2007, 2009). Secondly, equity is “being unable to predict students' ability to analyze, reason about, and especially critique knowledge and events in the world as a result of mathematical practice, based solely upon characteristics such as race, class, ethnicity, gender, beliefs, and proficiency in the dominant language” (Gutiérrez, 2007, p. 45, emphasis in original). This aspect of equity is what Gutiérrez uses to address critical mathematics which “squarely acknowledges the positioning of students as members of a society rife with issues of power and domination” (Gutiérrez, 2007, p. 40). Finally, equity is “an erasure of inequities between people, mathematics, and the globe” (Gutiérrez, 2007, p. 48, emphasis in original). While this third aspect is an ambitious endeavor, it is nonetheless an important aim, and Gutiérrez (2007) acknowledges that it may be necessary that the first two aspects are fully addressed before any change will occur in the third.

**Persistence**

For the purposes of this research, I define student persistence as the process which “leads students to remain in higher education and complete [a] degree or certificate regardless of the institution from which the certificate or degree is awarded” (Tinto,
2010, p. 53) and despite challenges which may arise (Tinto, 2017). This definition differs slightly from the definition used by some researchers who see persistence as the fulfillment of the student’s goal for which they entered college (Tinto, 2010). Still other researchers have defined persistence as continuous enrollment in the short- or long-term (e.g., Pascarella & Terenzini, 1980), or eventual completion of a bachelor’s degree (Pascarella et al., 1986).

My choice of definition reflects the fact that this research was conducted in a community college mathematics course required for students in majors or programs generally requiring further than an associate degree. While a 4-year degree may not be required for all of these students, I anticipate that their college goals include, at minimum, the completion of a certificate.

Organization of the Dissertation

This chapter provided an introduction to the necessity for and actions of developmental mathematics reform at an urban community college. Chapter II is a stand-alone review of the relevant literature on traditional and reform developmental mathematics analyzed through Gutiérrez’s (2009) equity framework. In Chapter III, I outline the methodology of the study, beginning with an elaboration of the theoretical perspective adopted. I then provide a full description of the setting and the data collection and analysis methods used. Chapters IV and V are stand-alone manuscripts reporting the results and implications of the research study. Chapter IV is an activity theory analysis of administrators’ and instructors’ perspectives of the process of reform at LCC in which I describe the various contradictions that arose and indicate the manners in which these contradictions could work as drivers of change. In Chapter V, I describe the implications
of the results of my study and make recommendations for researchers, community college administrators, and policy makers. Chapter VI includes a summary of the research findings, including discussion of the assumptions, limitations, delimitations and recommendations for future studies.
CHAPTER II

THE EQUITY IMPLICATIONS OF TRADITIONAL AND REFORM DEVELOPMENTAL MATHEMATICS

Each year, community colleges educate close to 12 million students—almost half of all undergraduates (AACC, 2018). Nearly 44% of the students enrolling at community colleges are informed upon enrollment that they are underprepared for college-level mathematics and must complete some number of pre-college-level courses as remediation (Bailey et al., 2015; Blair et al., 2018). Although the remediation is well-intentioned, many of these students never make it into, let alone through, the college-level mathematics courses required for their academic major.

The purpose of this paper is twofold. First, it aims to provide a background and history of developmental mathematics programs and various reform efforts to developmental programs. Second, it seeks to provide understanding of the issues regarding the reported goals, successes and failures of developmental mathematics by discussing existing studies and their results through the lens of Gutiérrez’s (2009) equity framework. This particular framework helped to understand if and when the assumption fails that developmental courses aim to equalize access to postsecondary educational experiences. This synthesis and summary guided my study investigating the experiences of administrators, instructors, and students at one community college replacing traditional
developmental courses with corequisite support in college algebra, as discussed further in Zakotnik-Gutierrez (YEAR). For a tabular view of the relevant studies cited in this paper, see Appendix B.

**Community Colleges and Traditional Developmental Mathematics Programs**

By the late 1800s, secondary school enrollment and completion rates were rising, leading to a demand for access to continuing education (Cohen et al., 2013). Meanwhile, a number of the most prominent universities at the time, including University of Michigan, University of Georgia, University of Minnesota, and Stanford University, began the push to make four-year universities responsible only for the development of higher-order scholarship (Cohen et al., 2013). Schools below university level were expected to provide general education, and junior colleges were born to teach the content previously taught during the first two years of university curriculum. These new colleges were created to either prepare students for continued research at the university level or to enter the workforce, which allowed the universities of the time to be more selective and to ensure that only students interested in research-oriented degrees would attend university (Cohen et al., 2013; Labaree, 1997).

Eventually, vocational and technical education became a third function of junior colleges, and by the 1950s these institutions had taken on the role of community enrichment, leading to the adoption of the name “community colleges” (Thelin, 2004). Over the following three decades, community colleges built their reputation as a public option for an affordable education, but declining transfer enrollments to four-year universities and declining graduation rates of these transfer students began to reveal
issues with the preparedness of students coming from community colleges (Brint & Karabel, 1989). In order to provide better general education and to improve the preparation of transfer students, community colleges took on the role of remediation for students (Brint & Karabel, 1989; Thelin, 2004). This focus on remediation created the developmental mathematics programs used in community colleges since that time, and open-enrollment policies, which have long been a popular marketing point of community colleges, have ensured these programs remain necessary (Bailey et al., 2010; Brint & Karabel, 1989; Mesa, Wladis, & Watkins, 2014).

Developmental courses are pre-college courses that teach primary and secondary school level content to students who demonstrate deficits in the knowledge required to enroll in credit-bearing college-level courses such as college algebra (Bailey et al., 2015; Makowski, 2017). Most developmental mathematics programs incorporate a sequence of courses which includes basic arithmetic, introductory algebra, and intermediate algebra, and students are placed into the sequence based upon a predetermined performance level on a standardized placement exam (Travers, 2017). These courses do not count as credit toward a degree but do count toward financial aid limits (Bailey et al., 2015; Larnell, 2017).

The overarching goal of developmental mathematics programs is to ameliorate students’ lack of preparedness and get them ‘up to speed’ with their peers, based on the assumption that by completing a specific sequence of non-credit bearing developmental courses, students will gain the academic and social skills necessary to be successful in college-level courses. Ideally, a student will pass each of their required developmental courses on the first attempt, meaning remediation could take as little as one semester for a
student who is placed one course below college level, to as many as three or four semesters for a student placed multiple levels below college level. Once students have successfully completed all of the courses within their developmental sequence they may enroll in credit-bearing college-level mathematics courses.

Developmental courses are an attempt to equalize access to postsecondary educational experiences (Bailey et al., 2010; Larnell, 2017) and assist students to develop other skills necessary to succeed in college or earn a credential, including study skills, time management, and other soft skills. When students do successfully remediate, they tend to perform nearly as well as their peers who are placed directly into college-level courses (Bahr, 2008; Wheeler & Bray, 2017). Too often, however, these courses act as a gatekeeper, rather than a gateway, delaying or denying entry to an academic program for students deemed by the system to be ‘deficient’ (Bailey et al., 2015; Larnell, 2017). Less than four in ten students referred for developmental mathematics complete the entire sequence, and at most one-fifth of students referred to a sequence of three or more levels below college-level successfully complete remediation (Bailey et al., 2010). These results point to a mismatch between the equalizing aim of developmental programs and their outcomes. To better understand this, I explored existing studies related to developmental programs and their results through Gutiérrez’s (2009) equity lens. Viewing the status quo of developmental mathematics through an equity lens illustrates why the noted failures are not simply the failures of individuals, but the failures of a system.

**Equity Framework**

The equity lens I used to view developmental mathematics is Gutiérrez’s (2009) framework, which is made up of four constructs of equity: access, achievement, identity
and power. Access and achievement make up what Gutiérrez (2009) calls the “dominant axis” because they pertain to the way students are supported as members of the existing dominant culture and practice of mathematics. Attention to access means ensuring all students have the resources to participate in quality mathematics learning, including quality teaching and opportunities to engage with rigorous curriculum and problem-solving situations. The achievement dimension refers to the attainment of student outcomes such as exam scores, course completion, degree completion, and persistence in college, which are naturally attended to in educational settings.

While attending to access and achievement are important, it is vital to note that doing so only perpetuates the status quo (Gutiérrez, 2013). Instead, it is necessary to support and empower students to be critical citizens who desire to “change the game” of teaching, learning, and doing mathematics (Gutiérrez, 2009). This can be done through a focus on identity and power, which make up the “critical axis” of equity (Gutiérrez, 2009). Identity is built from all of the personal and cultural aspects that inform how students see themselves. Identity is situated; what a student chooses to present in one situation may differ from that in another, and it is necessary to be aware of how students’ identities impact their participation in mathematics learning (Gutiérrez, 2013). Attending to issues of power requires a focus on who benefits from the teaching of mathematics and how. Not only must students be given agency within the classroom and power over the mathematics that they are learning, but they must be empowered to challenge the status quo (Gutiérrez, 2013). Even more, students must “be able to play the game of mathematics that is currently associated with power and intellectual potential and be able to change the game of mathematics to serve a better society” (Gutiérrez, 2007, p. 49).
Examining the characteristics of existing developmental mathematics programs using these four equity constructs highlights specific issues with the status quo. In fact, this analysis helps to explain why developmental courses often end up becoming gatekeepers rather than gateways to the large number of students enrolling each year. These problematic characteristics are discussed now in order to better understand the equity implications of existing developmental programs.

**Problematic Characteristics of Developmental Mathematics**

At its core, developmental mathematics is a grand idea: schools provide support to students through additional courses in which they are re-introduced the topics pre-requisite to college-level mathematics. In other words, by design developmental mathematics should grant access to students to ‘play the game of school.’ However, many students are simply unable to successfully navigate through the required developmental courses and into college-level mathematics. Moreover, students caught in this cycle of enrollment in noncredit developmental courses prior to being allowed to move forward are prone to lose confidence and motivation, abandoning concentrations relying on higher mathematics and even college careers (Bailey et al., 2010; Larnell, 2017). The low rates of success indicate the existence of problematic characteristics inherent in traditional developmental mathematics, including issues with placement exams, issues with instruction and pedagogy, issues with alignment to college programs, and issues related to students getting caught in a cycle of developmental courses.
Placement Exams

Colleges utilize placement exams for the purpose of determining which students are prepared to take which mathematics courses. Students who score at or above a predetermined level set by the college are allowed directly into college-level mathematics. Those who do not meet this threshold have traditionally been required to enroll in a lower-level developmental course, although some states and institutions have recently changed this requirement into a suggestion (Zachry Rutschow, 2019). Dependent upon the student’s actual score, they are generally placed into courses at one, two, three or more levels below college level, referred to as developmental mathematics courses. They are then expected to complete these required/suggested, noncredit developmental mathematics courses in order to access the appropriate college-level course.

The importance placed by colleges on one test to determine whether a student is college ready constitutes a serious issue. To begin with, there is disagreement on what ‘college ready’ looks like, and the definition is heavily influenced by the opinions of elite universities who themselves are becoming more competitive (Cullinane & Treisman, 2010). At the same time, high school graduation requirements are influenced by local politics, often favoring standards which most students can meet, and which may or may not be considered ‘college-ready’ at various institutions (Cullinane & Treisman, 2010). The construct is even more dubious when measured by a single placement test (Bailey et al., 2015). A student achieving a particular score on a standardized exam might be enrolled in developmental courses at one institution, but the same score may allow the student to take college-level courses at another institution. Even more, some students who are deemed ‘college ready’ and placed into college-level mathematics from the start often
struggle in these courses, evidence that perhaps they should be placed at a lower level. The underlying problem, then, is no standardized test is able to clearly distinguish between ‘college ready’ or not, yet a low score reinforces the assumption that the test taker is academically underprepared (Bailey et al., 2015; Larnell, 2017).

A number of issues arise when placement exams are used as the sole determining factor of course placement (Bailey et al., 2015). The first issue is that most students are unaware of the purpose and consequences of the exam until after they have already taken it and been placed into a sequence of noncredit courses (Fay et al., 2013). Although this may be attributed to students’ misunderstanding of the exam’s purpose, Bailey et al. (2015) hypothesize that the misunderstanding may in fact be intentionally fostered by colleges who downplay the importance of the exam in order not to discourage students from enrolling at the college. Students may be instructed they cannot fail, or the exam is simply to match them to the best course, so students choose not to study, not to take the exam seriously, or to rush through the exam, all actions having the effect of students earning a score that does not reflect their true academic level (Fay et al., 2013). In addition, many students are overwhelmed and unsure of how to study for an exam covering “a lifetime of math” (Fay et al., 2013) or are unaware of available study resources. Perhaps the most disconcerting reason that students fail to take the placement exam seriously is a lack of self-confidence coupled with a fear of taking college-level mathematics. Larnell (2017) calls this phenomena ‘satisficing,’ where students recognize that a low score on the placement exam will result in being placed in a lower-level noncredit course, so they “satisfy the requirements of the exam with minimal sufficiency” (p. 661) in order to intentionally place below their academic level.
There are also issues with the content and structure of placement exams. Content is often poorly aligned with the academic standards and expectations of college-level coursework, and the skills that are testable in multiple-choice questions are only a small subset of all of the skills and knowledge students need in order to successfully navigate college (Bailey et al., 2015). Moreover, exams lack measures of metacognition, critical thinking, problem solving, and motivation, which are all critical to student success (Venezia & Voloch, 2012).

As an example of the inaccuracy of placement exams, Bailey et al. (2015) describe the case of two students, one who scores just above and one who scores just below the college’s cutoff score. These two students are essentially equivalent in their mathematics ability, yet due to measurement error of the test, they are placed into two different courses. If placement were a determinant of student ability, the student who scores just above the cutoff would likely struggle in the college-level course and possibly become discouraged by their own performance. On the other hand, the student who scored just below the cutoff would be expected to do well in the lower-level course, brushing up on their skills in order to be prepared for the next course. This student would likely overcome the setback of an additional semester of math and progress through subsequent courses earning higher grades than the student who initially placed higher. However, Calcagno and Long (2008) found that while developmental students did show higher persistence rates into the second year, there was no difference in degree completion or credits earned between the two types of student, and other studies found similar results (Clotfelter et al., 2015; Martorell & McFarlin, 2011). One could argue each of the students in question was equally underprepared for college-level mathematics,
but the student who scored just below the cutoff, despite receiving additional assistance, does not actually have better long-term outcomes than the student who is allowed directly into college-level courses. Developmental mathematics programs simply do not lead to the idealized success for which they have been designed, and relying on exam scores to determine placement exacerbates this problem (Bailey et al., 2015).

In fact, two commonly-used placement exams, ACCUPLACER and COMPASS, were both found to misplace students in community colleges, either over-placing them into a college-level course when underprepared or under-placing them into developmental mathematics when a student could have passed college-level mathematics with a grade of B or higher (Belfield & Crosta, 2012; Scott-Clayton, 2012). Both of these studies (Belfield & Crosta, 2012; Scott-Clayton, 2012) utilized student college transcripts, placement test data, and high school data from transcripts to determine an accuracy rate of the placement in the following manner. First, an estimation sample was constructed from all students who had complete data (placement test score, full high school background, and demographic), had never enrolled in the college-level mathematics course in question, and had not taken a remedial course in that subject. Next, the researchers performed non-linear regression using a probit model to calculate parameters which were then used to calculate the probability of success in the college-level course for the full sample of placement test takers. Depending on actual placement and the predicted probability of success in the college-level course, students were categorized into four groups as shown in Table 1. The overall placement accuracy rate was calculated as the percentage of students placed into developmental mathematics and predicted not to succeed in college-level mathematics plus the percentage of students
placed in college-level mathematics and predicted to succeed there. Using this method, Belfield and Crosta (2012) found a misplacement rate of 33% for the ACCUPLACER and 27% for the COMPASS, and Scott-Clayton (2012) found a similar rate of 24% misplacement with the COMPASS.

Table 1

*Categorizations Based on Predicted Outcomes and Placement Decisions (Scott-Clayton, 2012, p. 20)*

<table>
<thead>
<tr>
<th>Placement Decision</th>
<th>Predicted to Succeed in College-Level Course?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placed into developmental</td>
<td></td>
</tr>
<tr>
<td>math</td>
<td>False negative</td>
</tr>
<tr>
<td>(underplaced)</td>
<td></td>
</tr>
<tr>
<td>Placed into college-level</td>
<td>Accurately placed</td>
</tr>
<tr>
<td>math</td>
<td></td>
</tr>
</tbody>
</table>

When examined through the lens of equity, the use of placement exams and results of these research studies indicate several inequities. In the simplest sense, placement in developmental mathematics denies students immediate access to the college-level courses they must complete for their programs of study. While it is possible this results in only a delayed entry into college-level courses, this delay too often results in students never progressing through the developmental sequence (Bailey et al., 2015; Larnell, 2017). More reprehensible, however, is the effect placement decisions have on students’ identity and sense of power. They are often confused about needing to retake courses they feel they have already successfully completed (Fay et al., 2013), and they
encounter a lack of power over their situation. In addition, being placed in lower-level courses contributes to a student’s mathematics identity as someone who is not a ‘math person’ or who ‘cannot do math.’ Even in the case of under-placement, students are likely to accept their categorization as ‘not smart.’ Furthermore, some students recognize that the only way in which they have power over the choice of courses is by intentionally performing poorly on a placement exam in order to place into a lower-level—and possibly, less frightening—course, the phenomenon which Larnell (2017) calls ‘satisficing.’ These threats to students’ access, identity and power all contribute to reduced achievement in both developmental and college-level mathematics.

**Instruction and Pedagogy**

Because the onus for developmental mathematics falls on community colleges, 46% of developmental courses are taught by part-time instructors, many of whom are less involved with the institution (Shields, 2005; Thirolf & Woods, 2017), are not necessarily prepared as educators (Bailey et al., 2015; Boylan et al., 2005; Datray et al., 2014), and tend not to be aware of the importance and practice of using inclusive pedagogy (Moriarty, 2007), all of which have a negative effect on the success of developmental mathematics students both within developmental courses and in their decisions to persist in college (Pascarella & Terenzini, 1980; Tinto, 1997; Tinto, 2006; Umbach & Wawrzynski, 2005). Even more, graduation rates are negatively impacted as the ratio of part-time to full-time instructors increases (Mesa, Wladis, & Watkins, 2014).

Most of these instructors care deeply about their teaching and desire for students to be able to think for themselves; however, they rely on ‘covering the material’ as a primary driver of instruction and often lack training and continuing education necessary
to develop teaching skills (Boylan, 2002; Datray et al., 2014; Grubb et al., 1999).

Moreover, although many instructors recognize the existence of different instructional methods, most tend to rely on a knowledge-transmission approach to teaching and often believe that the only prerequisite for good teaching is content knowledge (Bailey et al., 2015; Grubb et al., 1999; Mesa, Celis, & Lande, 2014). As students, these instructors were able to succeed within the transmission model and it seems reasonable to them that their students should learn the same way (Bailey et al., 2015; Lew et al., 2016). Further, as Ball et al. (2008) point out, this is a naïve perspective of instruction that discounts professional and pedagogical content knowledge.

He [Shulman] argued that “the currently incomplete and trivial definitions of teaching held by the policy community comprise a far greater danger to good education than does a more serious attempt to formulate the knowledge base” (Shulman, 1987, p. 20). Implicit in such comments is the argument that high-quality instruction requires a sophisticated, professional knowledge that goes beyond simple rules such as how long to wait for students to respond. (p. 391)

Just as teaching methods in developmental courses affect student success, the content also poses issues. Developmental mathematics courses tend to be narrowly focused on skills that have likely been taught many times before (Grubb et al., 1999). Instructional and practice exercises are often decontextualized and do not communicate clear student learning objectives as to why students should consider them necessary to study and understand (Boylan, 2002; Makowski, 2017). For example, students taking a basic mathematics course are often instructed on the algorithms for addition, subtraction, multiplication, and division, but not necessarily the meaning of the operations which might allow them to develop an intuitive sense of when and how the algorithms are useful in problem solving. Today’s everyday availability of technology ensures that
students will rarely, if ever, need to perform these calculations by hand, yet there are multitudes of real-life situations in which they may need to solve a problem and are unable to determine which operation to use.

When students encounter instructors who are not well-informed on current evidence-based teaching practices, they often encounter similar cognitive and affective difficulties which precipitated their placement in developmental mathematics (Shields, 2005). Most of these students have previously struggled with traditional, lecture-style mathematics teaching techniques, and it is naïve to assume those techniques would work now that the students are in college (Boylan, 2002). Given that students in developmental mathematics courses tend to be older and disproportionately students of color from academically vulnerable populations (Snyder et al., 2018) who have already faced racial discrimination or been underserved during their K-12 schooling (Bailey et al., 2010; Makowski, 2017), continuing to show students the same information in the same format through developmental mathematics ensures that students continue to face the very barriers they have faced their entire lives (Makowski, 2017). This is neither equitable nor right, and it only serves to reinforce the systems of inequity of the status quo. Not only do students continue to be denied access to quality mathematics learning, they remain powerless both within their mathematics classes and in terms of their path to college completion. Their mathematics identity remains bound to their prior poor experiences in mathematics as it is presented.

Understanding the negative ramifications of the above-described teaching characteristics, it is productive to turn to descriptions of the characteristics shown by research to positively influence student success in developmental mathematics courses.
According to Shields (2005), students who take developmental courses from full-time instructors committed to teaching developmental students ultimately perform better in college algebra. Faculty should be content experts as well as knowledgeable in evidence-based teaching practices and adult learning theory, and they should make a priority of being available on campus for students (Boylan et al., 2005; Cafarella, 2016b; Moriarty, 2007; Shields, 2005). In order to best reach their diverse students, instructors should be open to using varying instructional methods such as student-centered classrooms, collaborative learning, project-based learning, problem-solving techniques, technology to supplement learning, and culturally responsive teaching methods (Bonham & Boylan, 2012; Boylan et al., 2005; Datray et al., 2014; Shields, 2005). High-quality instruction serves to support students within the classes they are allowed to access, helping to remove the barriers caused by poor instruction (Makowski, 2017). Rather than the expectation that students must simply absorb the information being transferred, these methods give students agency and power over their learning and over the classroom, translating to a positive effect on mathematics identity. Moreover, success at the developmental level allows students access to the needed college-level courses.

**Misalignment with College Program**

In addition, developmental mathematics courses are often focused on skills and concepts which may not be well aligned with content in the subsequent courses that students take in their programs. For example, Bailey et al. (2015) cite the policy at one community college wherein a number of programs allow students to fulfill program mathematics requirements by completing a course that does not rely heavily on algebra—so students need not complete a college algebra course for their degree. However, the
college’s highest-level developmental mathematics course is designed to prepare students for college-level algebra, and it is required for all students who are placed into developmental mathematics, regardless of program. Therefore, many students are blocked from advancing because they are unable to complete a noncredit course that is irrelevant to their program of study (Bailey et al., 2015). It is not uncommon for many developmental mathematics courses to terminate in college algebra, which was designed and is often taught as a prerequisite to calculus. However, as few as 10% of all college algebra students continue on to take calculus, so even those students who successfully complete their developmental sequence and college algebra have not necessarily learned mathematics relevant to their programs of study (Dunbar, 2005). This misalignment of outcomes serves only to confuse students and hamper their overall success of degree attainment.

**Caught in the Developmental Cycle**

Nearly half of all students who are placed into developmental mathematics do not successfully complete their first assigned course, and many of these failures are attributed to a failure to enroll in the developmental course in the first place (Bailey et al., 2010). For those students who do complete their first course, the combination of misplacement, ineffective instruction, and misaligned content often act to ensure that students remain stuck in a repetitive cycle of enrollment in developmental courses before they are allowed to move forward into college-level courses (Larnell, 2017). Once a part of the cycle, students are required to complete multiple courses which do not count toward a degree, but which do count against financial aid benefits and eligibility. The best-case scenario for students is they must complete only one semester of pre-college mathematics, but the
reality is most students go much longer without earning credit due to them needing to retake at least one of the developmental courses (Bailey et al., 2015). Students lose confidence and motivation, and they abandon dreams of educational programs relying on higher mathematics and even college careers (Larnell, 2017).

Both the large attrition rate—more than 60% of developmental mathematics students fail to complete their full sequence (Bailey et al., 2010)—and the fact students are allowed to flounder in non-credit-bearing courses for multiple semesters are reason enough to conclude traditional developmental mathematics is not working. Community colleges’ open enrollment policies provide access to courses, but as Engstrom and Tinto (2008) point out, “access without support is not opportunity” (p. 46). Furthermore, it is inequitable. “For too many low-income students, the open door of American higher education and the opportunity it provides has become a revolving door” (Engstrom & Tinto, 2008, p. 47). This is especially disconcerting given that developmental mathematics students disproportionately come from underrepresented groups and are more likely to have high-risk characteristics which affect their academic outcomes, including no high school diploma, delayed enrollment, dependents, full-time employment, and part-time enrollment (Mesa, Wladis, & Watkins, 2014). Caught in this cycle attempting to progress to college-level courses, students become disheartened as their total time in college increases, but rather than college credits as evidence, they are left with only the tuition bill to show for it (Bailey et al., 2015; Larnell, 2017).

The current state of developmental mathematics programs is to provide access solely to developmental courses for most students. As previously argued, this is detrimental to students’ identities as learners and serves only to perpetuate the status quo.
Instead, mathematics departments must ensure that all students are provided access to quality learning, and that all students have access to the resources to participate. In addition, colleges must attend to student outcomes such as course completion and persistence in college, and support students in and out of class to attain those outcomes. Even more, departments and instructors must focus on students’ identities and issues of power in order to support and empower students to be critical citizens who desire to “change the game” of teaching, learning, and doing mathematics (Gutiérrez, 2009).

**Developmental Mathematics Reform Efforts**

Given the overwhelming research showing that traditional developmental mathematics programs exhibit numerous issues and are actually a disservice to students (Bailey et al., 2006; Bailey et al., 2015; Cafarella, 2016b; Calcagno & Long, 2008; Cohen et al., 2013; Cullinane & Treisman, 2010), many community colleges have critically reevaluated and revamped their offerings to better reach the majority of their students. Examples of reform efforts range from placement exam reforms (Zachry Rutschow, 2019), to accelerated sequences (Cafarella, 2016a; Cafarella, 2016b), to complete program redesign (Charles A. Dana Center, 2018; Huang & Yamada, 2017; Yamada et al., 2016) utilizing pathways models in which students are advised into mathematics courses designed to be most applicable to students’ academic majors of study. Detailed descriptions of these reform efforts follow.

**Placement**

Some institutions have attempted to ameliorate the issues of placement exams by utilizing multiple measures of placement assessment, including high school performance indicators and non-cognitive measures of commitment, motivation and perception of
abilities, using diagnostic testing instead of the oft-used adaptive testing, or implementing early assessment or transition programs to provide assessment to students while still in high school, allowing them to work on building college-readiness before college enrollment (Zachry Rutschow, 2019). The effects of these efforts on student success outcomes are mixed; the use of multiple placement measures, in particular high school performance characteristics, was shown to increase the accuracy of developmental placement (Belfield & Crosta, 2012; Hodara et al., 2012). Although students who completed early assessment programs tended to have a higher likelihood of being placed in college-level courses, this higher placement did not necessarily translate into higher college-level completion rates (Kane et al., 2018; Mokher et al., 2018). Diagnostic testing appears to be more effective at placing students, but there is little research regarding the effects on student success of such placement (Zachry Rutschow, 2019).

**Course Compression and Acceleration**

Course compression and acceleration are designed to minimize the amount of time students are required to spend in courses below college level, leading to less student burnout and increased student success (Cafarella, 2016a; Cafarella, 2016b).

Compression of developmental courses, in which two developmental courses or one developmental and one college-level course are condensed into one semester have shown promising trends of higher success than traditional developmental courses. For example, at a particular community college in New Jersey, students who score on the higher end of the placement exam have the option of taking a one-semester course which combines arithmetic and algebra, rather than the traditional two-semester sequence (Cafarella, 2016a). According to institutional data, this move resulted in an increase of 15
percentage points in developmental mathematics pass rates (Cafarella, 2016a). Another example is the Start Program implemented by some of the community colleges in New York City which replaces multiple courses and multiple semesters of developmental mathematics, reading, and writing courses with single intensive course that meets five hours per day, five days per week during one semester (Winerip, 2011). During the first three years of implementation, nearly 80% of participants remained enrolled for the entire semester and over half were able to pass all three remediation tests to continue on to college-level courses (Winerip, 2011).

Course acceleration also entails multiple courses condensed into one or two, with the added benefit that students have an opportunity to complete the required content in less than a traditional semester or quarter (Cafarella, 2016a; Cafarella, 2016b). Many of these programs utilize online programs such as Pearson’s MyMathLab™, and students are able to focus only on content modules they have difficulty with, working through the modules at their own pace. Courses generally meet in computer labs with faculty and tutors available to assist as needed, and students often are able to complete multiple courses within one semester (Cafarella, 2016a). A specific example of course acceleration is known as the Emporium model, first developed at Virginia Tech and implemented in developmental and college level courses at numerous institutions nationwide since the turn of the century (Twigg, 2011).

Institutional data associated with course acceleration models indicate positive student results. The accelerated course redesign of three developmental courses and three college-level courses at Cleveland State Community College led to an increase of 18% of students completing developmental mathematics (Squires et al., 2009). In addition, the
college algebra completion rate increased from 65% to 74% (Squires et al., 2009). A community college in Colorado reported a significant increase in the number of developmental students passing subsequent college-level mathematics after accelerating its developmental courses (Cafarella, 2016a). The University of Alabama’s emporium model for intermediate algebra resulted in C or higher grades for 78.8% of students compared with 40.6% of students four years prior in the traditional course (Twigg, 2011). Moreover, students who had taken the emporium course outperformed those from the traditional course in the first course of a two-course pre-calculus sequence (Twigg, 2011).

**Corequisite Models**

Corequisite models allow students testing at the developmental level to enroll directly into college-level courses with added supports (Fair, 2017; Zachry Rutschow, 2019). In this way, developmental mathematics learning competencies are embedded within the college-level course, and remediation is accomplished ‘just in time’ (Fair, 2017). There is no single optimal model of corequisite support, although courses generally include extended instructional time and are supplemented with mandatory tutoring and support sessions that run concurrently with the college-level (Dana Center Mathematics Pathways, 2018; Fair, 2017). Some models may contain accelerated basic skills content during the first few weeks of the semester followed by the college-level course in the same semester or may embed the developmental content into the college-level course stretched over two semesters (Complete College America, 2018; Dana Center Mathematics Pathways, 2018).

Corequisite models have contributed to positive student outcomes in developmental mathematics courses at both the community college and university level,
and they have shown to be a feasible solution to the problem of multiple semesters of remediation (Fair, 2017; Logue & Watanabe-Rose, 2014; Rodriguez, 2014). For example, institutional data from West Virginia Community and Technical Colleges showed an increase from 14% to 68% in the college-level mathematics pass rate (Complete College America, 2018). Furthermore, prior to a system-wide implementation of a corequisite model, the Tennessee Board of Regents reported that only 12.3% of developmental students successfully completed a credit-bearing mathematics course. After implementation, this rate increased to 55%, including a 10-fold increase for students who had ACT scores less than 15, a more-than-5-times increase for adults, and a rate for minority students more than seven times higher than the rate before implementation (Denley, n.d.).

**Guided Math Pathways**

As an alternative to the course restructuring efforts described above, many colleges have reformed their developmental mathematics programs to adopt a math pathways model. Put simply, a math pathway is a sequence of courses a student takes in order to meet the mathematics requirements of their program of study. Traditional developmental mathematics programs rely on essentially one pathway terminating at college algebra as the required college-level course (Bailey et al., 2015). The math pathways movement proposes pathways that are aligned with academic, career, and life needs rather than the arbitrarily chosen benchmark of college algebra for all students, (Bailey et al., 2015; Charles A. Dana Center, 2018). For example, the “Texas Math Pathways” are a set of five mathematics pathways, three algebraically intensive and two non-algebraic, corresponding to six meta-major areas (Zachry Rutschow et al., 2017).
These pathways are designed to provide a more specific mathematics experience and engaging coursework for students than previous algebra-based mathematics requirements (Zachry Rutschow et al., 2017).

A number of national reform groups have been integral in the development of guided pathways models, including Complete College America, the Carnegie Foundation for the Advancement of Teaching (Carnegie Foundation), and the Charles A. Dana Center at the University of Texas at Austin (Dana Center; Zachry Rutschow et al., 2017). While each of these pathways models differs slightly from the others, the underlying goals are consistent: to provide engaging, relevant mathematics courses to all students in higher education.

**Quantway and Statway**

Quantway and Statway were developed through a partnership between the Carnegie Foundation and the Dana Center in 2010 as alternative pathways to the traditional developmental mathematics sequence (Huang & Yamada, 2017; Yamada, 2017; Yamada et al., 2016; Zachry Rutschow et al., 2017). Both programs are intended for students in non-STEM programs of study who require only one college-level quantitative course, with those students focusing on areas such as allied health sciences, public safety, business, or social sciences advised into Statway, and students in other liberal arts majors advised into Quantway (Huang & Yamada, 2017; Yamada, 2017).

In these pathways, developmental mathematics curriculum is taught in service to the learning of statistics and quantitative reasoning, rather than in isolation (Huang & Yamada, 2017; Yamada, 2017). Both are designed under the premise that “all students are capable of learning ambitious mathematics and succeeding in developmental
mathematics courses with the right supports” (Yamada et al., 2016) and share the goals of accelerating students’ progress through developmental mathematics into successful college-level mathematics completion (Yamada, 2017). Six driving principles led the creation of and guide the implementation of Quantway and Statway: (i) acceleration of developmental mathematics requirements; (ii) implementation of a research-based instructional system; (iii) socioemotional supports; (iv) language and literacy supports; (v) faculty development; and (vi) participation in the network improvement community. Through these principles, Quantway and Statway address the barriers that tend to impede students’ success in developmental courses, such as multiple required remedial courses, poor instruction, and feelings of overwhelm and isolation. Through the embedded psychosocial and academic supports, students learn to navigate their social and academic worlds (Huang & Yamada, 2017; Yamada et al., 2016). Moreover, their course designs draw on instructional and programmatic strategies that explicitly challenge long-held misconceptions about the nature of mathematical learning, including the notions of passive information transmission and learning in isolation. Due to the different populations and course outcomes, the driving principles can be fulfilled in slightly different ways for each (Yamada et al., 2016). However, both programs place importance on building complex connections between peers and instructors, relationships which have been shown to influence students’ decisions to remain in college (Huang & Yamada, 2017; Umbach & Wawrzynski, 2005).

The list of driving principles may appear daunting to the casual reader, but “this comprehensive and systematic approach to tackling the typical barriers that developmental mathematics students face is key to [Quantway’s and Statway’s] success”
In matched comparison with students enrolled in traditional developmental mathematics courses, Statway students showed a significantly higher likelihood of successfully attaining college-level mathematics credit compared to traditional developmental mathematics students, even when their counterparts were allowed twice the amount of time (Huang & Yamada, 2017). Similarly, students who successfully completed Quantway 1, which prepares students for either Quantway 2 or another college-level course, were significantly more likely to enroll in a credit-bearing college-level mathematics course within one year (Yamada, 2017). Even more, these positive effects held across all sex and racial/ethnicity subgroups, providing “robust evidence that Quantway 1 increases student success in fulfilling developmental mathematics requirements and advances equity in student outcomes” (Yamada et al., 2016). These program evaluations were all conducted within the first three years of implementation, but they provide promising evidence that Statway and Quantway are, in fact, a step in the right direction for developmental mathematics reform. Even more, because both Statway and Quantway are fully designed courses, they are fairly easily integrated into current developmental mathematics offerings at any institution (Yamada et al., 2016).

**Dana Center Math Pathways (DCMP)**

Following a successful partnership with the Carnegie Foundation in 2010 developing Quantway and Statway, the Dana Center collaborated with the Texas Association of Community Colleges in 2012 to design the Dana Center Mathematics Pathways (DCMP; Zachry Rutschow et al., 2017). Similar to Quantway and Statway, the DCMP is a pathways initiative designed with the aim of streamlining the developmental
mathematics process and ensuring success for all students. There are four key principles to the DCMP: (i) all students, regardless of college readiness, enter directly into mathematics pathways aligned to their programs of study; (ii) students complete their first college-level mathematics requirement in the first year of college, regardless of readiness; (iii) strategies to support students as learners are integrated into courses and are aligned across the institution; and (iv) instruction incorporates evidence-based curriculum and pedagogy. These principles can be utilized by institutions to design any number of pathways, from developmental to college-level courses. Alternatively, the DCMP provides models including course materials for three alternative math pathways: statistics (for students in meta-majors of social sciences, social services, nursing, and health professions), quantitative reasoning (for students majoring in liberal arts, fine arts, or humanities), and a path to calculus (for students studying STEM fields) (Zachry Rutschow et al., 2017). The Center also offers materials for a developmental-level course, which it has called Foundations of Mathematical Reasoning. Upon completion of the Foundations course, students continue through one semester of college-level mathematics in statistical or quantitative reasoning or two semesters of college-level mathematics on the path to calculus (Zachry Rutschow et al., 2017).

As part of a large evaluation of the DCMP pathways, the Center for the Analysis of Postsecondary Readiness (CAPR) reported positive preliminary results of the program following the first and second semesters of implementation (Zachry Rutschow et al., 2017). The study compared courses and students within the DCMP model with courses and students utilizing a traditional developmental mathematics program and found that those traditional courses tended to focus more heavily on procedural understanding of
algebra, where students in the program group were more likely to encounter math problems drawn from real-life scenarios and to write out their reasoning. Perhaps more telling about success, however, is program students registered for and passed their developmental mathematics classes at higher rates than the traditional group students, with 78% registered for and 47% passed, versus 68% registered for and 36% passed, respectively. While the results are preliminary and might be affected by other factors not yet considered, they are certainly promising (Zachry Rutschow et al., 2017).

**Implications of Reform Efforts**

One theme common to all of these reform efforts is the focus not only on students’ successful completion of the developmental sequence, but on students’ ultimate persistence through college-level mathematics and college degree programs. Traditional developmental programs focus on persistence from one course to the next, defining success as course completion rather than program completion, but this is short-sighted (Bailey et al., 2015). In order to have an effect on overall student success, it is necessary to look further than one course to the next.

The equity impacts of developmental mathematics reform are staggering. Placement and structural reforms change students’ access to courses, reducing the number of required courses and allowing many students the ability to take higher-level courses more quickly than they may have previously been allowed. In addition, because students are not immediately relegated to the lower level, their mathematics identity is less bound to the notion that they are ‘not smart enough for’ or ‘less than’ the students who place immediately into college-level courses. With Guided Pathways reforms, students are encouraged to choose mathematics courses more in line with their interests.
and program of study, possibly resulting in students conceiving of their mathematics identities as part of, rather than apart from, their larger identities. Further, this gives students power over their situation by allowing them to choose the most applicable course rather than a one-size-fits-all, and students are encouraged to develop their mathematics identity as part of a group of mathematics learners in addition to individually.

**Conclusion**

Developmental mathematics programs have been around a long time and have fulfilled a need for some mathematics learners. Unfortunately, however, the number of negative experiences and results in developmental mathematics far outweigh the positive results. The downfalls of developmental mathematics, although examined individually in this paper, all contribute to the tendency for students to become caught in a cycle of noncredit-bearing courses. This cycle can be viewed as a traffic roundabout, simple to navigate for those who are familiar but confusing and daunting for the uninitiated. Once in the circle, there are multiple exits leading down different paths. One exit is the route directly into a credit-bearing course, indicating a swift completion of one developmental course. Another exit leads to a second traffic circle representing an additional developmental course necessary to navigate before continuing on the route to credit-bearing courses. Still other exits lead to additional courses, different programs, or even leaving college.

In addition to multiple exits, there are equally as many lanes a student can become trapped in, requiring multiple trips around the circle as individual courses are failed or dropped and reattempted. Placement, instruction, required content, and the many
characteristics that set apart community college students are all factors that steer students into the roundabout and trap them going around and around. As students complete more trips around the circle, they become more uncomfortable, more frustrated, and less confident in their ability to successfully exit. The constraint of the lanes makes it nearly impossible for students to access help. The developmental roundabout reinforces barriers to equity by directly contributing to students’ negative perceptions of their mathematical identities, holding them powerless to change the status quo, and limiting their access to quality mathematics learning.

On the other hand, developmental mathematics reforms aim to remove the equity barrier through bypassing the roundabout altogether. Rather, students are directed onto a straight path leading to college-level courses, with pull-outs and rest stops available. The path has been designed to minimize the amount of time before arrival at the college level. The reform efforts are a step in the right direction, but it is important to continue moving forward through evaluation of the reforms and consistent attempts to make the path to college level even straighter and freer of obstacles. Even with reform, equity issues still exist and must be confronted. For example, providing access to college-level courses more quickly is no different from traditional developmental mathematics programs if students continue to encounter poor instruction and a lack of resources and support. These students will no longer be circling the developmental roundabout, but they also will be no closer to success at the college level. The focus must remain on attention to all four equity constructs: access, achievement, identity, and power.

It is also timely to consider these four constructs for the other stakeholders in developmental mathematics. For example, instructors of these courses need further access
to learn how to be impactful teachers with an eye toward equity in their courses, and they must be given power to make changes toward equity for themselves and their students. Currently, there is minimal research focused on instructors, and even less pertaining to stakeholders such as administrators or policy makers. Furthermore, there is a need to explore developmental mathematics as an interconnected system with multiple components such as administrators, instructors, and policies in addition to students. The remainder of this dissertation describes the design, results, and implications of my study which focuses on administrators and instructors.
CHAPTER III

METHODOLOGY

The purpose of this qualitative case study is to provide an account of one community college’s redesign of mathematics courses to replace the currently offered sequence of developmental mathematics courses leading to college algebra. Specifically, this study aims to answer the following research questions:

Q1 What are the experiences of administrators, instructors, and students during a redesign of the developmental mathematics program at an urban community college?

Q1a What tensions and contradictions exist within and between the experiences of these three distinct groups?

Q1b In what ways are these tensions and contradictions related to the constructs of equity?

This chapter explains the study design, theoretical perspective, and analytical framework which drive the research design. The chapter will conclude with a description of the setting and the data collection and analysis methods, including examples of analysis. The structure of the study is summarized in Figure 1.
Study Design

The purpose of qualitative research is to understand how people construct meaning and make sense of their lives and their worlds (Merriam & Tisdell, 2016). As such, there are four key assumptions to qualitative research: the focus is on process, understanding and meaning through an emic, or insider’s, perspective, rather than an etic, or outsider’s, view; the researcher is the primary instrument for data collection and analysis; the research process is primarily inductive rather than deductive, building up concepts and theories rather than testing hypotheses; and the product is richly descriptive,
relying on words rather than numerical results (Merriam & Tisdell, 2016). It is the emic perspective, or what happens within the boundaries of the study, that differentiates case study methodology from other types of qualitative research (Stake, 1978). The case is the unit of study, and “…the single most defining characteristic of case study research lies in delimiting the object of study: the case” (Merriam & Tisdell, 2016, p. 38). For this study, the case is the activity system of developmental mathematics reform at Lowry Community College (LCC, a pseudonym), comprised of administrators and instructors involved with the reform process and students taking the reformed courses. The case does not include other college administrators, instructors not involved in teaching developmental mathematics, or students not enrolled in the reform developmental or college algebra courses. The case is further bounded by the physical location of the college, the individual course sections, and the timeframe of both the redesign process and the academic semesters.

This particular case is what Stake (1978) refers to as an intrinsic case: the researcher has an intrinsic interest in the specific case and wants to know more about it. The goal of the study is not to generalize to a larger population. Rather, the goal is to understand the case at hand, to “take a particular case and come to know it well, not primarily as to how it is different from others, but what it is, what it does” (Stake, 1995, p. 8). My interest in this study first came about when I learned of LCC’s plans for developmental mathematics redesign, and I wanted to understand and share their story of reform.
**Researcher Stance**

As a former community college developmental mathematics instructor, I was initially taken aback when I learned LCC was planning to discontinue teaching developmental mathematics courses. I immediately had visions of anxious, underprepared students floundering in college algebra, because I was not so naïve to assume all students would somehow, magically, be ready for college-level mathematics.

Of course, I was mistaken in my initial assumption as to what it would look like when community colleges made the move away from traditional developmental mathematics courses. These courses are not simply being thrown out; rather colleges are working to reform their programs to better serve students who have been, and continue to be, underserved. Through a mathematics education career with stints at two high schools, one community college, and two universities, I have long been an advocate for reform in K-12 and undergraduate mathematics education, but until recently I had somehow failed to acknowledge that developmental mathematics needs changing as well. In retrospect, I recognize that I encountered at my community college many of the same issues which I expand on in the various other chapters of this dissertation, especially the tendency for students to become ensnared in the cycle of developmental courses. However, until recently I had accepted this as the status quo rather than something that should be challenged. Now on the threshold of a new stage in my education career as I prepare to transition to a faculty position, I recognize that I am in a position to focus my belief in reform mathematics on developmental courses, which, I have come to realize through experience and the large amount of research I encountered during this dissertation study, are in dire need of resuscitation.
Theoretical Perspective

I used activity theory as the main perspective to frame the goals and design of this study. Activity theory is useful for analyzing human activity in context, so it was used as the primary theory to interpret the activities of students, instructors, and administrators during and resulting from the course redesign. In addition, because the driving force of the course redesign was a focus on equity and a goal of higher graduation rates, the use of equity and persistence frameworks ensures that these constructs and their implications remain at the forefront during the research process. I now describe each theory, and in the Data Analysis section I provide an example of how the theories inform and interact with each other.

Activity Theory

I utilized activity theory as an overarching theoretical perspective to the study design and data analysis. Activity theory allows for the consideration of multiple actors and the activities undertaken by them, providing a tool to interpret the interplay between those actors and their activities. As previously described, the focus of this study is the experiences of students, instructors, and administrators. Each of these three groups served as the perspective (or subject) of a separate activity system which was analyzed individually. In addition, because the experiences of these three groups are deeply interconnected, their three activity systems were analyzed collectively.

Activity theory stems from Vygotsky’s model of mediated act, wherein the direct connection between a stimulus and its response are mediated through some act or artifact (Vygotsky, 1978). Building on this concept, Leont’ev (1979) described activity as a goal-directed hierarchy of actions used to accomplish an object. Activity is encouraged by
motive, which is the driving force for the activity and actions. The basic components of activity, actions, translate this motive into reality in service of a goal. Actions are then carried out through operations that are associated with the conditions under which actions take place. Leont’ev’s (1979) view of activity focuses on the complex interactions between the individual and the community, explaining the difference between individual action and the collective activity system.

Activity theory as used in this study was articulated by Engeström (2015), who built onto the ideas of Leont’ev. Different from earlier models, the unit of analysis in Engeström’s model is the entire activity system, which integrates the subject, object, and instruments (tools and signs) into a unified whole, giving context to individual events. Figure 2 shows a model of an activity system wherein double-tipped arrows connect each pair of components to denote that components are held in tension with each other and cause reconstruction of the system.

**Figure 2**

*Theoretical and Analytical Framework of the Study* (Engeström, 2015)
In the model, the *subject* indicates the subgroup or individual whose agency defines the point of view of the activity system. The *object* indicates the raw material or problem space at which the activity is directed, which is transformed into *outcomes* through the assistance of physical and symbolic *tools*. The *community* is made up of all individuals and subgroups sharing the same general object. *Division of labor* occurs both horizontally as a division of tasks between the members of the community and through the vertical division of power and status, mediating between the community and the object by providing the power structure for accomplishing the object. The *rules* refer to the implicit and explicit regulations and conventions that constrain actions and interactions within the activity system. An example of an activity system is described in the manuscript in Chapter IV.

The system reconstructs itself through adapting to contradictions and changes within the existing tensions (Engeström, 2015). “Contradictions are not the same as problems or conflicts. Contradictions are historically accumulating structural tensions within and between activity systems” (Engeström, 2001, p. 137) and may exist at four levels in the central activity system (Engeström, 2015). The basic internal contradiction of a human’s activity is “its dual existence as the total societal production and as one specific production among many…Within the structure of any specific productive activity, the contradiction is renewed as the clash between individual actions and the total activity system” (Engeström, 2015, p. 66). This clash between individual actions and the total activity system comprise a *Level 1 contradiction* within a certain component of the central activity system. For example, if the individual instructors who comprise the collective subject of an activity system have differing beliefs about the specific aspects of
quality teaching, there will be discord when these instructors are asked to work together to design a new course. Level 2 contradictions occur between components of the central activity system, such as between the rules and the division of labor. In a certain mathematics department, there may be an implicit understanding that instructors have autonomy over their classes (rule). At the same time, developmental and college-level math instructors are expected to work closely together in order to ensure student success in both levels (division of labor). This may manifest as a contradiction in the event this collaboration leads to a loss of autonomy for either subset of instructors.

Level 3 contradictions occur between the object/motive of the “dominant form of the central activity and the object/motive of a culturally more advanced form of the central activity” (Engeström, 2015). For example, a third level contradiction could occur if college administration mandates that a mathematics department implement specific procedures corresponding to some idealized department; the procedures may be formally implemented but likely will still be dependent upon and resisted by the old form of the activity.

Level 4 contradictions occur through the interaction between the central activity and a neighbor activity system (Engeström, 2015). Neighbor activities include “object activities” wherein objects and outcomes of the central activity are embedded, “instrument-producing activities,” which produce the key instruments for the central activity, “subject-producing activities,” which include activities such as education and schooling of the subjects of the central activity, or “rule-producing” activities, which include activities such as administration and legislation (Engeström, 2015). Neighbor activities may also include central activities that are in some way connected to the given
central activity, for example the activity system for the instructors at a college and the activity system for the administrators at the same college, between which contradictions develop causing tension and perturbation within both systems (Engeström, 2015). Actual occurrences of these contradictions are described thoroughly in Chapter IV.

**Equity**

As mentioned in Chapter I, equity was a driving force behind the redesign at Lowry Community College. I utilized Gutiérrez’s (2009) equity framework as a lens through which to view both the traditional state of developmental mathematics and the reform efforts at LCC and elsewhere. This framework relies on the four dimensions of access, achievement, identity, and power (Gutiérrez, 2009).

Attention to access means ensuring all students have the resources to participate in quality mathematics learning, including quality teaching and opportunities to engage with rigorous curriculum and problem-solving situations. The achievement dimension refers to the attainment of student outcomes such as exam scores, course completion, degree completion, and persistence in college, which are naturally attended to in educational settings. These two constructs together make up what Gutiérrez (2009) calls the "dominant axis" because they pertain to the ways students are supported “to participate in the existing dominant culture and practice of mathematics” (Mathematical Association of America, 2017, p. 172).

While attending to access and achievement are important, it is vital to note that doing so only allows for a continuation of the status quo (Gutiérrez, 2013). Instead, we must support and empower students to be critical citizens who desire to “change the game” of teaching, learning, and doing mathematics (Gutiérrez, 2009). This can be done
through a focus on identity and power, which make up the “critical axis” of equity (Gutiérrez, 2009). Identity is built from all of the personal and cultural aspects that inform how students see themselves. Identity is situated; what a student chooses to present in one situation may differ from that in another, and it is necessary to be aware of how students’ identities impact their participation in mathematics learning (Gutiérrez, 2013). Attending to issues of power requires a focus on who benefits from the teaching of mathematics and how. Not only must students be given agency within the classroom and power over the mathematics that they are learning, but they must be empowered to challenge the status quo (Gutiérrez, 2013). Even more, students must “be able to play the game of mathematics that is currently associated with power and intellectual potential, and be able to change the game of mathematics to serve a better society” (Gutiérrez, 2007, p. 49).

**Persistence**

As also stated in Chapter I, one of Lowry Community College’s recent improvement goals was to increase their 3-year graduation rate. For this reason, I utilized Tinto’s (1975, 1997) persistence framework in the study design and data analysis. This framework, comprised of factors such as academic and social involvement, background characteristics, and goal commitment, helps explain students’ decisions to persist in education or “continue in pursuit of [an educational] goal even when challenges arise” (Tinto, 2017, p. 2). The model asserts that students with higher levels of involvement have higher tendencies to persist in college, whereas students with lower levels of involvement are more likely to drop out from college.
In this theoretical model, Tinto (1975) highlights that all students enter college with a collection of background characteristics, for example gender, ethnicity, prior schooling, and family support, which provide the foundation for their academic and institutional goals, as well as the level of commitment to those goals. These goals in turn influence students’ academic involvement and social involvement. Academic involvement includes students’ attention to grades (grade performance) and their desire to learn (intellectual development), whereas social involvement pertains to peer-group interactions and faculty interactions both inside and outside of formal classrooms. These shape students’ academic integration and social integration, which then further influence students’ commitments to their goals and form the bases of their persistence decisions.

Tinto’s perspective of persistence aligns directly with the dimensions of access and achievement. In particular, access is providing the opportunity for students to enroll in college, as well as the necessary support they need while they are there. Attending to access, then, is providing the resources and opportunities for students to become and remain academically involved and achieve success in courses and college programs. Further, attending to identity and power can impact students’ social integration through their interactions with other students and with instructors. Together, these constructs foster student persistence and provide a basis for students to eventually effect change in the higher education ‘game’.

These ideas of equity and persistence informed the interview and survey questions, as well as provided a lens through which I conducted classroom observations (see Table 3 on p. 64). They were used more extensively during the data analysis by informing the components of the activity systems and identifying tensions and
contradictions as drivers of change. This is described more fully in the Data Analysis section.

**Methods**

In this section I outline the methods I used to address the research questions in this study. I first provide a detailed description of the setting, followed by a comprehensive explanation of the data collection methods. I conclude the section by describing my data analysis methods and providing examples to illustrate.

**Setting**

Lowry Community College (LCC) is a community college located in a large urban area in the Rocky Mountain region. LCC has an annual enrollment of approximately 7,500 students, 1,500 who attend full-time and 6,000 who attend part-time. With a Hispanic population of 26.9%, the school has achieved the designation of Hispanic Serving Institution by the Hispanic Association of Colleges and Universities. The ethnic make-up of the remaining students is 1.7% American Indian/Alaskan Native, 8.0% Asian/Pacific Islander, 21.2% Black, 36.1% White Non-Hispanic, and 6.1% Unknown/Not Reported. This compares to the national community college enrollment of 17% Hispanic students, 0.8% American Indian/Native Alaskan students, 7% Asian/Pacific Islander students, 14% Black students, and 58% White students (Snyder et al., 2018).

In 2013, LCC worked with the Center for Urban Education (CUE) at the University of Southern California on their Equity Scorecard initiative. The Equity

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3 These data and the results of the Equity Scorecard come from published internal research which are not cited in order to maintain confidentiality.
Scorecard is a reflective process designed to assist colleges in identifying, addressing, and solving the problem of inequitable educational outcomes (Center for Urban Education, 2018). CUE provides support, tools and processes that enable campus members to conduct action research by critically examining student data, identifying where in the academic pathway there exists evidence of inequality by race or ethnicity, and designing a plan of inquiry to identify practices that have an impact on student outcomes in order to address the inequity (Center for Urban Education, 2018).

During the Equity Scorecard process, LCC insiders examined disaggregated student outcomes data from 2009 through which they discovered that full-time Black students had a lower 3-year degree completion or transfer rate than all other groups and the college average. In addition, Black students were overrepresented in remedial courses, not passing developmental mathematics and underrepresented in college algebra. Both of these discoveries came as a surprise to the team, as the college had recently placed in the 90th percentile of around 200 nationwide community colleges in college algebra success rates. As it stood, Black students graduated or transferred at a rate of only 29.7%, 5.2 points less than the aggregated college rate of 34.9%, and 10.7 points less than the rate for white students, the highest achieving group on this metric. The team set an equity goal that by 2017, Black students’ 3-year graduation/transfer rate would be 40.4%, equal to the rate for white students, which is higher than the college average because the team felt that setting the benchmark higher would benefit all students.

Once this equity goal was established, the equity team decided to focus on college algebra in light of the inequities in mathematics that they had found. College algebra was known as a barrier to transfer and graduation at LCC, so focusing their efforts on
improving success in this course would address not only the equity goal but also the larger goal of improved college completion from the state’s standpoint. Through the ensuing inquiry into which institutional resources had the potential to ameliorate the equity gap, the committee noticed the overwhelming use of a procedural teaching approach in developmental mathematics courses, which is consistent with research (Grubb et al., 1999; Shields, 2005). Further, this approach is also widely used at LCC’s predominantly white feeder high school. What is interesting, however, is math teachers at the predominantly minority feeder high school use a conceptual/discovery teaching approach. This realization brought to light how race is implied in curriculum and pedagogy and how this may contribute to the lower success rates for students unfamiliar with the procedural approach.

The results of the equity scorecard precipitated what are now four phases of redesign within the LCC developmental mathematics and college algebra courses. The first phase was the transition from four developmental courses into two that occurred as a collaboration between all of the colleges within the same community college system. The second was the implementation of a corequisite requirement for college algebra, and the third was the creation of a separate college algebra course including a modeling approach for non-STEM students who still needed the college algebra course. Even with these changes, LCC students continued to struggle in their developmental courses similarly to similar to the published research (e.g., Bailey et al., 2015).

4 Citation again withheld to protect confidentiality.
The fourth phase of LCC’s restructuring, and the focus of this research, was to replace the two developmental courses from Phase 1 with a 5-week developmental mathematics ‘boot camp’ followed by a 10-week college algebra course with corequisite support. The model allows students to complete both their developmental mathematics credits and their college algebra in a single semester. This combination of new courses meets 3 days per week for the 15-week semester. During the onboarding, students meet for three hours per day and work independently to complete 5 redesign-team-organized developmental mathematics modules utilizing Pearson’s MyLab™ Math software. Instructors are expected to utilize a flipped classroom model for this onboarding course. In week 6, the three-hour time slot is divided into a 2-hour college algebra class and a 1-hour mandatory support lab. A more detailed description of the process and results of this phase is located in Chapter IV.

Data Collection

Once I had received Institutional Review Board approval from both my home institution and Lowry Community College, I began the data collection process. Please see Appendix A for the IRB approval letters and informed consent forms.

Interviews served as the main source of data that are supported by data collected through surveys, classroom observations, and artifacts. The use of interviews to elicit experiences from different perspectives is appropriate because, as Patton (2015) states, “the purpose of interviewing, then, is to allow us to enter into the other person’s perspective” (p. 426). I used a semi-structured format for my interviews and focus groups in order to allow for flexibility in participant responses and new ideas to arise (Merriam & Tisdell, 2016). The use of many different data sources not only allows for triangulation
of the findings (Merriam & Tisdell, 2016), but I believe it provides a more comprehensive description of the phenomena and experiences. As noted in my research questions, I collected data from administrators, students, and instructors at the community college. All interviews were video- and audio-recorded, and transcripts, my notes, and any applicable artifacts formed the data corpus.

Table 2 provides a summary of the data collection activities which are then described in full. Appendices C, D, and E provide the survey and interview questions, with each question annotated to indicate the construct(s) to which it was targeted.

**Instructor Interviews**

I emailed all forty full-time and part-time mathematics instructors of the college during October 2018 and asked them to complete electronic surveys regarding their experience teaching at LCC during this redesign process. The survey also asked instructors to participate further through interview and classroom observations. This first round of data collection yielded 6 survey responses and one interview. I contacted all instructors again by email in January 2019 and directly asked them to participate by interview and/or classroom observation. This yielded one more participant, and through interaction with them during observations, I was able to meet two other instructors willing to participate.

**Student Interviews**

I contacted all students enrolled in the classes of participating instructors by email to complete an electronic survey regarding their experiences in mathematics classes, including their tendencies to persist and their perceptions of power and identity in the classroom. Within the survey, participants were asked to create a code to identify
their data for the researcher, and any information that would tie this code to the student was be destroyed. Students were also invited to participate further in either a semi-structured individual or focus group interview to be conducted near the end of the academic semester. Six students responded to the survey, four of whom agreed to be interviewed individually.

**Table 2**

*Data Collection Procedures and Sources*

<table>
<thead>
<tr>
<th>Who</th>
<th>What</th>
<th>When</th>
<th>Reason</th>
<th>Time Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Math Faculty (6)</td>
<td>Electronic Survey</td>
<td>After IRB approval, October 2018 and January 2019</td>
<td>• General perceptions of change and benefits (RQ1a, RQ1b)</td>
<td>15-20 minutes</td>
</tr>
<tr>
<td>Math Faculty (2)</td>
<td>In-Person Interview</td>
<td>November 2018 – March 2019</td>
<td>• Perceptions (RQ1a, RQ1b)</td>
<td>60-90 minutes</td>
</tr>
<tr>
<td>Math Faculty (2)</td>
<td>Classroom Observation</td>
<td>Fall 2018; Spring 2019</td>
<td>• Understand a ‘typical’ day (RQ1a)</td>
<td>1-2 weeks</td>
</tr>
<tr>
<td>Students in participating instructors’ college algebra classes (6)</td>
<td>Electronic Survey</td>
<td>November 2018 and March/April 2019</td>
<td>• Identify Students’ academic &amp; institutional goals (RQ1a)</td>
<td>15-20 minutes</td>
</tr>
<tr>
<td>Students in participating instructors’ college algebra classes (4)</td>
<td>Individual and Focus Group Interview</td>
<td>May 2019</td>
<td>• Specific perceptions (RQ1a, RQ1b)</td>
<td>60-90 minutes</td>
</tr>
<tr>
<td>Administrators (3)</td>
<td>In-Person Interview</td>
<td>December 2018 and February 2019</td>
<td>• Understand admin viewpoint (RQ1a, RQ1b)</td>
<td>60-90 minutes</td>
</tr>
</tbody>
</table>
Administrator Interviews

Relevant college administrators were interviewed individually between December 2018 and February 2019. Administrators involved with the redesign were the Dean of Students of the College of Professional Studies, the Assistant Dean of Students of the College of Professional Studies, who was the mathematics department chair when this phase of the restructuring was put into motion, and another former mathematics department chair who now serves as an inclusive pedagogy instructional coach with the Department of Instructional Intervention and Support.

Classroom Observation

“As an outsider an observer will notice things that have become routine to the participants themselves, things that may lead to understanding the context” (Merriam & Tisdell, 2016, p. 139). For this reason, I conducted three classroom observations of the course sections I was allowed access to. My observation notes are akin to ethnographic field notes in that my goal was to create a written record of observations, experiences, and interactions that occurred (Emerson et al., 1995). I conducted the observations through equity and persistence lenses, paying particular attention to the manner in which activities pertain to the Gutiérrez’s (2009) and Tinto’s (1975) constructs previously explained. Table 3 lists the questions I used to guide my observation of each construct. The observation data allowed the triangulation of findings from surveys and interviews (Merriam & Tisdell, 2016), as well as provided a rich description of the setting in order to paint a picture of a typical day in each classroom.
Each classroom was arranged in three rows of ten seats each, with an aisle splitting the seats in half. Each seat was equipped with a computer monitor, keyboard, and mouse. There was a whiteboard at the front of the classroom, and a computer for the instructor on a desk in the corner. During lectures, students would balance their notebooks on the minimal table space and peer over their computer monitors at the board, alternating between paying attention to the lecture and working on individual online homework assignments. Corequisite lab sessions were held in the same classroom, and students would work independently at these computer workstations while instructors would walk around the room answering questions as needing.

Table 3

*Questions to guide classroom observation for equity and persistence constructs*

<table>
<thead>
<tr>
<th>Equity Construct</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>Who participates and how?</td>
</tr>
<tr>
<td></td>
<td>Who asks/answers questions?</td>
</tr>
<tr>
<td></td>
<td>What resources are available to students during class?</td>
</tr>
<tr>
<td>Achievement</td>
<td>What types of feedback do students receive?</td>
</tr>
<tr>
<td>Power</td>
<td>Who is speaking?</td>
</tr>
<tr>
<td></td>
<td>Who is the authority for correctness?</td>
</tr>
<tr>
<td></td>
<td>How do students know when they are correct?</td>
</tr>
<tr>
<td></td>
<td>To whom do students refer when they are stuck?</td>
</tr>
<tr>
<td>Identity</td>
<td>How do students present themselves during class?</td>
</tr>
<tr>
<td></td>
<td>What do students do during class?</td>
</tr>
<tr>
<td>Social Integration</td>
<td>How do students interact with each other?</td>
</tr>
<tr>
<td></td>
<td>Do students work together or alone?</td>
</tr>
<tr>
<td>Academic Integration</td>
<td>Do students appear to be motivated to learn?</td>
</tr>
<tr>
<td></td>
<td>Do students appear to be motivated by teacher feedback?</td>
</tr>
<tr>
<td></td>
<td>Student feedback?</td>
</tr>
<tr>
<td></td>
<td>How do students act when they ‘get’ a concept?</td>
</tr>
</tbody>
</table>


Data Analysis

I utilized Jonassen and Rohrer-Murphy’s (1999) 6-step process to apply activity theory for data analysis, as described below.

*Step 1: Clarify the purpose of the activity system.* This step is used to describe the motives and conscious goals of the activity system. The broader context within which the activities occur is specified, guiding construction of the problem space. Motivations for the activity and interpretations of any perceived contradictions begin to be understood and articulated.

*Step 2: Analyze the activity system.* During this step, we define in depth the subject, object, community, division of labor, and rules. This process describes how subjects view their roles and beliefs within the system, how objects meet the goals of the system, the structure of social interactions within the community, the norms that influence the system, and the division of labor that mediates between the community and object.

*Step 3: Analyze the activity structure.* Here we outline the hierarchy of activity, concrete actions, and automatized operations. This step describes the interrelationships of thinking focused on the object while purposefully including an understanding of the intentionality of the actions and operations.

*Step 4: Analyze tools and mediators.* The purpose of this step is to elucidate the instruments, rules, and division of labor that mediate and constrain activity, actions and operations.

*Step 5: Analyze the context.* To analyze the context, we describe the subject-driven (internal) and community-driving (external) contextual bounds. This step defines
the larger activity systems (context) within which activity is bounded, including the assumptions and beliefs held by the subject, as well as the rules and structures held by the larger community. The aim is to describe ‘how things get done’ within the broader context.

Step 6: Analyze activity system dynamics. The final step is to ‘zoom out’ from the activity system to describe and assess how the components affect each other. This provides a description of the dynamics within and between neighboring activity systems over time, identifying catalysts of change and their influence on the activity system.

To realize steps 1 through 5, I began with an inductive open-coding method on the survey results to identify preliminary codes and themes as well as further areas to investigate during interviews. Next I used NVivo 12 to store the interview transcripts and continue inductive coding. I then utilized a more deductive coding process to apply the equity constructs to interview and survey data and identified new themes as they arose using a constant-comparative method (Corbin & Strauss, 2008). For example, I coded survey responses and transcripts broadly as to the activity system components (subject, rules, division of labor, etc.), and then I identified more specific themes within each of the components, such as the code ‘beliefs’ within the subject component. The ‘beliefs’ code was refined further to indicate data regarding ‘beliefs about teaching and learning’ and ‘beliefs about students.’ Similarly, the larger code ‘goals’ was refined to indicate ‘goals for students’ and ‘goals for self.’ Table 4 below shows a sample of the codes and themes used, and Appendix F contains a full list of codes and themes, as well as tables detailing the five steps. I used my classroom observation notes to triangulate survey and interview data, particularly in relation to how instructors described their classroom
(‘beliefs about teaching and learning’) and the equity construct codes pertaining to
identity and power.

**Table 4**

*Sample of codes and themes*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Motives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Students continue college program</em></td>
</tr>
<tr>
<td><strong>Goals for Students</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Students acquire dev math skills needed for College Algebra (CA)</td>
</tr>
<tr>
<td></td>
<td>• Students successfully complete CA</td>
</tr>
<tr>
<td></td>
<td>• Higher graduation rates</td>
</tr>
<tr>
<td></td>
<td>• Close equity gaps through fewer courses</td>
</tr>
<tr>
<td><strong>Goals for Self</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Maintain Employment</td>
</tr>
<tr>
<td><strong>Beliefs</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• About students</td>
</tr>
<tr>
<td></td>
<td>• Teaching and Learning</td>
</tr>
</tbody>
</table>

Steps one through five were completed for both the instructor and administrator
activity systems separately. I then applied Step 6 to analyze the dynamics of the systems
separately and how they interact with each other. At this stage I was able to elucidate the
contradictions. The manuscript in Chapter IV provides further information on how this
was completed as part of data analysis.

In this chapter I described the research methodology of my dissertation study. The
remaining chapters detail the results and implications of the data analysis. Chapter IV is a
full description of LCC’s developmental redesign and the contradictions resulting within
and between the administrator and instructor activity systems. In Chapter V, I elaborate
on the implications of these contradictions. Chapter VI is a final discussion of the entire
dissertation work.
CHAPTER IV

INSTRUCTORS' AND ADMINISTRATORS' EXPERIENCES: PERSPECTIVES FROM THE OTHER SIDE OF DEVELOPMENTAL MATHEMATICS REFORM

Introduction

Owing to years of open enrollment policies and low tuition rates, developmental mathematics programs have become a staple at community colleges. Although the goal of developmental programs is to provide access to education through remediating students’ perceived lack of content knowledge, developmental classes often end up acting as barriers rather than gateways to education. The growing body of research illuminating the downfalls of developmental math, in conjunction with increased political pressure has promoted a reform movement in mathematics departments nationwide. Although integral to the reform movements, instructor and administrator perspectives are often absent from the discourse. This paper gives voice to those perspectives through one community college’s reform efforts.

Background

Nearly 44% of all incoming undergraduates each year are told that they are underprepared for college-level mathematics and must complete some number of pre-college level (remedial) courses before they can fulfill their college mathematics
requirement (Bailey et al., 2015; Blair et al., 2018; Scott-Clayton, 2012). As a result, developmental mathematics programs have become a staple at community colleges in order to remediate students in preparation to take college-level courses. Unfortunately, many of these students never make it into, let alone through, the college-level mathematics courses required for their academic major. Rather than progressing through the developmental sequence as intended and gaining the preparation for college-level courses that they have been told they are lacking, students become discouraged and are caught in a cycle of enrollment and failure in non-credit courses (Larnell, 2017). Roughly half of all students required to begin college in developmental mathematics do not successfully make it into the first relevant college-level course, and those who do make it into that college-level course are less likely than their peers to pass (Bailey et al., 2010; Snyder et al., 2018).

Given these lackluster results, it is clear developmental mathematics is not working as intended. Considering the student population at community colleges is predominantly underrepresented groups (Mesa, Wladis, & Watkins, 2014; Snyder et al., 2018), and these same populations are disproportionately to developmental education (Bailey et al., 2015; Engstrom & Tinto, 2008; Mesa, Wladis, & Watkins, 2014), the numbers point to more than just a failure of developmental mathematics, but also an issue of equity. Students who are female, Black, Hispanic, or part-time all tend to be placed into a greater number of developmental mathematics courses than their counterparts (Bailey et al., 2010). Further, students who are male, Black, or part-time have a lower probability of successfully progressing through the sequence of developmental courses than do those who are female, white, or full-time (Bailey et al., 2010). Even more, Black
students who are placed three or more levels below college-level have a particularly high risk of exiting the sequence before completion (Bailey et al., 2010). Inequities such as these in educational outcomes are a problem of institutional performance calling for remediation of practices (Felix et al., 2015).

In response to the ineffectiveness of developmental mathematics, many institutions have begun program changes and redesigns in an effort to better serve all students. Some institutions have focused on placement issues by implementing multiple measures of placement assessment (high school performance characteristics and non-cognitive measures of motivation, commitment, or perception of abilities), using diagnostic testing rather than adaptive testing, or employing early assessment or transition programs which provide assessment to students while still in high school, allowing them to work on building college-readiness before college enrollment (Zachry Rutschow, 2019). The effects of these efforts on student success outcomes are mixed. The use of multiple placement measures, particularly high school performance characteristics, does increase the accuracy of developmental placement (Belfield & Crosta, 2012; Hodara et al., 2012), and students who complete early assessment programs tended to have a higher likelihood of being placed in college-level rather than developmental courses. However, the higher placement did not necessarily translate into higher college-level completion rates (Kane et al., 2018; Mokher et al., 2018; Trimble et al., 2017). Further, although the research regarding the overall effects of diagnostic testing on student success is limited, this testing appears to be more effective than adaptive testing at placing students for successful completion (Zachry Rutschow, 2019).
Other institutions have undertaken changes in the structure and sequencing of courses in order to accelerate students’ time of completion through models such as bridge courses, compression of developmental courses, or corequisite remediation. The goal of bridge courses and non-course-based options is for students to strengthen their skills and retake placement exams to place into college-level or higher-level developmental courses (Zachry Rutschow, 2019). Generally offered before students begin at the college or as extracurricular activities during the school year, bridge programs have shown mixed results in differing academic settings and warrant further study (Barnett et al., 2012; Murphy et al., 2010). Compression of developmental courses, in which two developmental courses or one developmental and one college-level course are condensed into one semester have shown promising trends of higher success than traditional developmental courses (Cafarella, 2016a; Cafarella, 2016b; Jaggars et al., 2015; Sheldon & Durdella, 2009). Corequisite models allow students testing at the developmental level to enroll directly into college-level courses with added supports (Fair, 2017; Zachry Rutschow, 2019). The college level course may be paired with a tutoring workshop or a developmental course for extra support or stretched to meet for more days each week or over two semesters rather than one. Corequisite models have contributed to positive student outcomes in developmental mathematics courses at both the community college and university level, and they have shown to be a feasible solution to the problem of multiple semesters of remediation (Fair, 2017; Logue & Watanabe-Rose, 2014; Rodriguez, 2014).

Similar to much of the research detailing the success and failure of traditional developmental mathematics programs (e.g. Bailey et al., 2010; Engstrom & Tinto, 2008;
Larnell, 2017; Scott-Clayton, 2012), it is important to note that the effects of each of the previously detailed reforms were measured quantitatively in regard to student success outcomes such as developmental course completion, college-level course enrollment and completion, college-level credits earned, and graduation rates. Relatively little research exists regarding other aspects of developmental mathematics reform, especially research detailing the experiences of the individuals involved. More importantly, the experiences of instructors and administrators are notably absent in the literature, although both are integral to program design and student success.

This qualitative case study sought to contribute to the small body of qualitative research regarding developmental mathematics reform by providing an account of one community college’s redesign of mathematics courses to replace the sequence of developmental mathematics courses leading to college algebra. Specifically, this study aims to answer the research question: What are the experiences of administrators and instructors during a redesign of the developmental mathematics program at an urban community college, and what tensions and contradictions exist within and between the experiences of these two distinct groups?

**Theoretical Perspective**

This study used activity theory as an overarching theoretical perspective to the study design and data analysis to describe the experiences that precipitated and arose from the activity of program change. Activity theory allows for the consideration of multiple actors and the activities they undertake, providing a tool to interpret the interplay between those actors and their activities. It “focuses on the interaction of human activity
and consciousness (the human mind as whole) within its relevant environmental context” (Jonassen & Rohrer-Murphy, 1999, p. 62).

Activity theory stems from Vygotsky’s model of mediated act, wherein the direct connection between a stimulus and its response are mediated through some act or artifact (Vygotsky, 1978). Leont’ev (1979) built on this concept, describing activity as a goal-directed hierarchy of actions used to accomplish an object. Activity is encouraged by motive, which is the driving force for the activity and actions. The basic components of activity, actions, translate this motive into reality in service of a goal. Actions are then carried out through operations that are associated with the conditions under which actions take place. Leont’ev’s (1979) view of activity focuses on the complex interactions between the individual and the community, explaining the difference between individual action and the collective activity system.

Activity theory as used in this study was articulated by Engeström (2015) who built onto the earlier ideas of Leont’ev. Different from earlier models, the unit of analysis in Engeström’s model is the entire activity system, which integrates the subject, object, and instruments (tools and signs) into a unified whole, giving context to individual events. The activity system changes by adapting to tensions or contradictions occurring within system components, between components, between neighboring activity systems, or between the object/motive pair of the central activity and the corresponding object/motive pair of a more advanced form of the same central activity (Engeström, 1993; Engeström, 2015). Figure 3 shows a model of an activity system wherein double-tipped arrows connect each pair of components to denote that components are held in
tension with each other and cause reconstruction of the system. The system reconstructs itself through adapting to contradictions and changes within the existing tensions (Engeström, 2015).

**Figure 3**

*Human Activity System (Engeström, 2015)*

In the model, the *subject* indicates the subgroup or individual whose agency defines the point of view of the activity system. In this study there are two activity systems anchored with two different subjects: instructors and administrators. The *object* (student success in college algebra) indicates the raw material or problem space at which the activity is directed, which is transformed into *outcomes* through the assistance of physical and symbolic *tools* (resources available to promote student success). The *community* is made up of all individuals and subgroups sharing the same general object. *Division of labor* occurs both horizontally as a division of tasks between the members of the community and through the vertical division of power and status, mediating between the community and the object by providing the power structure for accomplishing the
object. The *rules* refer to the implicit and explicit regulations and conventions that constrain actions and interactions within the activity system.

**Setting, Participants, and Data Sources**

**Setting**

Lowry Community College (LCC; a pseudonym) is an associate degree granting college located in a large urban area in the Rocky Mountain region of the United States. The college is part of a statewide community college system which oversees and coordinates academic and career and technical programs of 13 unique colleges. As of Fall 2018, LCC has an annual enrollment of nearly 8,000 students, 82% of whom attend part-time, and its Hispanic population of 31.6% has earned the school the Hispanic Serving Institution designation from the Hispanic Association of Colleges and Universities. The ethnic make-up of the remaining students is 1.9% American Indian/Alaskan Native, 8.6% Asian/Pacific Islander, 20.1% Black, 31.0% White Non-Hispanic, and 6.8% Unknown/Not Reported.

Over the past decade, LCC has worked to better ensure success for students getting into and getting through college algebra, the college-level math course of choice for a large percentage of students and one in which prior institutional review revealed equity gaps. The mathematics department has taken to regular review and revision of the college algebra course for content and relevance, undergoing three phases of revision prior to the current overhaul. Those phases appear in Table 5.

---

5 Demographic information retrieved from the college’s public web page
Table 5

Prior Phases of Developmental Math and College Algebra Revision

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Collaboration between all 13 colleges within the community college system to transition from four different developmental mathematics courses into only two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 2</td>
<td>Support labs required for all students in both of the developmental courses, as well as for college algebra students with placement exam scores below a certain threshold</td>
</tr>
<tr>
<td>Phase 3</td>
<td>Restructuring of college algebra course to include a modeling approach for non-STEM students</td>
</tr>
</tbody>
</table>

Prior to 2018, when the current redesign began, the developmental mathematics program at LCC consisted of two non-credit bearing developmental courses, Algebraic Literacy and Quantitative Literacy, which were prerequisites to either college algebra or a quantitative reasoning course. According to Mark (a pseudonym), a study participant and former mathematics instructor and department chair, LCC students were still struggling to complete their developmental courses and the department had noticed a disconnect between placement exam scores and student outcomes, similar to what is reported in the published research (e.g., Bailey et al., 2015; Fay et al., 2013; Larnell, 2017). In Fall 2018, LCC began a fourth phase of reform, adopting a pathways model of program design following Bailey et al.’s (2015) suggestions, as well as a corequisite model for college algebra and a condensed developmental course utilizing a flipped classroom model. This phase is the focus of this study and the details are explained further in this paper following the Analysis section.

As part of the pathways model, students enrolled at LCC are now able to fulfill their college-level mathematics requirement with one of three courses: a course in quantitative reasoning, a course in statistics, or college algebra, based on the educational
path of choice. College algebra remains the college-level mathematics course of choice for both STEM and non-STEM students, and the course has been redesigned again to include both the corequisite lab as in the past, as well as a condensed introduction to the developmental concepts most necessary for success in college algebra. The new model allows students to complete developmental mathematics credits and college algebra in a single semester. The details of this redesign are explained further after the Analysis section.

**Participants and Data Sources**

I invited select administrators and all full-time and part-time mathematics instructors (n=40) at Lowry Community College to participate in this study. I first contacted instructors by email during early fall 2018 and asked them to complete electronic surveys regarding their experience teaching at LCC during this redesign process. Survey and interview questions are available in Appendices C and D. At the end of the survey, instructors were asked to participate further through interviews and classroom observations. I contacted instructors by email again in early 2019 and directly asked them to participate by interview and classroom observation. Two instructors replied agreeably, and through interaction with them during observations, I met other instructors willing to participate. Information about the participating instructors is located in Table 6.
Table 6

Instructor Participants (all names are pseudonyms)

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Level</th>
<th>Status</th>
<th>Years at LCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td>College and Developmental</td>
<td>Part-Time</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Josh</td>
<td>College</td>
<td>Full-Time</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Pam</td>
<td>Developmental</td>
<td>Part-Time</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Vera</td>
<td>Developmental</td>
<td>Full-Time</td>
<td>&gt;15</td>
</tr>
</tbody>
</table>

I also conducted interviews with three administrators who were part of the course redesign. I first learned of the redesign from Gustavo (pseudonym), the Dean of Academic Affairs for the School of Professional Studies and Sciences. He oversees the mathematics department, and as the supervisor of the department chair, he participates in hiring and training instructors and scheduling courses. Mark (pseudonym) is a former mathematics instructor and 12-year department chair currently working as an inclusive pedagogy instructional coach at LCC. He was part of the previous college algebra and developmental course reforms and provided valuable insight into the program leading up to the most recent changes, which he was not involved with due to a sabbatical and his current position. Tony (pseudonym) is also a former mathematics instructor and former department chair, and he was instrumental in LCC’s move to replace developmental courses with corequisite support. His current position as the Assistant Dean of Academic Affairs in the School of Professional Studies and Sciences requires that he remain a part of the reform process, but he has since taken on a less active role within the mathematics department.

Individual interviews with instructors and administrators served as the main data sources. The use of interviews to elicit experiences from different perspectives is
appropriate for this study because “the purpose of interviewing, then, is to allow us to enter into the other person’s perspective” (Patton, 2015, p. 426). A semi-structured interview format was used in order to allow for flexibility in participant responses and for new ideas to arise (Merriam & Tisdell, 2016). Interviews lasted between 45 and 80 minutes, and participants were asked to describe their perceptions of the positive and negative aspects of traditional developmental mathematics as well as how they perceived this reform would affect students and themselves. (See Appendix D for a full list of interview questions.) All interviews were video- and audio-recorded, and transcripts were used for analysis.

Secondary data sources included interview notes, survey results, artifacts such as classroom handouts and syllabi, and classroom observations. Classroom observations were used to better understand the setting and a typical day in each class. Observation notes were akin to ethnographic field notes in that the goal was to create a written record of observations, experiences, and interactions that occur during the class time (Emerson et al., 1995). These secondary data were used to triangulate the interview findings (Merriam & Tisdell, 2016) and to provide a more comprehensive description of the phenomena and experiences.

**Analysis**

In this study, the process of course reform was viewed as a set of interconnected activities, each activity grounded in the perspective of a different stakeholder, namely the instructor perspective and the administrator perspective. The activity systems were characterized following Jonassen and Rohrer-Murphy’s (1999) six-step process for applying activity theory, outlined in Table 7.
### Table 7

*Six Step Process to Apply Activity Theory (Jonassen & Rohrer-Murphy, 1999)*

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Clarify the purpose of the activity system, describing conscious motives and goals of the activity system.</td>
</tr>
<tr>
<td>2</td>
<td>Analyze the activity system through defining and describing the subject, object, community, division of labor, and rules.</td>
</tr>
<tr>
<td>3</td>
<td>Analyze the activity structure by attending to the hierarchy of activity, concrete actions, and automatized operations.</td>
</tr>
<tr>
<td>4</td>
<td>Analyze tools and mediators, elucidating the instruments, rules, and division of labor that mediate and constrain the activity and operations.</td>
</tr>
<tr>
<td>5</td>
<td>Analyze the context through describing the internal and external contextual bounds.</td>
</tr>
<tr>
<td>6</td>
<td>Analyze activity system dynamics by assessing how the components affect each other within and between neighboring activity systems.</td>
</tr>
</tbody>
</table>

The first five steps were realized through an inductive open-coding method on the instructor survey results to identify preliminary codes and themes as well as further areas to investigate during interviews. The inductive coding was then continued with interview transcripts data, followed by a more deductive coding phase using a constant-comparative method, and new themes were identified as they arose (Corbin & Strauss, 2008). For example, survey responses and transcripts were coded broadly at first as to the activity system components (subject, rules, division of labor, etc.), and then themes were
identified within the component codes such as the specific beliefs, motives, and goals held by instructors. Pam’s interview statement “And so I’m not one of those teachers that likes the flipped class where the students learn it by themselves. I just feel like instruction is what they need and what they soak in the best” was coded under ‘Beliefs of Teaching and Learning.’ Classroom observation notes were used to triangulate the survey and interview data. This process identified the initial instructor and administrator activity systems, shown in Table 7 and described further below in the Results Section. Prior to discussing the activity systems, I first set the stage by describing the design of the reform at LCC as it is captured in the interview data.

**Design of the Reform**

Similar to many other reports in the published literature (e.g. Bailey et al., 2015; Mesa, Wladis, & Watkins, 2014), many of the students at LCC who were placed in developmental courses were not successfully completing those courses or college algebra, despite the reforms that had already occurred (Felix et al., 2015). Further, according to Mark, after the prior move from four developmental courses to two courses, Black and Latinx students continued to be placed disproportionally in developmental courses and were less likely than their white classmates to be successful.

In addition, since the move from four developmental courses to two courses, three participants (Vera, Tony, and Gustavo) mentioned during interviews they had heard talk among administrators and faculty that the state department of higher education or state legislature may soon move to prohibit colleges from requiring students to take non-credit bearing courses, as had previously happened in Florida (Park et al., 2018). As the
department head transitioning to an administrative position, Tony wanted to get in front of the ball:

Attending national conferences, hearing what was going on in California – what also is being legislated in Florida, Tennessee, Georgia – I saw the writing on the wall and was like, hey, everyone, do we want to be a part of this at the end or do we want to design it ourselves?

Rather than waiting for a directive to come from the state, Tony suggested that LCC begin working on their own solution, tailor-made to their unique situation, and with the advantage of time to work out problems. This way, in the event “something does become legislated…we can come back and say, we’re already doing that.” He approached the math department and assembled a team of volunteers representing part-time, full-time, college-level, and developmental mathematics faculty to design something to work best for LCC. According to Mark, the mathematics department had been using a variation of corequisite support in developmental and college-level math courses for a few years and were seeing positive results, so it seemed natural that a next step of reform would continue to utilize corequisite support.

Some instructors were hesitant about the change, especially if change meant fully going away from developmental courses. In Pam’s experience, “there are some students who need it in order to then be successful in college algebra” and beyond. Vera was adamant that the group design something that could still really help our students where they needed to be helped, i.e., in the dev ed, to the best of our ability. Because the reason apparently the state wants to get rid of it [developmental courses] is because they didn’t want them doing, you know, dev ed and taking so long, so they want them through [a college math course] in one semester… So what could we do to still do the best by our students and help them out, and get them through?
A major concern for instructors, particularly Vera and Pam, was that students may be able to get through the course in one semester, but they may not have as strong of an understanding as if they had completed a full sequence in developmental courses. For this reason, the design team decided to incorporate developmental content into an intensive on-boarding course at the beginning of the semester containing the topics they felt were the most important for a student’s success later in college algebra.

The result of the reform committee’s work is the following solution: There are now three placement options for students taking college algebra, dependent upon placement test score. Students who score high enough enroll in a 15-week college algebra course. Students scoring at the next threshold enroll in a 15-week college algebra course with a mandatory corequisite lab which meets for one hour directly before or directly after the two-hour math class. Students scoring below this threshold are required to take a 5-week on-boarding course followed by a 10-week college algebra course with mandatory corequisite. The onboarding course meets for three hours, three times each week, for five weeks. In week 6, those three hours of math are separated into two hours for the college algebra class and one hour for the corequisite lab. Students who do not satisfactorily complete the onboarding course finish the semester in a parachute course which provides an extended amount of time to work up to college algebra.

In order to best utilize the short amount of time during the onboarding course, the team designed a set of self-paced modules within Pearson’s MyLab™ Math (MML) for students to complete, including tests and quizzes. Instructors are expected to ‘conference’ personally with each student during every class period in order to assess their progress, in relation to both content understanding and the course expectations, and to determine
students’ course of action. For example, a student may think they are ready to move on to the next module, even though they have not fully completed the current module. The conferencing allows the student an opportunity to make their case for taking the test early in order to move on more quickly. Students work toward mastery of the content and are allowed as many attempts as needed (as time allows) to complete the modules. Due to limitations in the school’s online learning management system, students must be ‘graded’ on their progress with the content, but this grade neither affects their ability to move forward, nor is recorded on their transcripts. At the end of the five weeks, the student and instructor meet to determine whether they both believe the student should continue onto the college algebra course or enroll in the parachute course. This final counseling and decision to move on are discussed further within the Results Section.

Results

As noted in the Analysis Section, Jonassen and Rohrer-Murphy’s (1999) first five steps were used to construct an initial activity system from both the instructor and administrator perspectives. I summarize the key ideas of these perspectives under each component of the Activity Theory constructs in Table 8 below.
### Table 8

**Instructor and Administrator Activity Systems Resulting from Current Reform**

<table>
<thead>
<tr>
<th>Component</th>
<th>Instructor Perspective</th>
<th>Administrator Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object</td>
<td>Student success in college algebra</td>
<td>Student success in college program</td>
</tr>
<tr>
<td>Subject</td>
<td>Developmental and college-level math instructors</td>
<td>Relevant college administrators</td>
</tr>
</tbody>
</table>
| **Motives and Goals** | • Ensure students are able to continue their college education  
|                 | • Ensure students pass with understanding                                                | • Ensure students are successful in their programs of study |
|                 | • Maintain employment                                                                   | • Improve graduation and transfer rates              |
| Beliefs         | • Success in college algebra translates to success in further courses                   | • Students are more successful when they can complete |
|                 | • Instructor-specific beliefs about teaching and learning                                | requirements more quickly                            |
|                 | • Students need developmental math to do college algebra                                 | • Research-based programs can be implemented at LCC  |
| Community       | • Full- and part-time instructors at LCC                                               | • Schoolwide group of deans and administrators       |
|                 | • Administrators                                                                        | • Math instructors                                   |
|                 | • Professional memberships                                                              | • College system Board of Directors and other college administrators |
| Division of Labor| • Developmental and college algebra instructors work together to ensure student success | • Statewide program personnel and directors          |
|                 | • Administrators make decisions and expect faculty to make changes                      | • Administrators tell faculty what changes need to be made, and |
|                 | • Developmental instructors not considered qualified to teach college algebra           |   faculty enact those changes                        |
| Rules           | • Instructors have autonomy within their own classrooms, but all sections take a        | • Administrators secure professional development opportunities for |
|                 |   written common final exam                                                             |   faculty                                           |
|                 | • Guidelines for teaching onboarding course                                            | • Instructors have autonomy                          |
|                 | • Expectations for corequisite course                                                  | • Instructor ‘conferencing’ during onboarding course |
|                 | • Students placed via placement exam                                                   | • Corequisite course should not be a ‘glorified study hall’ during |
| Tools           | • Suggested course syllabus and required content                                        |   which students simply work on homework and get help |
|                 | • Textbook, including access to Pearson’s MyLab™ Math for instructors and students     | • Research and evidence from other institutions      |
|                 | • Complete assignment sets in MML for each section                                      | • Institutional data                                 |
|                 | • Department-specific and college-wide professional development and training            |                                                    |
|                 | • Technology resources                                                                  |                                                    |
The final step in the analysis is to ‘zoom out’ from the activity system to describe and assess how the components affect each other. This provides a description of the dynamics within and between neighboring activity systems over time, identifying the contradictions and tensions that act as catalysts of change, and describing their potential influence on the activity system. In the next section, I report these tensions and contradictions.

**Tensions and Contradictions**

**Within the Instructor System**

**Between Instructors**

Within the subject component of the Instructor system, the change has caused tension between instructors, especially those who teach developmental mathematics. A state law requires that college-level instructors possess either a master’s degree in math or at least 18 credits of graduate level mathematics (Higher Learning Commission, 2016). Traditionally, instructors lacking this qualification have been the primary instructors of developmental level courses, and most have been able to work nearly full-time due to the number of developmental courses taught each semester. With the new program, the only courses available for these instructors to teach are the 5-week onboarding course and the corequisite lab. Both of these options cause time constraint issues: the former because it meets for three hours on three days per week, but only for five weeks, and the latter because the labs only count for one credit hour but meet three times per week. By design, each of the college algebra classes feeds two different corequisite labs, and one of the lab instructors participates as an assistant during the college algebra class. The instructor
must be in attendance for the two-hour class, three times each week, but since this is only an assistant position the instructor is paid at a lower rate.

*Pam:* It took away a lot of our opportunities to teach classes. Um, because you know, the [prior developmental classes] were five credit hours. So you could teach two of those and get 10 credits, and now you teach for the first five weeks of class and you get three credits a class. Actually, I work more hours and more days now for less hours and money because after the first five weeks, so now we work three days a week instead of two days a week… And then for example, now like in the middle of the day, I have two hours [when I have nothing to do until my second lab]. I work a full extra day than I used to and struggle now to get my credits and my hours for my health insurance.

Vera agreed this is an issue and is unhappy that the part-time developmental instructors have been relegated to what amounts to a teaching assistant position. As the only full-time developmental instructor, Vera has worked with many of the others, noting

we have several amazing, amazing, adjunct dev ed teachers who can't at this point – or not that can’t, they absolutely can teach the other stuff as well as anybody, but are not allowed to. And we don't want to lose them. (emphasis added)

The compromise to continue offering some developmental instruction, however limited, was as important to keeping instructors as it was to prepare students. According to Vera, the question of the design was “two-pronged: how to take care of our students *and* how to take care of our teachers.”

Not only is this tension within the instructor subject component, owing to the structure of the activity system, it is also a contradiction occurring between the subject and the division of labor. Left unchecked, this tension could lead to feelings of animosity between instructors or toward the individuals who advocated for the reform, as well as feelings of being excluded or undervalued. The issue is not one that will likely fade away quietly, but the tensions could be viewed as a driver of change, leading to policy changes at the college and possibly state levels. For example, the college might reevaluate the pay
structure for the corequisite labs in order to better compensate instructors for their time and efforts. Even more, as LCC is likely not the only institution facing an over-abundance of instructors with fewer than 18 credits, the statewide system might be encouraged to advocate with the Higher Learning Commission for a reevaluation of the 18-credit requirement.

**Beliefs About Teaching and Learning**

A related tension within the subject component is the result of vastly different beliefs about teaching and learning held by the different instructors. The prior culture of instructor autonomy allowed these different beliefs to live in harmony, a kind of ‘you do your thing, I’ll do mine’ understanding. Administration, though invested in instructors and student success, kept a hands-off approach in regard to the day-to-day classroom happenings. However, when the on-boarding course was designed and implemented in the first semester, administrators felt that in order to maximize students’ in-class time, they should adopt a type of flipped model class in which students would do work outside of class, for example watching videos and attempting problems, in order to prepare for class-time spent working on different problems and projects with other students and the instructor. The choice to use MyLab™ Math (MML) modules for the content was also made at the administrative level.

Although Vera had experience with this type of classroom environment, she admits that some of the other instructors were not as comfortable. Their hesitancy with the model actually led to revisions after the first semester, and they regained some of their autonomy.
Vera: I still run mine very much like a flipped classroom just like I did before [prior to any reforms], which was actually way more successful than anytime I did a traditional lecture class. But other teachers, uh, have gone much more back to what they’re more comfortable with. So mine is much more chaotic. It's controlled chaos and it's much more self-paced. Whereas other teachers, even though everybody still uses MML and all that stuff, and all the quizzes and homework and tests are on MML, they will do traditional lectures and keep everybody together and that kind of stuff.

Amy noticed this discomfort during the training instructors received for the onboarding class:

A lot of the other instructors said, “But when are we going to teach?” so it was basically not really understanding, kind of the idea of a flipped classroom. So they kept asking, and they [administrators] would say ‘you’re going to talk with your students, and check their progress in MML, and if you need to go over something as a class you can, but they’ve got all these tools in MML that they need to be looking at before they come to class.’

This belief of teaching, wherein the teacher is the authority and must first tell students how to do something is evident in both the developmental and college-level teachers. As Josh put it:

I'm a very boring teacher. You know, like what you imagine, a very traditional college math class to be, is really what my class is. I go up to the board, I talk, talk, talk, and I write, write, write, and they write, write, write, and then that's it. You know, we don't really do fun games or activities or like that. But I guess to maybe put it in a better light, I would say it's kind of the, 'I do, we do, you do model.' I'm like, this is how you do it. Okay, now walk me through it. And then now, you try by yourself. And that's really just kind of a typical class.

Josh’s college algebra class was very much a lecture-style math class. He would lecture for most of the two-hour class, asking students to participate throughout and answering questions as they came up. During the one-hour lab, he would walk around the room to answer more specific questions and provide one-on-one help as students worked on their homework.
Although it seems that Josh’s belief stems from the way he has experienced math classes and learns himself, Pam’s belief comes from her experience teaching lower level courses.

I've always had a struggle with feeling like students at that level of math [below college-level] can learn it by themselves, um, watching a video without being able to ask their questions. And so I'm not one of those teachers that likes the flipped class where the students learn it by themselves. I just feel like instruction is what they need and what they soak in the best.

When she was following the directive that students work at their own pace utilizing the videos and other tools built into MML, Pam struggled with the chaotic nature resulting from such a wide range of sections and questions that students could be working on during any given day in class. She felt that her onboarding course went much better during the second semester when she was allowed to keep students on the same modules each day by teaching a lesson first before expecting students to attempt problems on their own.

Amy’s beliefs and teaching style were opposite to this. As she put it, “I don’t think lectures are super effective, so I try and limit it, but I think students like having them.” Although she would often start her college algebra class with a short lecture, hers was usually designed to clear up ideas that students had already been working with or to practice examples together. After the lecture, which was at most 30 minutes out of the two-hour class, students would work together on group quizzes or problem sets designed to help them learn and understand the concepts before moving on to the homework assignments. During class time, students would be actively doing mathematics, while Amy and her teaching assistant circulated the classroom to answer questions and provide feedback on class progress. Once students completed the required in-class assignments,
they were allowed to leave early but were encouraged to remain in the classroom in order to work on outstanding homework assignments with assistance available. Amy’s class structure remained true to her belief that mathematics is learned through doing, rather than watching.

As a driver of change within the activity system, when instructors were given autonomy over the structure of the onboarding course, this tension forced the system to adapt from its original design, in which all instructors utilized a student-centered classroom model. This change in particular may not have occurred as quickly if instructors had been provided specialized training and resources in how to implement the flipped-style teaching model expected in the onboarding course. Instead, it seems instructors were expected to discover the model themselves, and when they felt uncomfortable teaching in that environment, they were allowed to return to what they knew and felt competence with. Because this tension arose in part due to a lack of support, it is also visible as a contradiction between the instructors and the tools that were at their disposal. The contradiction indicates that instructors may hold a fixed mindset regarding their teaching, possibly believing that they are unable to change.

Moreover, this contradiction could promote change in the neighboring administrator activity system within their use of tools by provoking an evaluation of how and what resources are allocated for instructor professional development. This change has the potential to move both activity systems forward by then affecting instructor beliefs through professional development and training.
Between Instructors’ Goals for Students and Beliefs About Students

A third contradiction occurs as negative beliefs about students’ abilities held by instructors and administrators actually work against the desired outcome of the object in both systems. As mentioned previously, instructors were concerned that students may be able to pass the college algebra with corequisite support, but they may be lacking the foundation instructors believed students would have gained through completing one or more developmental courses. Josh’s concern with the redesign was influenced by his wife’s college experience, during which he says she “barely got through” the four developmental courses and college algebra she was required to take. “I tried to keep her educational needs that she had, you know, in the forefront of my mind. I was trying to [think about] how do we design it for students that really do need the extra time?”

Pam believes very strongly that students must be given the opportunity to take full developmental courses, because they really do need the instruction.

I think it’s so important to start at the very beginning with each concept as if they don’t know it, because there's so many [who] actually don’t, and I think the mistake maybe a lot of teachers make, or not a lot, but, is to assume students know things. They really don’t.

These beliefs about LCC students’ preparedness led the redesign committee to the unique corequisite design that was implemented. Many involved in the redesign were afraid that removing all structured developmental courses would set students up for failure in college algebra and beyond. The absolute belief that students referred to developmental math “don’t know things” (Pam) and that the only way they may possibly learn them is through stand-alone courses caused many to doubt the ability of the
corequisite course to successfully teach developmental course content. However well-intentioned this belief may be, Mark cautioned that this deficit model view is not best and needs to be examined:

[T]hat traditional point of view of thinking about students and what skills they don't have is often the wrong question. I think it's often more a question of students becoming refreshed. I think sometimes it's the case that the way students learn it is very different from the way you taught it... If the narrative we tell about students is that they don't know something, they lack, they don't have the skills, oftentimes that's just not true (emphasis added). It's that the way we're asking them to understand things doesn't match with the way they learned it. And often those are the students who have to bear that burden for what we don't know.

The resulting model, then, represents a contradiction with the outcome in that instructors’ and administrators’ negative beliefs directly influenced the design of the program meant to help students succeed. The ultimate outcome of the program redesign was to increase student success in college algebra through reforming the teaching of developmental mathematics; however, both instructors and administrators were hesitant to implement such change due to their static belief about students’ fixed abilities. Rather than assuming the best of students and their abilities, the corequisite model that was adopted continues to perpetuate a deficit view of students which may have further negative consequences on their college algebra success.

Tensions and Contradictions Between Activity Systems

Expectations Versus Implementation

A contradiction occurs between the administrative expectation of the corequisite course and the actual implementation of the course. Both Gustavo and Tony indicated that the corequisite course was intended to be used as academic support through just-in-
time remediation, as opposed to additional homework time. The course was expected to provide further teaching and practice of the skills and content necessary to fully understand college algebra, beyond homework questions. For example,

_Tony_: If we were going to be talking about radicals from that algebra point of view, we needed to really understand radicals from the arithmetic point of view. And because it was more of a just-in-time reminder, essentially, we would move through it a little bit faster than if I were teaching it for the first time.

As an instructor, Tony had noticed a number of concepts in college algebra that students needed additional time and practice with, and the intent of the course is to provide more projects and learning opportunities in these areas. Ideally, the corequisite course should be a combination of review, practice, and preview of upcoming content. Both Vera and Josh noted that administrators were adamant the course not be a ‘glorified study hall,’ and Josh was part of the team who designed content materials to be used during the corequisite class as learning resources.

In implementation, however, most sections of the course became primarily a study lab during which students worked on their MML homework and were able to ask questions. Although Josh did attempt to embrace the ‘no study hall’ rule during the first semester he taught the corequisite course, he had a change of heart as the semester continued, in particular because the resource material was not intended to be a specifically graded assignment.

Really the biggest I guess, complaint, that I got from students was: Can I just work on my homework and you can just help me if I have questions? Why are you giving me new stuff to do when I still have all this other homework to do?

According to Josh, the administrative “intention was, you know, we have tutoring services at all times on the campuses, so [students] can get that extra homework help
then, *outside* of class. You know, class time is used to really reinforce the ideas.” While he agrees with this idea in principle,

it's really just all about student needs, and you know, if they don't have time to go to the tutoring center, you know, they have husband, wife, kids, siblings, jobs, dogs, like all of their other classes, I need to be here to help them in whatever way is best.

Josh’s perception on how best to help his students is to answer their immediate questions on the homework problems, as those directly impact students’ overall understanding and success in college algebra. Amy, Pam, and Vera hold similar views toward the course, although each noted they often would supplement students’ study time with additional whole-class instruction or activities over concepts that were particularly troublesome for students, such as rationals, logarithms, and graphing.

It seems there are at least three possible outcomes of this contradiction in expectations: 1) instructors continue to facilitate the corequisite course as a study hall against administrative wishes, 2) administrators and reform design team change their expectations of the course to be an intentional study hall, or 3) administrators and instructors together use the contradiction to evaluate both the definition of a corequisite course and to examine the expectations of the college algebra course necessitating a structured lab time to complete homework. The first two outcomes have the same end result: college algebra expectations remain the same, and students, although they may be able to complete specific homework assignments and get through the course, may still lack understanding of the underlying concepts. Although the second would cause a minor reconstruction in the Administrator activity system, the first would leave the system unchanged.
The third possible outcome has potential for a more valuable system reconstruction. All of the instructors cited the large amount of required homework in the college algebra course as the leading reason that they provided the time for students to complete it. This begs the question whether such a high number of problems is truly necessary in order for students to demonstrate understanding. Moreover, it is likely that students have difficulty with the college algebra content (and problems) because they need help with the underlying concepts they traditionally may have acquired in a developmental course, not simply because outside obligations prevent them from completing homework assignments. Allowing this reconstruction to occur will result in a conscious review of the motives and pedagogical choices behind the college algebra course, as well as move LCC closer to a corequisite model in which instructors learn to embrace the corequisite course as an opportunity to provide instruction in developmental content.

**Role of the Onboarding Course**

Another tension occurs as a result of misinterpretation between expectations and implementation of the onboarding course. As previously described, the course is designed to be self-paced as students work their way through five MyLab™ Math modules on content drawn from developmental mathematics curriculum. The goal of the course is 80% mastery of the content in each of the modules; however, the decision to move on to college algebra is based upon additional factors, including the instructor’s observations of the student’s work ethic and motivation, the student’s own confidence in their ability, and even extenuating circumstances. The intent is that student and instructor would come to an agreement whether or not the student is ready to move on to college algebra,
somewhat regardless of whether the student has actually completed all of the modules. The rubric used to guide this decision intentionally leaves room for negotiation. For example, Vera described a student whose unexpected childcare challenges and broken-down car precluded her from being able to attend class during many days of the onboarding session. Although she had only completed two of the five modules, the work that she had completed was done well and both she and Vera were confident she would be able to get through the college algebra.

However, some of the onboarding instructors held the 80% mastery as a hard rule and barred students from continuing on to college algebra, requiring them instead to spend the remainder of the semester in the alternate ‘parachute class’ which was implemented as a second chance for students needing more than the five weeks to complete the developmental content. As the instructor of this parachute class, Vera encountered a handful of these students who she felt would have been successful in college algebra had they been allowed to move on. She was disappointed that this occurred and had already made plans to better train instructors for the next semester.

Reform Team Makeup

Another tension that arose was in regard to the selection of the participants in the design process. Pam was very disappointed that she was overlooked to participate, as she is invested in the students at LCC and desires to have her input valued. Speaking of the committee who led the reform, she said:

There was, I believe if I remember right, one dev ed teacher and the rest were all, either not even math teachers or a couple of upper level math teachers, which to me, you have to be down in the trenches for a few years at least to know where these students struggle, this is where they will be successful, and this is where they won't. I was not invited [to be on the committee], I think, ‘cause they kind of
had their idea of where they wanted to go with it, just wanted people on the committee who wanted to go that same exact direction… But you know what? I wasn't going to buck the system. I mean, I knew it was happening anyway. I just wanted my feedback heard along the way. If I’m going to be teaching a new class, I want to be part of the process of building that class.

As someone who had been active in curriculum decisions regularly over her 15 years at LCC, Pam felt she had been intentionally left out of this decision. This perceived rebuff exacerbated Pam’s resentment at the lack of available classes to teach in addition to being told how to teach. The other participants did not state their feelings on this topic explicitly, but it is likely that others of the developmental faculty feel similarly. Feeling excluded from participating in these program changes could lead instructors to feel even further undervalued and underappreciated. This tension underscores how important it is to involve faculty in program and curriculum decisions and could produce changes in the activity system through the next phase of the redesign. Although it is likely unreasonable to include all faculty on an initial planning team, faculty inclusion could occur through open dialogue and requests for participation and feedback throughout the redesign process.

**Discussion and Conclusions**

The purpose of this study was to describe the experiences of administrators and instructors as Lowry Community College underwent a redesign of its developmental mathematics. These experiences have been revealed through quotations and description throughout the paper as the story and analysis of the reform process from activity theory lens. In addition, a number of tensions and contradictions were exposed and identified as drivers of change.
Although the tensions and contradictions evident in the reconstructed activity systems evoke negative feelings and results, it is important to note that they arose out of only the first step of LCC’s developmental math redesign. As previously mentioned, this reform was undertaken proactively in order to best benefit the students and instructors at Lowry Community College, and those involved intend to refine and restructure the program until it truly is the best for the school. As with prior reform efforts, the stakeholders view this current reform as a fluid process which they must continue to evaluate and transform. The tensions and contradictions discussed in previous section provide a starting point for the transformation. Moreover, this activity theory analysis of tensions and contradictions proved a powerful tool in detecting and promoting possible changes to the activity systems. More broadly, the analysis provides a means through which the transformation may occur.

Regarding the contradiction between the corequisite expectations and implementation, further work must be focused on reconciling the intent of the corequisite course. All participants indicated concern that the fast pace of both the onboarding and college algebra courses might unintentionally be leaving students behind. No doubt the overwhelming amount of content and ‘fast’ pace of the onboarding course may contribute to raised anxiety levels for many students, before they even get into the college-level math course that they are likely anxious about already. In addition, Tony mentioned the redesign committee’s belief that LCC’s students are not ready for a full corequisite model (with no prerequisite onboarding, but corequisite support throughout an entire 15-week algebra course), so this current reform is a ‘stair-step’ to the full model. Perhaps a true corequisite model may serve students better, wherein more attention is paid during the
corequisite course to developing understanding of the needed skills and concepts, rather than quick access to tools to complete homework problems. Barring this move, instructors and administrators must work together to agree on a balance between honoring students’ desire for homework assistance and supporting students’ understanding of the concepts they may be lacking. Moreover, the college algebra course must be examined for content and relevance, including scrutiny of the quantity and frequency of required homework problems. Are homework expectations reasonable, or is the sheer quantity of problems the main driver of student stress?

The contradictions bring to light other questions about the purpose and design of the onboarding course. From its inception, it was designed to cover all of the most important developmental mathematics content that had previously taken two semesters (and before that, four semesters). Should students be required to complete every module before they are allowed to continue? What is the minimum number of modules needed to complete? How important is attendance at this stage? How should advising work? Are all of the problems for each topic really necessary? Although the intent of the course may appear to be clearly stated, many instructors had different understandings of how it was supposed to be actually implemented and used. The reform team would be wise to call on all of the prior instructors of the course to reexamine and restructure.

The tension between instructors’ beliefs of teaching and learning also must be addressed with openness and collaboration between instructors and administrators. Although they had found previously that some instructors were more effective than others,
Mark: Looking at individual course success rates, we could never correlate success rates, good success rates or bad, to sort of what the teacher was doing. Whether it'd be like a flipped class vs. a non-flipped, I mean, we just couldn't. And so, when I was chair, we took the approach of giving wide ability to teach as you want, but with the understanding that we paid attention to course success rates.

Instructors are valued for their knowledge and trusted to do their jobs well with minimal interference. It seems, however, that this has led to stagnation for instructors and discomfort when they were asked to teach in a manner that differed from their preferred style. In fact, instructors were given very little training on how to implement the flipped classroom model, which likely led to a large portion of that discomfort. In addition, there are few mathematics-specific professional development opportunities for instructors, so it is no wonder that instructors tend to have a fixed mindset in regard to their teaching.

More development opportunities including training in research-based practices should be implemented for all part-time and full-time faculty.

As with any research, there are certain limitations to this study. As an individual unaffiliated with LCC, I was unable to conduct research there without naming an employee there as an investigator. Gustavo filled this role in name only, and although I attempted to be clear of the measures I would take to protect confidentiality, I suspect fear of retaliation may have caused some instructors to refuse participation. It is possible his role as a Dean may have influenced some instructors’ participation or lack thereof. Instructors who participated appeared to provide full responses without this fear, perhaps feeling as participant Pam did, that “I hope they would respect my opinion” whether or not she agrees with the changes made. It is also possible participants may have chosen not to participate due to the belief their experience or opinion was unwarranted or
uninteresting. Given the case and the delimiting choices made, I contend the aim of this research was not generalizability of the results. Rather, the results provide suggestions for LCC as they continue to evaluate the success of their reform and move toward further improvement. Moreover, though not prescriptive to a larger population, the results provide insight and lessons that may be useful to other institutions enacting developmental mathematics reform.

Altogether, this phase of reform is a positive first step. Although the school is held to this model for one more year (save minor modifications), both administrators and instructors were clear during interviews that they are open to necessary adaptations of this reform. Moreover, as no state demands have yet to be officially articulated, the school does have a small luxury of time to continue crafting the best program for their students and faculty.

The following manuscript in Chapter V describes the implications to practitioners of these results.
CHAPTER V

LESSONS LEARNED FROM A DEVELOPMENTAL MATHEMATICS REFORM EFFORT

Introduction

In response to the failing state of developmental math, many institutions have undertaken program reform in order to best reach all students and attempt to close various equity gaps. Efforts including acceleration and compression of developmental courses, corequisite support of college-level courses, and changes to placement procedures have been shown to positively impact student success (e.g., Huang & Yamada, 2017; Zachry Rutschow, 2019); however, it is important to realize those reforms not only affect student outcomes, but they have wider-ranging implications on the larger community including instructors and administrators.

As part of a larger study, I recently investigated the experiences of instructors and administrators involved in developmental mathematics reform efforts at Lowry Community College (LCC; a pseudonym) through the lens of activity theory (Zakotnik-Gutierrez, YEAR), which is detailed fully in Chapter IV. Responding both to the political threat of an upcoming law disallowing the teaching of developmental courses past 2022, and to internal research identifying equity gaps among students who were referred to developmental mathematics, LCC made the decision to replace the developmental
mathematics sequence with an intensive 5-week onboarding course to be followed in the same semester by a 10-week college algebra course. Students enrolled in the onboarding course are also required to enroll in a semester-long one-credit corequisite support course which is coordinated with the college algebra class.

Although the effects of this reform on student outcome measures may not be evident for some time, a number of direct effects to instructors came to light immediately. As part of the reform, many of the developmental instructors who had been mainstays at the college found themselves eligible to teach only the onboarding courses and the corequisite support lab, and they have since struggled to piece together teaching schedules consistent with prior semesters. In addition, due to the top-down nature of the reform design and implementation, instructors felt undervalued and uncomfortable as some of their classroom autonomy was replaced with specific directives in the name of reform.

I used activity theory (Engeström, 2015) as a theoretical and analytical framework to identify a number of tensions and contradictions arising from the reform process that illuminate conflicts as a result of reform as well as act as drivers of change for the reform process. These tensions and contradictions are described within the Implications for Researchers section, and in this paper, I discuss the implications of these findings on the practice of researchers, administrators, and policy makers in regard to developmental mathematics reform.

**Implications for Researchers**

Community colleges are uniquely placed between the K-12 and university levels, and as such, do not ‘fit in’ with either in regard to student profile, faculty profile, and,
often, academic goals. For this reason, during the past decade, a number of researchers have highlighted the necessity for more research focused on mathematics at the community college level. For instance, Sitomer et al. (2012) argued the need for four strands of new research in mathematics in community colleges: instruction, students, curriculum, and technology and eLearning. Mesa, Wladis, and Watkins (2014) echo those four strands and note the lack of coherence in the existing research.

The impression that we get by looking at the current literature on community college mathematics education has the same feel of disorganized guerrilla warfare. The current pressure for accountability (Rothkopf, 2009) pushes institutions to implement programs that are marketed as increasing student success (e.g., personalized learning), but most of these programs are born out of political pressures to demonstrate better outcomes, with outcomes weakly defined as completing remedial work, persistence from one semester to the next, or earning a degree or certificate (see Rothkopf, 2009) (p.179).

While the need remains for new research in all of the above-mentioned areas of mathematics in community colleges, it is particularly pressing to investigate instruction, because “instruction is the core mission of community colleges” (Mesa, Wladis, & Watkins, 2014, p. 179). Specifically, as colleges continue to implement developmental reform, it is incredibly valuable right now to investigate how course reform impacts instruction and forces it to evolve. I propose Activity Theory (Engeström, 2015) as a good methodology to do so.

**Activity Theory as Methodology**

As previously noted, I used activity theory to view course reform as a set of interconnected activities, with each activity grounded in the perspective of a different stakeholder. In particular, I focused on the instructor perspective and the administrator perspective, and activity theory allowed me to detect tensions and contradictions between
these stakeholders. Although these areas of discord would likely have been identified using any theoretical framework, the power of activity theory is that it forces the researcher to operationalize these not as static occurrences but as dynamic drivers of change. This notion is particularly helpful in the study of reform implementation, as it allows not only an evaluation of initial implementation but directly identifies possible areas of future change. I now summarize what activity theory is, including how it was used in my study.

Activity theory has evolved from Vygotsky’s (1978) model of mediated act, wherein the direct connection between a stimulus and its response are mediated through some act or artifact. Building from this model, Leont’ev (1979) described activity as a goal-directed hierarchy of actions used to accomplish an object. Activity is encouraged by motive, which is the driving force for the activity and actions. The basic components of activity, actions, translate this motive into reality in service of a goal. Actions are then carried out through operations that are associated with the conditions under which actions take place. Leont’ev’s (1979) view of activity focuses on the complex interactions between the individual and the community, explaining the difference between individual action and the collective activity system.

Engeström’s (2015) model of activity theory further extends Leont’ev’s earlier ideas. Contrary to earlier models, the unit of analysis is the entire activity system which gives context to individual events. The activity system integrates the subject, object, and instruments into a unified whole, allowing for the analysis of interactions. Figure 4 shows an activity system wherein double-tipped arrows indicate that each component influences and is influenced by each of the other elements. The components that describe human
activity are explained below (Engeström, 1993) and followed by an example from my study in Table 9:

Subject: The subgroup or individual whose agency defines the point of view of the activity system.

Object: The raw material or problem space at which the activity is directed, which is transformed into outcomes through the assistance of physical and symbolic tools.

Community: All individuals and subgroups sharing the same general object.

Division of labor: The horizontal division of tasks between the members of the community and the vertical division of power and status.

Rules: The implicit and explicit regulations and conventions that constrain actions and interactions within the activity system.

**Figure 4**

*Human Activity System (Engeström, 2015)*
Table 9

Administrator-centered activity system (Zakotnik-Gutierrez, YEAR)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Object</th>
<th>Tools</th>
<th>Rules</th>
<th>Community</th>
<th>Division of Labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrators</td>
<td>Student Success in College Algebra</td>
<td>Institutional data; Research/Evidence at other institutions</td>
<td>Instructor autonomy; Coreq. Course not a ‘study hall’</td>
<td>Other college admins; Math Faculty</td>
<td>Secure PD; Admin. Mandate change, faculty enact</td>
</tr>
</tbody>
</table>

While delineating the components of the activity system and identifying the hierarchy of actions are a good place to start, the power of activity theory lies in the dynamic nature of the activity system. Inner contradictions of the activity system act as catalysts for disruption and change, and the system constantly reconstructs itself through adapting to contradictions and changes within the existing tensions (Engeström, 2015). The four levels of contradictions which may occur in a central activity system are described below (Engeström, 2015).

**Level 1.** Within each component of the activity system, the basic internal contradiction of a human’s activity is “its dual existence as the total societal production and as one specific production among many…Within the structure of any specific productive activity, the contradiction is renewed as the clash between individual actions and the total activity system” (p. 66). This level of contradiction appeared in my study as tension between the individual instructors who comprised the collective subject of the instructor activity system. In particular, instructors’ beliefs about teaching and learning were not consistent and led to discord in relation to how the new course was to be taught.
**Level 2.** These are contradictions between components of the central activity system. Although not specifically noticed in my study, an example of this type of contradiction might occur between the division of labor and the explicit or implicit rules of the system. For example, in a certain mathematics department, there may be an implicit understanding that instructors have autonomy over their classes (rule). At the same time, developmental and college-level math instructors are expected to work closely together in order to ensure student success in both levels (division of labor). This may manifest as a contradiction in the event this collaboration leads to a loss of autonomy for either subset of instructors.

**Level 3.** Level 3 contradictions occur between the object/motive of the “dominant form of the central activity and the object/motive of a culturally more advanced form of the central activity.” For example, in my analysis I found that a third level contradiction occurred when college administration mandated that the 5-week onboarding course would be student self-paced and utilize a flipped classroom model, based on an ‘ideal’ implementation of this kind of course. The instructors attempted to formally implement the course in this way, although many were resistant to the change from what they were used to and reverted back to their comfort zones.

**Level 4.** Fourth level contradictions happen between the central activity and a neighbor activity system. Neighboring activity systems may be connected to the central activity system through sharing the same object, producing key instruments for the central activity system, shaping or producing the subjects of the central activity system, or producing rules that regulate the central activity system. In my study, the administrator activity system and the instructor activity system shared the object of “student success in
college algebra.” A fourth level contradiction that was observed in my study was due to the administrative expectation that the corequisite course be used for remediation through activities, lessons, and assignments outside of the specific college algebra course. While the instructors with whom I spoke understood this as important, all felt students needed this time in order to complete the college algebra homework and had promptly brushed aside those suggestions for the course in favor of assisted homework time.

When I applied the lens of Engeström’s (2015) activity theory, course reform became an activity. In this way, I was able to see the various components of the activity from multiple perspectives and how they interact with and against each other in service of the objective of student success in college algebra. More specifically, the framework allowed me to detect contradictions such as those previously described and identify the manner in which they can be used to reconstruct the course reform activity in order to promote further change. This characteristic of activity theory makes it a particularly useful framework to utilize when studying course reform.

**Research Regarding Instruction**

A survey of recent literature about developmental mathematics and reforms (see Cafarella, 2016a; Jaggars et al., 2015; Zachry Rutschow, 2019) reveals that not much has changed in the intervening years. Research remains largely focused on vaguely defined notions of student success with little attention paid to the larger community involved. Moreover, reforms continue to be implemented to address political pressures in such a manner that structural change is made without necessary regard to changing the larger departmental or institutional culture (Zakotnik-Gutierrez, YEAR). Understanding the larger culture requires an understanding of instructors and their instruction. For instance,
Sitomer et al. (2012) suggest investigating the ways in which teachers’ attitudes toward mathematics determine their instructional practice, both positively and negatively. Through my exploration of instructors’ experiences during the reform process, I found that teachers’ beliefs regarding the importance and structure of developmental mathematics resulted in negative experiences for them when they were asked to change their practice (Zakotnik-Gutierrez, YEAR). Researchers have a fairly sound understanding of instruction at the K-12 and undergraduate levels of mathematics, but it is not clear how that generalizes to community college instruction. For this reason, it is necessary to focus more research on community college instructors and instruction. With a better understanding of this unique population and culture, relevant professional development can be developed and implemented to best address the necessary change in culture that occurs through reform efforts and prepare instructors for everyday practice.

**Implications for Administrators**

The study at Lowry Community College (Zakotnik-Gutierrez, YEAR) highlighted some of the tensions and contradictions that occur when community colleges undertake developmental mathematics reform. As a top-down initiative, it seems that administrators were not equipped to predict the effects of tensions between stakeholders on the overall reform implementation. For example, the shift away from developmental classes left some instructors with uncertainty over their futures due to having fewer courses to teach, as well as uncomfortable in their own classrooms. In addition, instructors who were used to autonomy over their classrooms were asked to change their teaching style nearly overnight in order to implement a change that they might not even believe in. Instructor participant Amy noticed this discomfort during training for the implementation:
At the meetings that they had to train people, the thing that [administrators] felt was important was the conferencing with students and a lot of the other instructors kept asking “When are we going to teach?” It was basically not really understanding the idea of a flipped classroom. So [instructors] kept asking, and [administrators] would say “you’re going to talk with your students, and check their progress in MyMathLab, and if you need to go over something as a class you can, but they’ve got all these tools in MML that they need to be looking at before they come to class.”

By applying activity theory, these tensions were detected and are now able to be used to inform the next stage of implementation. In this way, the framework proves a useful tool for those involved in reform efforts as well as researchers and evaluators.

Although the tensions and contradictions initially manifest as negative outcomes of the reform, they act as instruments of change for this reform as well as implications to be considered by future reform efforts. Through my research (Zakotnik-Gutierrez, YEAR), I identified three areas of focus for administrators: faculty collaboration and buy-in, instructor retention and faculty culture, and support for professional development.

**Faculty Collaboration and Buy-In**

Although administrators and the reform design committee at LCC had been clear about their motives and implementation expectations, the group did face some pushback from other instructors. This redesign team consisted of the Assistant Dean of Academic Affairs in the School of Professional Studies, the Director of Instructional Intervention and Support, an administrator from the concurrent enrollment department, and one each full-time and part-time instructor at both the developmental and college level. At least one part-time instructor was left feeling slighted when she was not selected to be part of the committee, and she was also vocal about being uncomfortable with the teaching directives of the committee that resulted in the loss of her autonomy. She said,
you have to be down in the trenches for a few years at least to know where these students struggle, this is where they will be successful, and this is where they won't. I was not invited [to be on the committee], I think, ‘cause they kind of had their idea of where they wanted to go with it, just wanted people on the committee who wanted to go that same exact direction…I wasn't going to buck the system. I just wanted my feedback heard along the way. If I’m going to be teaching a new class, I want to be part of the process of building that class.

Moreover, she was deeply concerned students would be unsuccessful in college algebra, and if they did manage to pass, then they would struggle even more in further mathematics classes because they had ‘missed out on the important concepts’ in developmental math. As a long-time developmental math instructor, her concerns seemed to be the result of her beliefs that students placed into developmental mathematics are indeed lacking skills and knowledge, and the only way to remedy this is through multiple classes of developmental mathematics classes. Referring to developmental courses, this instructor stated, “especially for the students that are in these classes, I think it's so important to start at the very beginning with each concept as if they don't know it, because there's so many actually don't.” It is possible her beliefs about students and their abilities could have been changed provided she received the resources and support to do so, such as mentoring or professional development. As a result, however, she did not fully buy-in to the reform efforts. More importantly, due to the top-down mandate for change which included all of the content, structure, and timeline for implementation, she had neither time nor opportunity to develop the necessary acceptance before she was expected to follow the directive.

This experience highlights the necessity for administrators and reform committees to proactively seek out input from all of the individuals who will be expected to implement the change (Thirolf & Woods, 2017). In addition to gathering this input, it is
also necessary to address questions and concerns in a concrete manner (e.g. training or development opportunities) so skeptical stakeholders may develop both understanding and trust in the reform. Instructor buy-in is crucial to successful implementation of
developmental mathematics reform (Dana Center Mathematics Pathways, 2018), and although unanimous buy-in is likely impossible, the number of skeptics can be minimized with clear and open communication.

**Instructor Retention and Faculty Culture**

I also found that LCC’s shift away from developmental courses exacerbated a tension between college-level and developmental-level instructors. A recent requirement of the accreditation agency deems instructors ‘qualified’ to teach college-level courses if they have completed at least 18 graduate credit hours in mathematics (Higher Learning Commission, 2016). Prior to the reform, instructors not meeting this qualification were relied upon to cover developmental level courses. They had always been limited to which classes they could teach, but this constraint did not feel particularly constraining before. However, with the redesign to discontinue developmental classes, these instructors were constrained even further and felt uncertainty over their future careers. With this program reform, LCC faced both a shortage of instructors ‘qualified’ to teach the college algebra courses, and an abundance of ‘unqualified’ instructors without classes to teach. This issue shines a light on the need to examine the efforts and policies the college uses to recruit, retain, and develop the necessary ‘qualified’ instructors.

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6 I use the word ‘qualified’ throughout because this is the word used by the accreditation agency. In the Implications for Policy Makers section I expand on this notion.
Community colleges regularly rely on part-time instructor pools to cover most of their classes, but as the ratio of part-time to full-time instructors increases, graduation rates (Mesa, Wladis, & Watkins, 2014) and likelihood to transfer to a four-year institution (Thirolf & Woods, 2017) are negatively impacted. Moreover, Shields (2005) found that students who took developmental mathematics with full time instructors were more successful in college algebra. These results are evidence enough to suggest that “when the single most important key to successful programming is hiring the best faculty, experienced, full-time, well-educated professionals (similarly compared to other institutional colleagues) should be given priority” (Shields, 2005, p. 48).

This is not to say that colleges must discontinue all use of part-time faculty. Rather, those faculty must be supported in the same way as full-time faculty and invest in the institution their time and commitment to growth. All faculty should be regularly available on campus for students, and they should be knowledgeable in research-based teaching and adult learning theory as well as being content experts (Boylan et al., 2005; Cafarella, 2016b; Moriarty, 2007; Shields, 2005). In order to best reach their diverse students, instructors must utilize varying instructional methods including student-centered classrooms, collaborative learning, project-based learning, problem-solving techniques, technology to supplement learning, and culturally responsive teaching methods (Bonham & Boylan, 2012; Boylan et al., 2005; Datray et al., 2014; Shields, 2005). Mathematics departments must proactively search out instructors with these qualifications, rather than simply relying on degrees or credits earned.

In addition to hiring practices, it is also necessary to turn a critical eye to instructor retention practices. In his model of student persistence, Tinto (1975) argues
that the quality and level of academic and social integration greatly influences students’ decisions to persist in college, and this integration was shown to actually mitigate the negative effects on persistence of fixed background characteristics (Pascarella et al., 1986; Pascarella & Terenzini, 1980; Tinto, 1997). Applying this model to instructors at the departmental level, instructors who are more fully integrated will be more likely to remain teaching at the school and desire to remain active with other faculty and students. Fostering instructor integration could include opportunities for collaboration on course, program, and curriculum decisions; intentional team teaching and planning opportunities; professional learning communities; or planned social activities. Intentional faculty mentoring relationships could also be cultivated to support individual educational development and help to ease feelings of isolation often felt by part-time instructors (Datray et al., 2014; Thirolf & Woods, 2017). Lastly, a continuing commitment to quality professional development will encourage instructors to grow both individually and as a collective whole. The reality of instructor recruitment is constrained by budgetary concerns and competition from other institutions, leading colleges to hire candidates who do not necessarily meet all of these standards. Colleges can overcome this by investing in the faculty they do hire and providing development and support for those faculty to improve as educators. Not only will instructor quality improve in this way, mathematics departments will be arguably more effective, and students will likely encounter more success.

Another important use of professional development is to ameliorate the problem caused by not enough ‘qualified’ instructors and too many instructors without enough classes to teach. As will be discussed further in the section applying to policy makers,
many of these instructors are indeed quality mathematics instructors, despite not yet meeting the extrinsic accreditation requirements. Rather than pushing them aside as course offerings evolve, colleges can capitalize on their experience while assisting them to gain the necessary credential, either through graduate mathematics credits or some sort of alternative credential. In fact, LCC’s accreditation agency includes an option for faculty members to be ‘qualified’ using a measure of “equivalent experience [in which] the institution defines a minimum threshold of experience and an evaluation process that is used in the appointment process” (Higher Learning Commission, 2016, p. 3).

Developing this alternative measure of ‘qualified’ instructor would help colleges solve both problems of instructor shortage and class shortage.

Support for Professional Development

A third consideration for administrators that arose from LCC’s reform efforts is the need for resources and support for instructors’ professional development. Many community college mathematics departments rely on instructors with little formal preparation in teaching methods or learning theories (Blair et al., 2018; Grubb et al., 1999). Most of these instructors do care deeply about their teaching, citing an aversion to lecture and a desire for students to be able to think for themselves; however, they rely on ‘covering the material’ as the primary driver of instruction and are often left on their own to develop their teaching methods due to lack of training and professional development (Boylan, 2002; Datray et al., 2014; Grubb et al., 1999). Although instructors espouse the value of different instructional methods, most continue to rely on behaviorist, teacher-
centered strategies and often believe the only prerequisite for good teaching is a strong mastery of mathematics content (Grubb et al., 1999; Mesa, Celis, & Lande, 2014).

While these teaching methods are not entirely ineffective, student-centered classroom activities and inquiry-based learning are more effective than instructor-centered, lecture-focused classes (Datray et al., 2014; Shields, 2005). “Because teaching is the core mission of community colleges,” and high-quality instruction leads to student gains (Mesa, Celis, & Lande, 2014, p. 179), colleges must support high-quality mathematics instruction. This need is especially present in regard to developmental mathematics reform, as the students most affected by reform are those who would traditionally have placed in lower-level developmental courses and have likely been unsuccessful in lecture-based courses in the past (Boylan, 2002). Moreover, developmental part-time instructors’ participation in professional development has been shown to positively affect student retention rates (Datray et al., 2014).

As part of reform and in general, colleges must commit to providing professional development opportunities for instructors’ continued learning. At minimum, instructors must be trained in the specific teaching methods they are asked to implement in reform projects. This was not the case for the LCC instructors who were asked to teach the computer-module-based onboarding class, leading to feelings of confusion and discomfort. More important than minimal training, however, are development opportunities through which instructors are both exposed to research-based pedagogy and instructional methods and also supported in implementing those methods in their own classes. Instructional coaching (Knight, 2007), lesson study (Stigler & Hiebert, 1999) and faculty mentoring partnerships (Datray et al., 2014) are all possible avenues for this
development., as is AMATYC’s Project ACCCESS (Advancing Community College Careers: Education, Scholarship, and Service) designed to mentor and empower new mathematics instructors. 

Implications for Policymakers

A final consideration that must be made is regarding the outside policies constraining the decisions and actions that colleges are able to make. One policy in particular that has caused problems for LCC is the recent requirement from the state’s accrediting agency that mathematics instructors hold a master’s degree or higher in mathematics or a relevant subfield, including completion of a minimum of 18 graduate credit hours in mathematics. The policy is intended to “ensure that students have access to faculty members who are experts in the subject matter they teach and who can communicate knowledge in that subject to their students” (Higher Learning Commission, 2016, p. 1). Although this policy was enacted with good intentions, it is necessary to consider the downstream implications of such a policy. Activity theory analysis revealed that the policy itself becomes a mediating tool of subsequent activity, affecting nearly all aspects of the math department. The policy contributes to departmental separation, effectively ‘othering’ those instructors who are ‘unqualified’ to teach college-level courses and are now facing job insecurity as the number of available developmental courses is limited. Many of them have enjoyed the developmental math niche for years, and they are both disappointed and frustrated at the lack of opportunities for them to continue teaching. The department is increasingly squeezed between two policies: one
requiring instructors to have 18 credit hours to teach college-level courses, and the other limiting what kinds of non-college-level courses are allowed.

Since students are no longer enrolling in semester-long developmental courses because of this other new policy that was implemented, the college faces higher enrollments in college-level courses and must find ‘qualified’ instructors to teach them. At the same time, the department is flush with ‘unqualified’ instructors and attempting to keep as many of them working as possible. Many of these instructors are skilled and qualified educators, but a policy such as this forces colleges to hire individuals with the graduate credit hours (practicing engineers, for example), but possibly no background in educational theory or pedagogy.

The determination of what makes an instructor ‘qualified’ is dubious at best. To assume that coursework in the subject matter translates into the ability to effectively communicate and teach content is both naïve and impertinent because it devalues the professional expertise of teaching. Adhering to this definition of ‘qualified’ invalidates the rich professional expertise known as pedagogical content knowledge (PCK) which integrates simple content knowledge with specific pedagogical considerations and has been shown to be important for student understanding (Ball et al., 2008).

Along those lines, the accrediting agency does include the caveat that the institution may use other factors such as equivalent experience to determine whether faculty members are ‘qualified’ by defining a minimum threshold of experiences and an evaluation process (Higher Learning Commission, 2016). However, all of the participants of my study mentioned only the 18-credit requirement. This leads me to question whether such an option is indeed a feasible option for colleges, or if the requirements for the
alternative are either ill-defined or overly labor-intensive for institutions to implement. If policy makers are going to include this kind of alternative ‘qualification,’ it is necessary to have transparent guidelines in order to assist institutions. It would be prudent for the agency to revisit these policies in favor of a more comprehensive qualification requirement.

**Conclusion**

Developmental mathematics reform is an important topic for research and policy changes for several reasons. Colleges are beginning to reconsider polices that have long resulted in students spending increased amounts of time in completing degrees or leaving college in a cloud of failure, both as a result of political pressures and of a focus on equity. I recently completed a study of one community college’s developmental reform implementation (Zakotnik-Gutierrez, YEAR) which was motivated by both of those factors. While the results of this reform on student success measures may be slow to appear, the reform process did illuminate a number of recommendations for administrators, researchers, and policy makers.

Reform initiatives often begin at the administrative level as a top-down approach, and as such, administrators play a critical role. Nevertheless, departmental changes are unlikely to be successful if instructor buy-in is not an active focus both before and during reform. This can happen in a number of ways, but the overarching theme can be boiled down to three areas of focus: recruitment, retention, and development. Of these three areas, quality professional development is arguably the most important, as it can be used
as an incentive for both recruitment and retention, as well as continued instructor learning in order to promote buy-in or help instructors become ‘qualified’ in regard to accreditation requirements.

The implications for mathematics education researchers are twofold: activity theory as a methodology for studying course reform and a renewed call to investigate community college instruction. The activity theory methodology proved particularly useful in operationalizing the reform process as an activity, allowing the identification and interpretation of contradictions between stakeholders. Viewed in this manner, tensions and contradictions are used as agents of change to direct the next stage of the activity or reform. In addition, the study revitalizes the necessity for researchers to understand the instruction at community colleges as different from what is known about K-12 and university level instruction.

A final recommendation is toward policymakers with consideration toward credentialing and qualifying instructors. Before implementing well-meaning policies, it is necessary to consider the downstream effects such policies will have on departments and other related programs.
CHAPTER VI

DISCUSSION

The preceding chapters of this dissertation have provided, in detail, the full aspects of the design, action, and results of my study. I begin this chapter with a brief summary of the study itself, including the research questions. Next I explain the assumptions, delimitations, and limitations of the study, followed by summaries of the major findings and the implications of those findings. I conclude with a discussion of future avenues of research.

Summary of the Study

The purpose of this study was to contribute to the research on developmental mathematics reform by providing a multi-perspective account of Lowry Community College’s developmental mathematics program redesign. In particular, the study aim was to answer the following research questions:

Q1 What are the experiences of administrators, instructors, and students during a redesign of the developmental mathematics program at an urban community college?

Q1a What tensions and contradictions exist within and between the experiences of these three distinct groups?

Q1b In what ways are these tensions and contradictions related to the constructs of equity?
To answer these questions, I collected data from instructors, administrators, and students using online surveys, video- and audio-recorded individual interviews, and classroom observations. Using Engeström’s (2015) activity theory as both a methodological and analytical framework, I was able to elucidate participants’ experiences (Q1) and the tensions and contradictions existing in the activity system (Q1a). Chapter IV contains a full discussion of these two research questions from the perspective of administrators and instructors. As discussed next in the Limitations section, the student data I was able to collect did not allow me to answer the research question from the student perspective.

Cutting across the entire analysis, I have employed Gutiérrez’s (2009) equity framework to learn important lessons about the equity implications of the identified contradictions as well as within the status quo of developmental mathematics (Q1b).

**Assumptions, Delimitations, and Limitations**

In addition to the theoretical considerations that framed this study, I also made assumptions about the data collection and methodological choices which served to (de)limit the parameters of the research. In particular, I assumed individuals would want to participate in surveys and interviews, believing their experiences to be relevant and merited. In addition, I assumed participants would respond honestly and without fear of retaliation for their remarks. In this section, I elaborate on the delimiting choices I made, including their effects on these assumptions and the resulting limitations of the study.

As an investigation into the activity of developmental mathematics reform, the case was bounded by the actions and common goal of the administrators, instructors, and students involved. Although any one of these groups of individuals could comprise a case
on their own, in this instance it is not meaningful to separate any of them from the larger activity system, thus further defining the case boundary. The study was also bounded by time because I wanted to gather the experiences during the initial implementation of the new courses. Due to delays working with two separate Institutional Review Boards, I was unable to complete data collection during the first semester of implementation as I had wanted. Most of the data was collected during the second semester of implementation, which I believe still provided the perspective from the newness of the reform I desired. I chose to conduct interviews before the end of the semester when individuals’ experiences were not technically complete, which may have had an effect on their perceptions of the redesign. My original concern had been that waiting until the following semester to conduct interviews may have caused me to lose contact with potential participants or may result in participants’ experiences no longer being fresh in their minds, especially in terms of student participants. As it were, the delayed IRB approval made conducting interviews after semester’s end impossible.

As an individual unknown to most of the students and employees at LCC I made the decision to email surveys only to students whose instructor had invited me to class. I made the assumption that students who recognized me from observing their class would be more likely to respond. In the end, only a small number of students (n=6) participated in either the survey or individual interviews, and these students were all from only one of the observed classes. I have no way of knowing whether I may have had more student participation by contacting all students enrolled in the reformed courses. However, I did cast a wider net when I originally emailed all instructors asking for participation and received a similarly small response.
Another complication that arose from my not being affiliated with LCC was a college policy disallowing outside individuals from conducting research there. As a compromise, my first contact with the school, Gustavo, agreed to serve as a Co-PI on my study. His affiliation was in name only, but his role as a Dean may have influenced some individuals’ participation, especially within the relatively small instructor pool. Although I attempted to be clear about both Gustavo’s role and the measures I would take to protect confidentiality, I suspect fear of retaliation may have caused some instructors to refuse participation. Instructors who participated appeared to provide full responses without this fear, perhaps feeling as participant Pam did, that “I hope they would respect my opinion” whether or not she agrees with the changes made.

Other potential student and instructor participants may have chosen not to participate due to the belief their experience or opinion was unwarranted or uninteresting. Subsequently, I did not get the number of responses I had hoped for, and I was unable to meaningfully analyze the student data I did have. I also chose not to utilize the persistence lens to analyze my student data as I had originally planned, due to the limited amount of student data as well as not having access to longer-term data that would be necessary.

Given the case and the delimiting choices made during this research, I acknowledge the aim was not generalizability of the results. Rather, the results provide suggestions for LCC as they continue to evaluate the success of their reform and move toward further improvement. Moreover, though not prescriptive to a larger population, the results provide insight and lessons that may be useful to other institutions enacting developmental mathematics reform.
Summary of Major Findings

The results of this study are the tensions and contradictions I identified within the activity system of developmental mathematics program reform. As constructs of activity theory, contradictions are taken at more than face value; more specifically, contradictions are analyzed for their power to act as catalysts for change within the activity system to promote reconstruction. These contradictions provide the answer to research question 1a, and their use as drivers of change is explained fully in Chapter VI. I provide a brief discussion of the contradictions here, as well as the answer to Q1b for each.

Divide Between Developmental and College Level Instructors

Due to a policy of instructor ‘qualification,’ the department was divided even prior to the reform between instructors responsible for teaching college-level courses and those who were allowed only to teach developmental courses. A full elimination of traditional developmental courses would have rendered many of the department’s part-time instructors no longer employable. In compromise, the reform team designed the 5-week onboarding and corequisite courses which would still qualify as developmental courses for those instructors. Nevertheless, there were still fewer of these courses available for developmental instructors. At the same time, the department faced a shortage of instructors for the additional college algebra courses needed to accommodate students who would previously have taken lower level courses. These tensions combined to widen the divide between instructors in the department.
This status distinction between instructors pertains to issues of access and identity (Gutiérrez, 2009). By cutting down on the courses that individuals are allowed to teach, LCC limited instructors’ access to teaching quality courses. In some cases, the action also removed students’ access to certain quality instructors who are no longer permitted to teach full courses. This contributes to the ‘othering’ of developmental instructors and reinforces any beliefs they are ‘not good enough’ or ‘not smart enough,’ regardless of their teaching ability. It also reinforces the notion that content knowledge is sufficient for good teaching, a notion that discredits the value of pedagogical content knowledge (Ball et al., 2008).

Beliefs About Teaching and Learning

Prior to the reform, LCC instructors were given full autonomy over their courses provided they covered the required material and utilized the required textbook. Individual instructors’ beliefs of teaching and learning therefore greatly influenced what individual sections of the same course looked like. With the implementation of the reform, the design committee decided that in order to maximize the use of time during the 5-week onboarding course, instructors must utilize the self-paced MyLab™ Math learning modules. Structurally, students were expected to use in-class time to complete problems within the modules and out-of-class time to view videos of instruction and utilize the learning supports built in to MyLab™ Math. The role of the instructor during this class was to individually conference with students regarding progress, goals, and specific concerns, as well as to answer questions as needed. Not only had these instructors’ autonomy been taken, many felt this expectation did not allow them to actually ‘teach’
students the material. They had difficulty reconciling this new class structure with their belief that students must be explicitly told how to do math.

These requirements caused some instructors to feel powerless over their classrooms and instruction. They also felt less efficient and less effective at the profession they had grown to love and felt successful in. Their identity as a good teacher was tested when they were expected to teach in a way that they were uncomfortable with.

**Beliefs About Student Abilities**

Another belief of instructors and administrators that caused tension within the activity system is the belief that students who were referred to developmental mathematics could not be successful in college algebra or further mathematics unless they specifically took the developmental mathematics courses. Instructors were concerned that removing the developmental requirement would put students at a disadvantage in college algebra, despite support from the corequisite course in which developmental concepts were intended to be presented. This concern prompted the adoption of the 5-week onboarding course to ensure students would at least receive instruction on the ‘most important’ of the developmental topics. This belief also indicates doubt in the usefulness and effectiveness of the corequisite course.

This tension speaks loudly to students’ identities and the forces which affect and shape them. When students are placed in developmental mathematics, they immediately receive the ‘remedial’ label, regardless of the circumstances leading to that placement. They doubt their ability to do mathematics and have feelings of being ‘less than’ or ‘not ready.’ Even though the beliefs about students described above may be rooted in a desire
to protect students from something that is ‘too hard’ or ‘too fast,’ they serve to perpetuate students’ identities as ‘not smart enough’ for college mathematics.

**Expectations Versus Implementation**

A final contradiction arose as tension between the expectations for the corequisite course and the actual implementation of the course. In particular, administrators involved in the reform process were explicit in their expectation that the corequisite course not be utilized primarily as a study hall for students. Rather, the expectation was that the course would primarily be used for instruction and practice of relevant developmental topics, along with a balance of review and preview of topics covered during the college algebra course. With the course structured in this way, students would receive the necessary skills and content they may be lacking or unconfident using. The reform team designed small lessons for the corequisite course with this goal in mind, and instructors were expected to follow through.

Although initially implemented in this manner, the corequisite course did not remain with this structure. Citing the large volume of college algebra homework questions and a desire to help students in what seemed a more tangible way, instructors pushed aside these supplemental lessons and the corequisite course quickly became an opportunity for students to work on their college algebra homework and receive help. Understanding how the corequisite course was actually implemented illuminates why instructors were concerned the corequisite course would not effectively assist students with learning the developmental content. Implementation in this way would be putting all of their developmental mathematics eggs in one basket, so to speak.
Implications of Findings

As described fully in Chapter V, the dissertation findings have specific implications for policy makers, mathematics education researchers, and administrators. I now briefly discuss these implications.

Policy Makers

A source of tension within LCC’s math department is the recent enactment of a policy officially limiting the types of courses certain instructors are allowed to teach. Although instructors without the required 18 graduate credit hours in math had previously been limited in course selection, the problem was exacerbated when the department phased out all but two courses at this lower level, resulting in a shortage of instructors available to teach the extra sections of college algebra and a surplus of instructors without courses to teach. Policies such as these are no doubt well meaning; however, it appears in this instance to have been enacted without full consideration of the downstream effects to departments.

Moreover, this policy raises questions about the relative arbitrariness of how policies are defined. In particular, where does the perceived importance of 18 credit hours come from? How do those credit hours translate into teaching ability and pedagogical content knowledge? And finally, what are the equity implications of a policy such as this when we consider who has access to earning such credits?
Mathematics Education
Researchers

The literature review provided in Chapter II illuminated the small amount of research pertaining to instructors and administrators within a large body of research regarding developmental mathematics reform. This study further highlighted this deficiency by identifying a number of factors within the instructor and administrative perspectives of reform that have the potential to promote or hinder student success within such reform. As researchers, we must explore what community college instructors are doing and how, and we must use this knowledge to both prepare and develop these instructors.

A second research implication of this study is the use of activity theory as a methodology and analytical framework to study course reform. As fully discussed in Chapters IV and V, activity theory proved a powerful tool to operationalize the reform process as an activity, allowing the interpretation of contradictions as drivers of change.

Administrators

In Chapter V, I elaborate the three areas of focus for administrators indicated by the study results. Although the areas are distinct, they can be boiled down to one motif: support for quality professional development. One theme in the data was instructors’ concern that students would not be successful in mathematics if they did not complete the standard developmental mathematics courses. Instructors appeared to go along with the administrators’ push for reform, although they did not necessarily buy in to the changes being made or understand why those changes may be necessary. The individuals on the reform committee tasked with creating a plan for LCC had an opportunity to learn about
the successes of similar reforms, but other instructors were not given this opportunity or the time to undertake it themselves. Similarly, once the committee decided on a course of action, instructors were informed what they were expected to do. For example, instructors were told the 5-week onboarding course was expected to utilize a flipped classroom model, but instructors were not given training or information on how to implement this aside from a directive to talk to Vera, a full-time developmental instructor who had spent multiple years developing her own version of a flipped classroom model. Had administrators proactively provided comprehensive development opportunities for instructors to learn about prior reform successes as well as the new teaching pedagogies they would be expected to utilize, instructors may have been more confident in the reform and their own ability to change.

An additional benefit of professional development is that it might allow administrators to provide credentialing opportunities for instructors previously labeled as ‘unqualified’ to teach courses above developmental level. An alternative credentialing program could be developed which would allow LCC to retain skilled educators who may not have the ability to attain 18 graduate credit hours in mathematics. Finally, a strong commitment to instructor professional development may assist the department in attracting the best candidates to open positions and in improving the skills of the instructors they already employ.

**Future Research**

My dissertation research has provided evidence of the instructor and administration perspectives of developmental mathematics reform, two perspectives that are notably absent in prior research in this area. As noted in the limitations section, I had
originally planned to include the student perspective as well, but due to the limited data I was unable to do so. A natural next step would be to return to LCC using the lessons learned during this study to investigate the student perspective.

Another next step would be to use the same study design and bounds at another institution currently or previously undergoing similar reform. Specifically, participants mentioned another college in the same community college system which had already implemented a full corequisite model prior. Noting concerns for this model, my participants described an influx of students and instructors to LCC seeking traditional developmental courses following the other school’s change. Investigating the case at this institution would provide valuable insight on a similar student and instructor population to LCC. In addition, since this institution is further along in the reform process, it would be interesting to see how the reform process plays out in the future and what contradictions arise or still exist.

As noted earlier, there continues to be a need for more research regarding community college instructors and instruction. To that end, it would be powerful to apply Tinto’s (1975) persistence framework to investigate the reasons faculty choose to remain at their particular community college. Results could lead to an increased focus on ensuring retention of faculty as well as students.
REFERENCES


U. Waschescio (Eds.), *The culture of the mathematics classroom* (pp. 76-103). Cambridge University Press.


Gutiérrez, R. (2009). Framing equity: Helping students "play the game" and "change the game". *Teaching for Excellence and Equity in Mathematics, 1*(1), 4-7.


http://www.jstor.org/stable/42802597


APPENDIX A

INSTITUTIONAL REVIEW BOARD MATERIALS
Expedited Review of Research Form

9/6/11
Date Submitted
Community College System
Institutional Review Board
File Number

Expedited Review Form
Page 2

Developmental Mathematics Reform: Analyzing Change at an Urban Community College

Title of Research Project

Jennifer Zakotnik-Gutierrez  UNCO  307-220-1563  jennifer.zakotnik@unco.edu

Principal Investigator/Project Director  Department  Phase Extension  Email address

Prof. Studies & Sciences  2243

Co-investigator/Student Investigator  Department  Phase Extension  Email address

Anticipated Funding Source:  N/A

Projected Duration of Research:  12 months  Projected Starting Date:  10/2018

Other organizations and/or agencies, if any, involved in the study:  University of Northern Colorado

Expedited Review Category (see categories on page 1—check one)  1  2  3  4  5  6  7

SUMMARY ABSTRACT: Please supply the following information below: BRIEF description of the participants, the location(s) of the project, the procedures to be used for data collection, whether data will be confidential or anonymous, disposition of the data, who will have access to the data. Attach copy of the Informed Consent Form and/or the measures (questionnaires) to be used in the project.

**Please See Attached**

RESPONSIBILITIES OF THE PRINCIPAL INVESTIGATOR:

- Any additions or changes in procedures in the protocol will be submitted to the IRB for written approval prior to these changes being implemented
- Any problems connected with the use of human subjects once the project has begun must be communicated to the IRB Chair
- The principal investigator is responsible for retaining informed consent documents for a period of three years after the project.

[Signature]
Investigator/Project Director Signature

[Signature]
Co-Investigator/Student Signature (if appropriate)

[Date]
9/16/18

Signature of IRB Committee Chair:

[Date]
[Signature]
[Date]
[Signature]

IRB Chair: Check 1 box:  [ ] Approved  [ ] Approved with Conditions  [ ] Refer to Full Committee Review
Institutional Review Board

DATE: August 10, 2018

TO: Jennifer Zakotnik-Gutierrez
FROM: University of Northern Colorado (UNCO) IRB

PROJECT TITLE: [1292684-2] Developmental Mathematics Reform: Analyzing Change at an Urban Community College

SUBMISSION TYPE: Amendment/Modification

ACTION: APPROVED
APPROVAL DATE: August 10, 2018
EXPIRATION DATE: August 9, 2019
REVIEW TYPE: Expedited Review

Thank you for your submission of Amendment/Modification materials for this project. The University of Northern Colorado (UNCO) IRB has APPROVED your submission. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on applicable federal regulations.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of August 9, 2019.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Nicole Morse at 970-351-1910 or nicole.morse@unco.edu. Please include your project title and reference number in all correspondence with this committee.

Jennifer -
Thank you for your patience with the UNC IRB process. Your application materials are very clear and thorough - the documentation of site permission, associated IRB permission and response to Dr. Weiler's question regarding name on the study materials is very much appreciated.

This revised and amended package of your application has been approved by Dr. Weiler, the first reviewer, and subsequently, upon review of your materials, I am also recommending approval. Please be sure to use all of these materials (e.g., consent forms) and protocols in your participant recruitment and data collection.

Best wishes with this interesting research and don't hesitate to contact me with any IRB-related questions or concerns.

Sincerely,

Dr. Megan Stellino, UNC IRB Co-Chair

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Northern Colorado (UNCO) IRB's records.
Email Survey Introduction and Consent

Dear Student/Instructor/Professor:

I am a graduate student in the PhD program in Educational Mathematics at the University of Northern Colorado. I am currently conducting my dissertation research and would like to invite you to participate in my project. The goal of the project is to provide an account of the developmental mathematics program at LCC during the recent design and implementation of the new college algebra course with corequisite support. I hope to describe the different experiences of three groups of participants: students, instructors, and administrators.

[STUDENT VERSION] You have been invited to participate because you are currently enrolled in either the new college algebra course or one of the traditional developmental mathematics courses. I am interested in your perspective on your mathematics education and how LCC is contributing to it.

[INSTRUCTOR VERSION] You have been invited to participate because you are currently teaching one or more developmental mathematics courses at LCC. I am interested in your perspective on the developmental mathematics program at LCC, including the changes that are happening through implementation of the new course.

If you wish to share your perspective, I ask you to complete the survey by visiting the following link.

The survey will take about 15-20 minutes of your time and includes a list of open-ended questions. All survey responses will be kept confidential, and although you will be asked to provide some personal information, such as gender and ethnicity, your survey responses will not be directly linked to you. The first page of the survey will provide this information in more detail. Agreeing to continue to the survey will be your consent to participate in this study.

Keep in mind that you may skip any question or stop at any time while taking the survey. The survey will remain active until October 15, 2018.

Thank you in advance for your participation in this research study.

Sincerely,

Jennifer Zakotnik-Gutierrez
University of Northern Colorado
Jennifer.zakotnik@unco.edu

Student Interview Consent
CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: Developmental Mathematics Reform: Analyzing Change at an Urban Community College

Principal Investigators: Jennifer Zakotnik-Gutierrez, Department of Mathematical Sciences
Jennifer.zakotnik@unco.edu, 970-351-2907

DEAN, School of Professional Studies and Sciences, LCC

Research Advisor: Dr. Gulden Karakok, Department of Mathematical Sciences
Gulden.karakok@unco.edu 970-351-2215

Purpose and Description: The purpose of this project is to provide an account of students’, instructors’, and administrators’ experiences in developmental mathematics courses at LCC, including traditional developmental courses and the newly implemented college algebra course.

To investigate these experiences, I wish to conduct one 60-to-90-minute focus-group interview with you and up to 4 other students at the end of the Fall 2018 semester. The interview will be video-and audio-recorded and any written notes may be collected for analysis. Interviews will be scheduled at mutually convenient times and will be conducted on the LCC campus.

I will take every precaution in order to protect your confidentiality and agree to keep confidential anything that is said in the interview. I will save all video- and audio-recordings and written data on a password-protected computer, and no person other than the principal investigators will see the raw data, video, or audio. All hard copies of notes or other data will be scanned and saved as an electronic file, and then I will securely shred the hard copies. This consent form will be kept for 3 years in a locked file cabinet in the office of Gulden Karakok at UNC, Ross 2250B. You will be assigned a code name that will identify your data throughout the analysis, but there will be no link between your name and your code name. All data will be destroyed three years after the completion of this project.

Potential risks in this project are minimal. As in any video or audio recorded situation, you might feel embarrassed to talk or feel uncomfortable to share your thoughts. I
understand such feelings and will try to make sure you feel comfortable. For example, I will try to place the audio and video-recorders in a place that they are not disturbing you and the other students. Please be advised that although the researchers will take every precaution to maintain confidentiality of the data, the nature of focus groups prevents the researchers from guaranteeing confidentiality. The researchers would like to remind participants to respect the privacy of your fellow participants and not repeat what is said in the focus group to others.

There is no compensation for participating in this interview.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Nicole Morse, Office of Research, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910. You may also contact the Community College System Institutional Review Board, Office of the Provost, at PHONE.

________________________________________________________________________
Participant’s Signature Date

Jennifer Zakotnik-Gutierrez

________________________________________________________________________
Researcher’s Name Researcher’s Signature Date
CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: Developmental Mathematics Reform: Analyzing Change at an Urban Community College

Principal Investigators: Jennifer Zakotnik-Gutierrez, Department of Mathematical Sciences
Jennifer.zakotnik@unco.edu, 970-351-2907

DEAN, School of Professional Studies and Sciences

Research Advisor: Dr. Gulden Karakok, Department of Mathematical Sciences
Gulden.karakok@unco.edu 970-351-2215

Purpose and Description: The purpose of this project is to provide an account of students’, instructors’, and administrators’ experiences during the design and implementation of the new college algebra course.

To investigate these experiences, I wish to conduct one 60-to-90-minute individual interview with you during the Fall 2018 semester. The interview will be video-and audio-recorded and any written notes may be collected for analysis. Interviews will be scheduled at mutually convenient times and will be conducted on the LCC campus.

I will take every precaution in order to protect your confidentiality. I will save all video-and audio-recordings and written data on a password-protected computer, and no person other than the principal investigator will see the raw data, video, or audio. All hard copies of notes or other data will be scanned and saved as an electronic file, and then I will securely shred the hard copies. This consent form will be kept for 3 years in a locked file cabinet in the office of Gulden Karakok at UNC, Ross 2250B. You will be assigned a code name that will identify your data throughout the analysis, but there will be no link between your name and your code name. All data will be destroyed three years after the completion of this project.

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Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Nicole Morse, Office of Research, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910. You may also contact the Community College System Institutional Review Board, Office of the Provost, at PHONE.

__________________________
Participant’s Signature  Date

Jennifer Zakotnik-Gutierrez

__________________________
Researcher’s Name  Researcher’s Signature  Date

DEAN

__________________________
Researcher’s Name  Researcher’s Signature  Date
APPENDIX B

LITERATURE BY CATEGORY
<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Purpose</th>
<th>Method (if applicable)</th>
<th>Data</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahr</td>
<td>2008</td>
<td>Compare long-term academic outcomes of students who remediate successfully to those who do not require remediation</td>
<td>Hierarchical multinomial logistic regression</td>
<td>6 years of course enrollment; looked for degree/certificate attainment and/or transfer</td>
<td>Institutional data from Chancellor's Office of CA Community Colleges, Fall 1995 cohort of 1st time college freshmen</td>
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<tr>
<td>Bailey et al.</td>
<td>2010</td>
<td>Compare Achieving the Dream colleges to national two-and four-year colleges. Also compare study results to NELS 1988</td>
<td>Large-scale quantitative analysis</td>
<td>Longitudinal records for all first-time credential-seeking students in specified cohorts; includes demographics; enrollment; number of credits accumulated; the receipt of degrees or certificates; referral; enrollment &amp; completion of dev ed; enrollment &amp; completion of first college level courses</td>
<td>Data sets from Achieving the Dream: Community Colleges Count initiative and Integrated Postsecondary Education Data System; National Educational Longitudinal Study (1988)</td>
</tr>
<tr>
<td>Blair et al.</td>
<td>2018</td>
<td>Report of Conference Board of the Mathematical Sciences 2015 survey of undergraduate mathematical and statistical sciences in the nation's two- and four-year colleges and universities</td>
<td>Descriptive statistics disaggregated by preparation level</td>
<td>Individual student academic records, including demographic info</td>
<td>Data set from FL Education Data Warehouse; 20,591 students who previously would have been referred to dev. math</td>
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<td>Park et al.</td>
<td>2018</td>
<td>Investigate 1st-semester math course enrollment and pass rate for under-prepared 1st-time college students after dev. math policy change</td>
<td>Multivariate analysis of covariance on integration scales from survey instrument and discriminant analysis and classification analysis estimate contributions to group discrimination and predictive utility of scales</td>
<td>Student records; Student responses to college expectations survey completed at beginning of college experience and college reality survey completed 1 year later</td>
<td>773 students chosen as random sample out of all incoming freshmen at Syracuse University</td>
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<td>Pascarella &amp; Terenzini</td>
<td>1991</td>
<td>Investigate predictive ability of Tinto's (1975) model of persistence relying on student integration</td>
<td>Student reports of engagement and perceptions of support; Faculty reports of engagement and interactions; demographics info for both</td>
<td>Data sets from National Survey of Student Engagement (20,226 seniors, 22,033 first-year students) &amp; Faculty survey from institutions participating in NSSE</td>
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<tr>
<td>Snyder et al.</td>
<td>2016, 2018</td>
<td>2015 and 2016 Digest of Education Statistics report on surveys and activities carried out by the National Center for Education Statistics</td>
<td>HLM to model relationship between average faculty behaviors and and student engagement and learning</td>
<td>Student reports of engagement and perceptions of support; Faculty reports of engagement and interactions; demographics info for both</td>
<td>Data sets from National Survey of Student Engagement (20,226 seniors, 22,033 first-year students) &amp; Faculty survey from institutions participating in NSSE</td>
</tr>
<tr>
<td>Umbach &amp; Wawrzynski</td>
<td>2005</td>
<td>Explore relationship between faculty practices and student engagement</td>
<td>HLM to model relationship between average faculty behaviors and and student engagement and learning</td>
<td>Student reports of engagement and perceptions of support; Faculty reports of engagement and interactions; demographics info for both</td>
<td>Data sets from National Survey of Student Engagement (20,226 seniors, 22,033 first-year students) &amp; Faculty survey from institutions participating in NSSE</td>
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<td>Belfield &amp; Crosta</td>
<td>2012</td>
<td>Examine validity of COMPASS and ACCUPLACER placement test and high school data predicting course grades and college performance</td>
<td>Correlations between placement tests and grades in dev ed, credits earned, GPA; then used Scott-Clayton's (2012) methods</td>
<td>College transcript data</td>
<td>Dataset provided by statewide community college system</td>
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<tr>
<td>Calcagno &amp; Long</td>
<td>2008</td>
<td>Identify causal effect of remediation on student outcomes</td>
<td>Regression discontinuity</td>
<td>Test scores; demographic characteristics; citizenship; previous education</td>
<td>dataset from FL Department of Education, Education Data Warehouse; 1st time community college students</td>
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<td>Scott-Clayton</td>
<td>2012</td>
<td>Evaluate the effectiveness of COMPASS placement exam</td>
<td>ANOVA to calculate correlation coefficients; probit model to calculate predicted probabilities of success in college-level course for full sample of test takers</td>
<td>COMPASS scores; high school GPA overall and math; cumulative numbers of college prep units in math and overall;</td>
<td>42,000 first-time entrants in a large urban community college system</td>
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<td>Method (if applicable)</td>
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<td>Cafarella</td>
<td>2016a</td>
<td>Describe instructor experiences with dev. math compression and acceleration</td>
<td>Qualitative study</td>
<td>Structured interview transcripts</td>
<td>6 dev. math instructors at 3 community colleges during recent course reform</td>
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<td>Denley</td>
<td>n.d.</td>
<td>Comparison of Co-Req model to prior dev math</td>
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<td>Enrollment and earned passing grade in co-req math class disaggregated by ACT subscore and demographic factors; Enrollment and passing grade in college-level course in prior dev math model</td>
<td>Institutional data at TN Board of Regents community colleges and universities</td>
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<tr>
<td>Hodara e al.</td>
<td>2012</td>
<td>Understand approaches used to ameliorate placement problems</td>
<td>Qualitative</td>
<td>Interview transcripts</td>
<td>183 stakeholders at state-level offices and community colleges in 7 states</td>
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<tr>
<td>Huang &amp; Yamada</td>
<td>2017</td>
<td>Evaluation of Statway program; compared students who had enrolled in dev math 1 year prior to Statway students’ enrollment to view same time-frame</td>
<td>HLM to calculate propensity score for each student &amp; estimate effectiveness of Statway vs. dev. Ed. In college-level math completion</td>
<td>Background characteristics; prior course enrollment; course performance</td>
<td>2283 students in Year 3 Statway cohort w/matched comparison of 1422 students enrolled in dev math; 2862 students in Year 4 Statway cohort w/ matched comparison of 1284 students enrolled in dev math</td>
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<tr>
<td>Kane et al.</td>
<td>2018</td>
<td>Evaluate effects of TN SAILS program which shifts remedial math to high schools</td>
<td>Comparing changes in outcomes of students in schools with SAILS to changes in outcomes for schools without SAILS</td>
<td>Enrollment, demographics, grades, ACT scores of all HS seniors 2011-2016; postsecondary enrollment, completion, course grades, credit accumulation; posttest survey of students enrolled in SAILS</td>
<td>K-12 school districts and public 2- and 4-year colleges in TN</td>
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<tr>
<td>Authors</td>
<td>Year</td>
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<td>Method (if applicable)</td>
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<td>Logue et al.</td>
<td>2016</td>
<td>Compare pass rates for students in dev math (elem alg) with pass rates for students in college-level statistics class who had been assessed as needing elem alg</td>
<td>Randomized Control Experiment; Compared mean pass rates of students by group</td>
<td>Course grades; total credits earned; pre- and post semester math attitude survey; post-semester student satisfaction survey</td>
<td>907 students at 3 community colleges in NYC Randomly assigned students to traditional remedial elementary algebra, elem algebra with weekly workshops, or college-level statistics with weekly workshops</td>
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<td>Mokher et al.</td>
<td>2017</td>
<td>Examine impact of FL legislation intended to reduce need for dev. ed.</td>
<td>Regression Discontinuity</td>
<td>College-readiness test scores, race-ethnicity, gender, socioeconomic status, ELL, 10th grade GPA, college outcomes</td>
<td>Data from FL K-20 Education Data Warehouse and National Center for Educational Statistics' Elem/Secondary Info System; 145,580 students</td>
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<td>Yamada</td>
<td>2017</td>
<td>Evaluation of Quantways (QW course)</td>
<td>HLM to calculate propensity score and estimate effectiveness of QW vs. dev math</td>
<td>Enrollment in college math during subsequent year &amp; math GPA</td>
<td>2,406 QW1 students and 7,778 matched comparison students across nine colleges</td>
</tr>
<tr>
<td>Yamada et al.</td>
<td>2016</td>
<td>Evaluation of Quantways 1 course</td>
<td>HLM to calculate propensity score and estimate effectiveness of QW1 vs. dev ed. Students w/ similar characteristics</td>
<td>Student Characteristics; course enrollment, performance</td>
<td>3,992 QW1 students and 12,448 matched comparison students across</td>
</tr>
<tr>
<td>Zachry Rustschow et al.</td>
<td>2017</td>
<td>Investigate effects of Dana Center Math Pathways</td>
<td>Random Assignment to compare outcomes for students in DCMP w/students in traditional dev. and college-level math sequence</td>
<td>Qualitative and Quantitative data on experiences and outcomes of students, inclu., age, gender, race/ethnicity, enrollment status</td>
<td>594 students at 4 colleges</td>
</tr>
</tbody>
</table>
APPENDIX C

INSTRUCTOR SURVEY QUESTIONS
Thank you for opening this survey. Your opinions and experiences are very important! Please read the following information regarding the research study.

You are invited to take part in a research study aimed at providing an account of the experiences of students, instructors, and administrators regarding developmental mathematics courses and the recent design and implementation of the new college algebra course with corequisite support. Your contributions will help me to explain the overall experience with this process and with the course, possibly helping to inform future reform efforts.

This survey is completely voluntary and should take about 15-20 minutes of your time. You can stop at any time during the survey. If you have any further questions about the research project, please contact Jennifer Zakotnik-Gutierrez by email: jennifer.zakotnik@unco.edu.

WHO WILL SEE THE INFORMATION YOU GIVE? Only the principal investigator will see the results of this survey. You will be asked to include a code number with your data, which will be used only by the principal investigator and will not be easily traceable back to you. You will be given the opportunity to provide contact information if you would like to participate further. This contact information will not be tied to your survey response.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Please take all the time you need to read through this document and decide whether you would like to participate in this research study. If you decide to participate, your completion of the research procedures indicates your consent. Please keep this form for your records. If you have any concerns about your selection or treatment as a research participant, please contact Nicole Morse, Office of Research, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910. You may also contact the Community College System Institutional Review Board, Office of the Provost, at PHONE.

PAGE 2
1. Why did you choose to work at LCC? [AT: Subject]
2. What is your role at LCC? [AT: Subject]
3. In general, what are your goals for your students? [Gutiérrrez: power, access, achievement]
4. What do you do as an instructor to help your students reach those goals? [Gutiérrez: power, access, achievement; Tinto: institutional commitment]

5. What is your role in the college algebra redesign? [AT: subject, possible tensions within instructor system-division of labor, community]

6. How will the redesign affect you? [AT: subject, possible tensions within instructor system-division of labor, community]

7. How do you anticipate the redesign will affect students? [Gutiérrez: power, access]

8. What is your understanding of the reasons behind the redesign? [general experience, equity]

9. What is your understanding of any equity goals at LCC? [general experience, equity]

10. How do you believe the redesign may contribute to any equity goals? [general experience, equity]

11. Outside of teaching classes, in what ways are you involved with students at LCC? [Tinto: social integration]

12. What is your gender? [Instructor identity, possible source of tension between student and instructor systems]

13. What is your ethnicity? [Instructor identity, possible source of tension between student and instructor systems]

14. Please provide a personal code: 1 letter followed by 4 digits. This code will be used solely by the researcher to identify your responses. The code and all responses will be kept confidential.

15. Would you be willing to participate in an individual interview to further explore these questions? If so, please provide your name and email address where you can be contacted. You will not be contacted unless you choose to be.
APPENDIX D

INSTRUCTOR AND ADMINISTRATOR INTERVIEW QUESTIONS
Instructor Interview Questions

1. Please remind me of your role at LCC and why you choose to work there. [AT: subject]
   a. Follow up (if needed/want to further explore from survey): What is your role in the college algebra redesign? How will the redesign affect you? What is your understanding of the reasons behind the redesign?

2. Please explain the process of the course redesign and implementation. [AT: division of labor, community, possible tensions between instructor and administrator systems]

3. Please describe a typical day in your current class. [Gutiérrez: power, access; Tinto: social integration (teacher involvement)]
   a. What is your role?
   b. What is the role of the students?

4. How does your experience teaching this class compare to teaching previous developmental math courses? (applies only to instructor currently teaching the new course)

5. How do the experiences of students in this course compare to the experiences of students in your previous developmental math courses? (applies only to instructor currently teaching the new course)

6. What do you see as the positive aspects of developmental mathematics? [general RQ1]

7. What do you see as the negative aspects of developmental mathematics? [general RQ1]
   a. How do both the positive and negative aspects inform what you do as an instructor?

8. How do you anticipate the redesign will affect students? [Gutiérrez: power, access, identity]

9. What resources does the college or department provide to you as an instructor? [AT: tools, community; Gutiérrez: access]

10. Are there any resources you feel you are lacking? [AT: tools, community, possible tensions between instructor and administrator systems; Gutiérrez: access]
     What is your understanding of the next steps in the developmental mathematics redesign? [AT: division of labor, possible tensions between instructor and administrator systems]
Administrator Interview Questions

1. What is your role at LCC? [AT: subject]
2. Tell me about why the college has undertaken the college algebra redesign. [general experience; Gutiérrez: access]
3. Please explain the process of the course redesign and implementation. [AT: division of labor, community, possible tensions between instructor and administrator systems]
4. What is your role in the college algebra redesign? [AT: subject]
5. How will the redesign affect you? [AT: subject]
6. (If necessary after previous) What is your understanding about any equity goals of the college? [AT: rules, object, outcome]
7. (If necessary after previous) How do you feel the redesign affects the college’s equity goals? [AT: rules, object, outcome]
8. How do you believe this redesign will affect students? [Gutiérrez: power, access]
9. How do you believe the redesign will affect current instructors? [Gutiérrez: power; AT: division of labor possible tension between instructor and administrator systems]
10. What resources does the college provide to math instructors? [AT: tools; Gutiérrez: access]
11. Are there any resources you feel are lacking? [AT: tools; Gutiérrez: access]
12. What do you see as the positive aspects of developmental mathematics? [Gutiérrez: access, power; AT: possible contradiction between instructor and administrator systems]
13. What do you see as the negative aspects of developmental mathematics? [Gutiérrez: access, power; AT: possible contradiction between instructor and administrator systems]
14. What are the next steps for the redesign after this first semester? [General experience and motivation]

What are your next steps? [General experience and motivation]
APPENDIX E

STUDENT SURVEY AND INTERVIEW QUESTIONS
Thank you for opening this survey. Your opinions and experiences are very important! Please read the following information regarding the research study.

You are invited to take part in a research study aimed at providing an account of the experiences of students, instructors, and administrators regarding developmental mathematics courses and the recent design and implementation of the new college algebra course with corequisite support. Your contributions will help me to explain the overall experience with this process and with the course, possibly helping to inform future reform efforts.

This survey is completely voluntary and should take about 15-20 minutes of your time. You can stop at any time during the survey. If you have any further questions about the research project, please contact Jennifer Zakotnik-Gutierrez by email: jennifer.zakotnik@unco.edu.

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Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Please take all the time you need to read through this document and decide whether you would like to participate in this research study. If you decide to participate, your completion of the research procedures indicates your consent. Please keep this form for your records. If you have any concerns about your selection or treatment as a research participant, please contact Nicole Morse, Office of Research, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910. You may also contact the Community College System Institutional Review Board, Office of the Provost, at PHONE.
1. Why did you choose to attend LCC? [Tinto: Institutional commitment]
2. What are your educational/college goals? [Tinto: goal commitment]
3. How will attending LCC help you to reach these goals? [Tinto: institutional commitment; social and academic integration]
4. In what ways are you involved at LCC? [Tinto: social integration]
5. What mathematics course(s) have you taken in the past? [Gutiérrez: access, achievement]
6. What mathematics course(s) are you currently enrolled in? [Gutiérrez: access; Tinto: goal commitment]
7. What mathematics course(s) is required for your degree? [Gutiérrez: access; Tinto: goal commitment]
8. Please describe a day in your dream math class. What is your role in class? [Gutiérrez: identity, power; Tinto: social and academic integration]
10. What is your ethnicity? [Gutiérrez: identity]
12. How many years has it been since you finished/left high school? [Gutiérrez: identity]
13. How many years has it been since you enrolled at LCC? [Gutiérrez: identity]
14. Have you attended college at any other institutions? Please list them. [Gutiérrez: identity]
15. Please write the two-digit month and two-digit day of your birthday, followed by the last digit of the year in which you were born. For example, a person who was born on March 9, 1960, would write 03090. This code will be used solely by the researcher to identify your responses.
16. Would you be willing to participate in a focus group and/or individual interview to further explore these questions? If so, please provide your name and an email address where you can be reached. You will not be contacted unless you choose to be.
Student Interview Questions

1. Remind me of your educational goals and how you think LCC will help you to reach them. [Tinto: institutional and goal commitment]
   a. Possible follow up: What type of degree do you need? Where will you go to finish your schooling?

2. What activities do you do outside of school? [Gutiérrez: identity]

3. Describe your experiences in mathematics prior to this semester, either at LCC or somewhere else. [Gutiérrez: access, identity; Tinto: institutional commitment]
   a. Follow up: Describe a typical day in class. [Gutiérrez: power, identity]

4. Describe your experience in mathematics this semester, including what a typical day looks like.
   a. Follow up question to both #3 and #4 (if this does not come out): What role does the instructor play during class? What role do you (and other students) play during class? [Gutiérrez: power, identity; might allude to tension between rules and community, or between student and instructor system]

5. How has your experience this semester compared to previous semesters/experiences? [Tinto: academic and social integration; Gutiérrez: identity, power]

6. Was this course a positive experience for you? Why or why not? [Tinto: academic and social integration; Gutiérrez: identity, power, access]
   a. What was it about the course that made it a positive/negative experience for you?

7. In what ways does this math class affect your involvement at LCC? [Tinto: social and academic integration]

8. Do you feel that your instructors are involved in your experience at LCC? What does this look like? [Tinto: social integration, institutional commitment]

9. In what ways do you think LCC is invested in your learning? [Tinto: social and academic integration]

10. In what ways do you think this math department is invested in your learning? [Tinto: social and academic integration; Gutiérrez: access]
    a. Follow up: What do you think would be some evidence of this that I (researcher) could see?
APPENDIX F

DATA ANALYSIS CODING INFORMATION
The following pages show sample codes elucidating Jonassen and Rohrer-Murphy’s (1999) six-step process to apply activity theory. Steps 1 through 5 were realized through an inductive open-coding method on the instructor survey results to identify preliminary codes and themes as well as further areas to investigate during interviews. The inductive coding was then continued with interview transcripts data, followed by a more deductive coding phase using a constant-comparative method, and new themes were identified as they arose. For example, I coded the data broadly at first to denote the activity system components (i.e., subject, object, division of labor, etc.), and then I identified more specific themes within the component codes. These general and specific themes are listed below, followed by descriptions for each of Jonassen and Rohrer-Murphy’s (1999) 5 steps. Once I had constructed the activity systems, I performed Step 6, which was to ‘zoom out’ from the activity system to describe and assess how the components affect each other. This step provided a description of the dynamics within and between the neighboring activity systems over time, and I identified contradictions and tensions and described their potential influence on the activity system. Unless otherwise noted, the data cited refers to the interview with the indicated individual.
## Table F1

### Themes from the Data

<table>
<thead>
<tr>
<th>Activity System Component</th>
<th>Themes within Component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Object</strong></td>
<td><strong>Student success in College Algebra</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Actions</strong>-</td>
</tr>
<tr>
<td></td>
<td>• Math instructors provide access to content</td>
</tr>
<tr>
<td></td>
<td>• Provide content during class, office hours, tutoring lab</td>
</tr>
<tr>
<td></td>
<td>• Build relationship with students</td>
</tr>
<tr>
<td></td>
<td>• Help Students learn how to do school</td>
</tr>
<tr>
<td><strong>Subject</strong></td>
<td><strong>Motives</strong></td>
</tr>
<tr>
<td></td>
<td>Students continue college program</td>
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<tr>
<td></td>
<td><strong>Goals</strong></td>
</tr>
<tr>
<td></td>
<td>• Students acquire dev math skills needed for College Algebra (CA)</td>
</tr>
<tr>
<td></td>
<td>• Students successfully complete CA</td>
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<tr>
<td></td>
<td><strong>Community</strong></td>
</tr>
<tr>
<td></td>
<td>• Maintain Employment</td>
</tr>
<tr>
<td></td>
<td>• Higher graduation rates</td>
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<tr>
<td></td>
<td>• Close equity gaps through fewer courses</td>
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<tr>
<td></td>
<td><strong>Beliefs</strong></td>
</tr>
<tr>
<td></td>
<td>• About students</td>
</tr>
<tr>
<td></td>
<td>• Teaching and Learning</td>
</tr>
<tr>
<td></td>
<td>• About Self</td>
</tr>
<tr>
<td><strong>Instructors</strong></td>
<td><strong>Community</strong></td>
</tr>
<tr>
<td></td>
<td>• Community beliefs</td>
</tr>
<tr>
<td></td>
<td>o Dev math necessary for CA success</td>
</tr>
<tr>
<td></td>
<td>o Math is learned sequentially and builds on lower concepts</td>
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<td><strong>Division of Labor</strong></td>
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<td></td>
<td>• Dev math and CA instructors work together</td>
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<td>• Dev math instructors not ‘qualified’ to teach CA</td>
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<tr>
<td></td>
<td>• Administrators make decisions and expect faculty to follow through</td>
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<tr>
<td></td>
<td>• Administrators provide professional development</td>
</tr>
<tr>
<td><strong>Administrators</strong></td>
<td><strong>Instructor Autonomy</strong></td>
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<td></td>
<td><strong>Expectations for new courses</strong></td>
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<tr>
<td><strong>Rules</strong></td>
<td><strong>Tools</strong></td>
</tr>
<tr>
<td></td>
<td>• MML with integrated textbook</td>
</tr>
<tr>
<td></td>
<td>• Required Course content</td>
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<tr>
<td></td>
<td>• MML assignment sets</td>
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<td></td>
<td>• Professional development</td>
</tr>
<tr>
<td></td>
<td>• Technology resources</td>
</tr>
<tr>
<td></td>
<td>• Research</td>
</tr>
<tr>
<td></td>
<td>• Institutional Data</td>
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</tbody>
</table>
**Step 1: Clarify the purpose of the activity system.** This step is used to describe the motives and conscious goals of the activity system. The broader context within which the activities occur is specified, guiding construction of the problem space. Motivations for the activity and interpretations of any perceived contradictions begin to be understood and articulated.

### Instructor Activity System

#### Broader Motives of Course Reform

- Students able to continue college program
  - All instructors: Desire for students to continue in college program
  - Amy: Concern that math is the gatekeeper; the reform class will “get them through college” and at least math won’t be holding them back; “I think that this is great for the students be they’re not math majors so they just need their credit to continue their degree.”
  - Josh: “Everyone’s got to get through [college algebra] and so, um, do you want to get it done in a semester or do you want to do it in two and a half years? Maybe a student gets through two Dev ed classes and they’re like, ‘this is just costing too much money. This is taking too much time. I just can’t make that kind of commitment.’ And so, they leave and they stop, whereas opposed to, ‘yeah, I can, I can just knock it out in a semester.’”

- Goals
  - Students acquire dev math skills needed for College Algebra (CA)
    - Pam: A lot of students are “lacking skills” and need the dev classes before CA
    - Pam and Vera: Students gain ‘school-going’ skills in dev courses (timeliness, work ethic, etc.)
  - Students successfully complete CA
    - All instructors: Desire for students to be successful in CA
    - Josh, Amy, and Vera: Corequisite course is helpful as a time to help students complete homework-students need this to complete CA
    - Josh: speaking of students in his coreq class, “they said, ‘why are you giving me new stuff to do when I still have all this other homework to do?’”
    - Amy: concern is “students who start dev math but never finish”
  - Maintain Employment
    - Vera: Dev ed instructors “unqualified” (though perfectly capable as educators) to teach college-level courses
    - Vera: Onboarding course and TA positions are a compromise to provide teaching opportunity for dev ed instructors
    - Pam: Loves teaching at LCC and wants to stay, but hours are difficult

### Administrator Activity System

#### Broader Motives of Course Reform

- Students able to continue college program
- Gustavo: Math courses used as gatekeeper to other programs; reform efforts brought this to light
- Gustavo, Tony: Cite Complete College America data that students who complete math in first year have higher college success
  - Gustavo: “we’re still using a placement requirement, but regardless of where they place in that first year or in that first semester with us, will be able to complete their college level course [in the first year]”

#### Goals

- Students successfully complete College Algebra
  - All admin: minimizing number of courses needed should lead to less attrition
- Higher graduation rates
  - All admin: If students are successful in math within first semester or year, should be more likely to complete college program at LCC
- Close equity gaps through fewer courses
  - Mark: prior institutional data showed LatinX students less successful in dev math courses and CA, greatly due to attrition
  - Gustavo: “it’s still the primary [goal] is closing our equity gaps. For us as an institution, our equity gap exists between our, uh, LatinX student population and our Black student population in comparison to our White students.”
Step 2: Analyze the activity system. During this step, we define in depth the subject, object, community, division of labor, and rules. This process describes how subjects view their roles and beliefs within the system, how objects meet the goals of the system, the structure of social interactions within the community, the norms that influence the system, and the division of labor that mediates between the community and object.

Instructors Activity System

Object: Student success in College Algebra

- Realized through actions:
  - Dev math instructors provide access to developmental content
    - Vera & Josh: Onboarding includes topics most important for CA-condensed from what was once 4 different courses
    - All instructors noted that onboarding and coreq labs are only option for dev math instructors
    - Josh, regarding his role on redesign committee: "I'm not a dev ed teacher. Um, I kind of was more approaching things from the CA side of things of like, you know, like what do we need students to know or to be exposed to or whatever to, you know, be successful in CA”
    - All instructors: implicit assumption that completion of dev math modules is ‘enough’ for CA prep
  - College-level instructors provide access to CA content
    - Specific CA courses structured differently by instructor, but follow same content
    - Amy: After short lecture, students work alone on homework assignments or in groups on ‘projects’ (more in-depth problems than homework)
    - Josh: “Boring” lecture to get through content; helps students as needed
    - Josh, Amy, Pam circulate to answer student questions during lab time and class time (as needed)

Community (others who share same object) These overlap, as Administrators are part of the Instructor community, and vice versa

- Dev math and college-level instructors
  - Community beliefs affecting system
    - Josh: noted wife’s struggle with 4 dev classes and CA; although content was important, time frame was a deterrent
    - Pam: “Because sometimes these particular students and minorities and all that, they have come from a background of not getting what they should have in education. So now they have to start here and the community college was one of the few places they can start at that level because it can’t in a four year college.”
    - Pam: “If people do away entirely with dev math, what happens to this huge number of students who need it in order to then be successful in the CA…In dev ed classes, so much of the teaching process is not just math, but you know, each day kind of reminding them of what they should do between now and the next class and helping them with their study skills.”
    - Vera: “if you asked any one of us, do we think this is the best thing for our students? Unequivocally, we’d all say, no, absolutely not. These students need dev ed.”
    - Vera and Pam note encounters with students who are afraid not to have dev math, due to time out of school, prior experience
      - Vera: “I can't tell you how many students, when they're getting ready to leave the [onboarding] and go into the [CA] have said to me, I am so glad you have this.”
    - All instructors noted belief that math is learned sequentially and builds on lower concepts
    - Amy: Dev math too often a gatekeeper, esp. for non-STEM students
      - Note: neither dev math instructors noted concern about students’ time-to-finish or inability to complete required courses, although both college-level instructors did.

Individual instructor beliefs about teaching and learning

- Amy and Vera both note belief that lectures are less effective than students engaged in working problems; refer students to MML for resources
- Amy: “I try and limit lecture but I think students like having them. But MML has videos and all these resources, so I kind of try and make my classroom to be more of a flipped classroom, but students don’t always like that, so I kind of go back and forth.”
- Jason: lecture-oriented with opportunities for students to ask questions and practice what has been shown (evident during observation)
• Pam: instruction is step-by-step presentation of concepts and procedures; “I've always had a struggle with feeling like students at that level of math can learn it by themselves, um, watching a video without being able to ask their questions. I'm not one of those teachers that likes the flipped class where the students learn it by themselves and I just feel like instruction is what they need and what they soak in the best. And then having time to do it by themselves.”
• Pam, describing Vera’s style: “She doesn't lecture at all. She doesn't teach them at all. They learned on their own, but she's right there to answer questions and they work together. me, I, I want to teach them.”

Division of Labor (mediator between community and object)

• Dev math and CA instructors work together
  o Josh, Vera, Pam, Amy noted communication between CA instructor and dev instructors who teach onboarding and coreq classes
  o Pam: goal/purpose of the lab “depends on what the CA instructor wants”
• Dev math instructors not ‘qualified’ to teach CA
  o Gustavo: Citing Higher-Ed requirement: “all of our instructors that we're bringing on board must have a master's degree in [math] and/or the master’s degree plus 18 credit hours in [math] because all of these courses are going to be eventually coreq’d and dev classes won’t be taught anymore
  o Pam: “I work a full extra day than I used to and uh, and struggle now to get my credits and my hours for my health insurance. Probably most of the staff is having that problem.”
  o Vera: “We have several amazing adjunct Dev ed teachers are not allowed to teach the other stuff [college-level courses]. And we don't want to lose them either.”
• Administrators make decisions and expect faculty to follow through
  o Tony asked faculty to be on redesign team; perception is he picked members who would agree with him (Pam interview)

Rules

• Instructor Autonomy
  o Mark: “[In prior institutional review,] we could never correlate success rates, good success rates or bad, to what the teacher was doing, whether it'd be like a flipped class vs a non-flipped. I mean, we just couldn't. So we took the approach of giving wide ability to teach as you want, but with the understanding that we paid attention to course success rates.”
  o Gustavo and Tony both noted, aside from coreq expectations, instructors can teach how they want
  o Amy & Vera noted no overall teaching requirements aside from content coverage
  o Pam, describing Vera's style: “She doesn't lecture at all. She doesn't teach them at all. They learned on their own, but she's right there to answer questions and they work together. me, I, I want to teach them.”
• Placement by exam
  o Gustavo: “Right now we're still using a placement requirement, but regardless of where they place in that first year or in that first semester with us, will be able to complete their college level course.”
  o Tony noted that final exam is one of assessment pieces that will be used to evaluate redesign
• Common Final exam
  o Jason, Amy, Gustavo, Mark all pointed this out
  o Tony noted that final exam is one of assessment pieces that will be used to evaluate redesign
• Expectations for teaching onboarding
  o Vera: “[Tony] really thought that [a flipped model] would be the best kind of model for us to use, to help the students maximize their time in the classroom.” And so, um, that's the way we kind of set it up...then he thought it would be even better if they just [do it on computer], because then, as teachers, we can spend more of our time working with the students instead of having to grade papers and all that kind of stuff.”
o Pam: “That first semester they said, this is how we want everybody to run the class... wanted it students just working on their own at their own pace... we were also encouraged to do a group project every day, which I did as well. Worksheets, stuff like that”

o Vera: “We had somebody in charge of the committee that decided they all needed to be the same, decided how every minute of each class was going to be run... it was based on the flipped model and I was pretty much the only one in the Dev ed who's ever done the flipped model.”

o Amy, Vera & Pam note ‘conferencing with students’ expectation for course

• Expectations for teaching coreq
  o Jason: “When we were designing the coreq labs, the main goal of that one hour was to, um, either reinforce or review”
  o Tony: When he taught the support lab prior, he noticed “some of the things in the CA content that students needed additional practice with, beyond the homework that they were given in the CA class... So [for those things] it was like, okay, we need to come up with more projects, more opportunities for students to, to learn about or use this in this coreq, um support class.”
  • “also opportunity to answer any questions about the homework, remaining time, was to prep for the next class.”
  • “So we definitely have made it a strong encouragement that they try and not turn it into a study hall. But we don't have any competencies or anything that we're assessing in those labs, to kind of force additional tasks to happen in there.”
  o Vera: “my idea was that they already have so much that they have to do in [CA] and so many problems and so many concepts and all this kind of stuff that it did not make any sense to just pile more work on them,” supplementing as needed

Administrator Activity System

Object (Shared with Instructor Activity System)

Community

• See Instructor System

• Other members, including other LCC deans and administrators and statewide system leadership are an implicit part of the Administrator community, although they were not explicitly indicated during interviews.

Division of Labor (mediator between community and object)

• Administrators make decisions and expect faculty to follow through
  o Tony asked faculty to be on redesign team; perception is he picked members who would agree with him (Pam interview)
  o See coreq and onboarding sections under ‘Instructor Rules’

• Administrators provide professional development
  o Amy pointed out “they’ve had a lot of PD, and they pay us to attend” though she is not specific as to type
  o Mark pointed out opportunities provided by his office, Center for Inclusive Excellence; (see Step 4)

Rules

• Instructor Autonomy (See Instructor System)

• Vera, Amy, Pam: Instructors are expected to ‘conference’ with students during each class of the onboarding course

• Coreq course should not be ‘glorified study hall’ (see Instructor System)
Step 3: Analyze the activity structure. Here we outline the hierarchy of activity, concrete actions, and automatized operations. This step describes the interrelationships of thinking focused on the object while purposely including an understanding of the intentionality of the actions and operations.

### Instructor and Administrator Activity Systems

- Ensure students get necessary content during class, office hours, tutoring lab
  - Instructors, Tony
- Build relationship with students
  - Josh, Vera, Pam, Amy
- Help Students learn how to do school
  - Vera, Pam
Step 4: Analyze tools and mediators. The purpose of this step is to elucidate the instruments, rules, and division of labor that mediate and constrain activity, actions and operations.

Instructor Activity System

- MML with integrated textbook
  - Both Josh and Amy noted that they used MML primarily because students had used it in the onboarding course and would be familiar
  - Josh, regarding computerized vs paper: “math is math, it hasn't changed in a really, really long time, you know, so where a math problem comes from, whether it's on a computer or it's in a book or it's on a worksheet, it's probably the same exact problem. It's really just the medium that it's being delivered in.”
- Required Course content
  - Josh & Amy indicated that instructors were given leeway to structure class as they pleased as long as required content was covered
- MML assignment sets
  - Amy compiled the MML homework sets for all CA classes for Fall 2018
    - For the second semester with the course, she revised the sets and was better able to tailor assignments to what students needed practice with
- Professional development
  - Amy: “they’ve had a lot of PD, and they pay us to attend”
  - Note-she did not clarify whether this was department specific or school-wide, or content
  - Mark: Evening PD sessions are regular offerings. It's not targeted specifically for those who teach math. Yeah, we have quite a bit of training. So we do four trainings around inclusive excellence during the year, and those are required for full time faculty. [pt faculty are welcome to come.]” He also noted an inservice day for FT, and an evening inservice for PT.
  - Josh notes there was MML training
  - Josh, regarding information from the committee: “we did also offer information sessions to like, before things got started, you know, this is what it is, this is what it looks like, this is what we're doing. Just kind of giving updates and details and, you know, just stuff moving forward.”
  - Josh: “Am I actually handed resources to use? No, but am I ever denied resources that I ask for? No… I mean if there's something I'm lacking, I'm not aware that I'm lacking it. Um, and I feel very confident that if I discovered I was lacking it and I brought it to attention to my department chair or Dean or vice president or whoever, they would make sure I had it.”
- Technology resources
  - Implied, classes are computer-based

Administrator Activity System

- Research and Evidence from other institutions
  - Tony pointed out national movements (Complete College America) to reform
  - Tony & Vera: Reform committee began process by conducting a literature review
- Institutional Data; Tony & Gustavo both mentioned plans to use student data from Onboarding class, CA, and other content courses for evaluation purposes
**Step 5: Analyze the context.** To analyze the context, we describe the subject-driven (internal) and community-driven (external) contextual bounds. This step defines the larger activity systems (context) within which activity is bounded, including the assumptions and beliefs held by the subject, as well as the rules and structures held by the larger community. The aim is to describe ‘how things get done’ within the broader context.

<table>
<thead>
<tr>
<th>Instructor and Administrator Activity Systems</th>
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<tbody>
<tr>
<td><strong>Subject’s Assumptions/Beliefs; Formal and Informal Rules and Roles imposed by Larger Community</strong></td>
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<tr>
<td>- Success in college algebra translates to success in further mathematics courses</td>
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<tr>
<td>- Instructor-specific beliefs about teaching and learning</td>
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<td>o Amy and Vera: Lecture is not effective and use it minimally; Vera has spent years creating a flipped classroom model that works for her</td>
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<td>o Josh: &quot;I'm a very boring teacher. You know, like what you imagine, a very traditional college math class to be, is really what my class is. I go up to the board, I talk, talk, talk, and I write, write, write, and they write, write, write, and then that’s it. …I would say it's kind of like the, I do, we do, you do model”</td>
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<td>o Pam: Believes teaching is lecture; “I've always had a struggle with feeling like students at that level of math [below college-level] can learn it by themselves, um, watching a video without being able to ask their questions… I just feel like instruction is what they need and what they soak in the best.”</td>
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<td>- Students need developmental math to do college algebra</td>
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<td>o Pam: A lot of students are “lacking skills” and need the dev classes for content</td>
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<td>o Pam and Vera: Students gain 'school-going' skills in dev courses (timeliness, work ethic, etc.)</td>
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<td>o Tony: students are not ready for a ‘full’ coreq model so the current reform is a stair-step</td>
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<td>- Mathematics has long been used as a gatekeeper</td>
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<td>o Amy: “I can think of several students who I think ‘this will get you thru and you’ll get on to the next thing.’ Hopefully they can get through their other classes, but at least the math won’t be holding them back.”</td>
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<tr>
<td>o Gustavo: Many other courses had indicated math courses as prerequisites in order to limit student enrollment</td>
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<td>- [Admin] Students are more successful when they can complete requirements more quickly</td>
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