Understanding the learning experiences of developmental math students

by

Eric Lawrence

B.S., Kansas State University, 1998
M.S., Kansas State University, 2005

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Curriculum and Instruction
College of Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

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Abstract

Developmental math education is designed to offer a pathway to college-level subject readiness. Existing research in developmental math education has evidenced success stories while also revealing opportunities for improvement. Prior studies have focused on issues of self-efficacy and have also contended with not only what helps students learn better, but also how this learning should be measured in the first place. Increasing external pressures from politicians and business interests underscore the need for greater understanding of how developmental math students can learn more effectively.

The research question for this study is: *How do developmental math students experience learning in their developmental math coursework?* Rather than beginning with an existing theory of how these students learn, this study used a grounded theory methodology to develop a framework from the students' descriptions of their experiences. Data was collected over two phases. The first phase was a brief online survey that served as a baseline for discovering relevant themes. These formed the basis for questions in the extended individual interviews for the second phase of data collection. In vivo, axial, and focused coding were used to create the emergent framework for how developmental math students learn.

The survey identified themes of course engagement, affective teacher qualities, course structure, and student positionality as meaningful for the students. Analysis of the interviews led to the resultant theory that the students' experiences were fundamentally influenced by the students' ability to receive one-on-one help, their perception of their instructors' willingness to help, and the extent to which their courses provided a supportive structure to organize the learning. Implications, limitations, and opportunities for further research are discussed as well.

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Acknowledgements

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Chapter 1 - Introduction

The National Center for Developmental Education (2019) defined developmental education as "the integration of courses and services guided by the principles of adult learning and development" (section "NCDE Mission Statement," para. 1). Research in developmental math education has offered evidence of success in helping students persist and complete college-level coursework. For example, Bahr (2008) analyzed data from nearly 86,000 freshmen across 107 community colleges and found that students who completed remediation performed similarly in college-level math classes to students who did not remediate, concluding that "remedial math programs are highly effective at resolving skill deficiencies" (p. 420). Calcagno and Long (2008) concluded that remediation might promote early persistence as well (p. 22).

At the same time, research has also shown difficulties with developmental education outcomes. Martorell and McFarlin (2007) conducted a data review in Texas, arguing:

> Aside from weak evidence that remediation improves the grades received in college-level mathematics courses, we find little indication that students benefit from remediation. Our estimates indicate that remediation has a minimal impact on the years of college completed, academic credits attempted, receipt of an academic degree, and labor market performance. (cover page, abstract)

While Calcagno and Long (2008) found possible improvement in early persistence, they also claimed that remediation may not be helpful for students close to the cutoff between remediation and college-level coursework (p. 22). Boatman and Long (2010) subsequently found that remediation for students at the cutoff has mostly negative effects, although they also argued that remediation could have positive effects for students at lower levels of academic preparation (p. 21).

Claims abound that developmental education is actually a barrier to learning, with low completion rates often cited as *prima facie* evidence that developmental education does not work. Calls to reform developmental education may be further complicated by not being accompanied with means for colleges to make such reforms. This can particularly be a challenge for community colleges that may not be able to fund the requested changes.

MDRC (originally founded as the Manpower Demonstration Research Corporation in 1974) released the report "Developmental Education: A Barrier to a Postsecondary Credential for Millions of Americans" in 2013. The thrust of MDRC's criticism was completion; the phrase "completion rates" appears four times in a report of only two pages (MDRC, 2013). The MDRC argued for "comprehensive, long-term reform strategies that address all aspects of a community college student's experience" (MDRC, 2013, p. 2) but offered no suggestions for financing reforms. Also, the MDRC claimed without evidence that many students who do not achieve the minimum placement score are ready for college-level material, and that developmental education instructors often do not understand adult learning (MDRC, 2013, p. 2). The report illustrates the double-edged sword that developmental education advocates may encounter: being told that current practices are insufficient for addressing difficulties in developmental education while simultaneously not being given the means needed to make improvements.

Perhaps the most prolific organization calling for reform in developmental education over the last decade has been Complete College America (CCA). Founded in 2009, CCA's mission is "leveraging our Alliance to eliminate achievement gaps by providing equity of opportunity for all students to complete college degrees and credentials of purpose and value" (CCA, n.d.-a). CCA's completion agenda revolves around six principles:

- *15 to Finish*: encouraging students to complete 15 credit hours per semester (30 credits per year, including summers)
- *math pathways*: creating alternative math course lines leading to statistics or quantitative reasoning
- *corequisite support*: adding an additional course or lab to college-level classes for underprepared students
- *momentum year*: supporting each student for first-year benchmarks, including at least nine credits within the student's major, as well as advising
- *academic maps with proactive advising*: placing students using "highly-structured academic maps" with milestones and prerequisites, while offering extensive advising support
- *a better deal for returning adults*: encouraging adults to return to college with accelerated courses, flexible schedules, and credit for prior learning and experience (CCA, n.d.-c)

Not one of the principles explicitly deals with funding the reforms (CCA, n.d.-c). As of early 2019, CCA listed 37 states among the members of its alliance, as well as the District of Columbia and Puerto Rico (CCA, n.d.-b). CCA has received financial and policy support from the Lumina and Bill & Melinda Gates Foundations (Fain, 2012).

Reform efforts have not always been made with a velvet glove. Influenced by CCA, the Texas Association of Business (TAB) used billboard advertisements in 2011 that targeted two separate community college systems (Fain, 2011) based on graduation rates. In October, TAB took aim at Austin Community College with a billboard that claimed a 4% graduation rate in three years and asked, "IS THAT A GOOD USE OF TAX$?" (Fain, 2011). Two months later, TAB ran a similar billboard against Dallas County Community College District, which cited an 8% graduation rate in three years and mused, "IS THAT FAIR TO THE STUDENTS?" (Zeeble, 2011). Community college leaders argued that the billboards were misleading because they focused on full-time students rather than part-time students who represent the bulk of attendees (Fain, 2011; Zeeble, 2011). TAB president Bill Hammond remarked, "I consider myself a critical friend of public higher education," (quoted in Fain, 2011, section "True Believer on Completion," para. 9). Texas Association of Community Colleges vice president Steven Johnson expressed a desire to work with TAB, but he claimed that the association "has done little to work with community colleges in the state" (Fain, 2011, section "True Believer on Completion, para. 1-2).

In response to this type of criticism, the NCDE and the National Association for Developmental Education released a joint statement with a main title of "Remediation: Reports of Its Failure Are Greatly Exaggerated" in 2019. NCDE and NADE conceded that developmental education was very much in need of improvement, and that both organizations supported sincere reform efforts. But they also argued that such efforts had been undermined by considerable distortion of data by policy makers and the media (NCDE and NADE, 2019, para. 2). The organizations added:

> To say that remediation has completely failed is to denigrate the innovative and successful efforts of countless instructors on countless campuses to help students overcome underpreparedness. . . . There are many professionals doing an outstanding job of teaching remedial courses and getting excellent results that are not reflected when large sample data is aggregated. These professionals should not have their efforts denigrated by those who understand neither the available research nor the challenges

> involved in teaching underprepared students. In fact, it is their efforts that have led to many of the innovations now being promoted in the developmental education reform movement. (NCDE and NADE, 2019, para. 3)

The joint statement acknowledged that while current developmental education practice is not without its shortcomings, there are also plenty of success stories that demonstrate how remediation can work when done well.

There is a distinct need for developmental education instructors to gain greater understanding of how their students can learn successfully, as these students may experience learning very differently than the instructors did as students themselves. Prior to this research, the investigator was full-time math faculty at a community college for nine years, teaching developmental math extensively. Additionally, the researcher conducted two similar investigations with students about their college math experiences (albeit not specifically on *developmental* math) for graduate coursework. The first was an action project in Spring 2017 on what adult math students viewed as helpful and unhelpful in their learning. The second was semester-long study in Spring 2018 that asked about the learning experiences of undergraduate math students, the impact of student-teacher interactions for these students, and the impact of course experiences on the students' sense of feeling in control of their learning. While these projects provided some level of insight, they also confirmed the importance of further investigation of how developmental math students can learn effectively.

The current study differs from the investigator's prior works in a couple ways. First, this research is on a considerably larger scale than those projects, which allows for more in-depth exploration, which is certainly needed in the study of developmental math education. Of course, this is not to say that research in developmental math ed does not exist. But much of it is focused on specific elements of developmental math students' experiences, particularly math anxiety and self-efficacy; the current knowledge base is described further in the literature review.

This research throws the doors open, so to speak, by letting the students elaborate on exactly what they believe impacts their learning. To the extent that concerns regarding math anxiety and/or self-efficacy arose from the current investigation, this occurred not because the investigator prompted students specifically about these concerns. Rather, the findings are the results of the students' thoughts and not the researcher's prior notions of what impacts these students.

This connects with the second aspect in which this research differs from the investigator's previous related projects. Those works included open-ended questions for students with encouragement for the students to elaborate in their responses. However, the questions often focused on specific aspects of their times as math learners. As examples, students were asked to describe their classroom experiences, assignments, and instructor interactions.

Even as open prompts, the questions were still somewhat leading. Asking about these elements implicitly identified the aspects of their math learning that the researcher regarded as important. But the questions for this study permitted the students to tell the investigator what was important to them, rather than imposing values that might not coincide with those of the students. This research structured the question prompts and the interactions with students in ways that encouraged the students to be forthright about their learning experiences.

The purpose of this study is to generate a theoretical framework for the experiences of developmental math students, in the hope of informing how instructors can teach these students more effectively. The research question for this study is: *How do developmental math students* *experience learning in their developmental math coursework?* The contents of the remainder of this dissertation are as follows:

- Chapter 2 is a literature review that describes existing research on developmental math education to highlight what is already known in this area. It then shifts to different perspectives on what it means to learn—both in general and with math—to frame context for how students might view their learning.
- Chapter 3 overviews the methodology. This begins with a description of the students and their college. It then notes the data collection process which occurs over two phases: an initial online survey for baseline data, followed by individual interviews using questions that were developed as a result of the survey analysis. The coding process for the analysis is described as well. A section on grounded theory is included for additional perspective on why the research was conducted as it was for this study.
- Chapter 4 reports the results. This starts with a review of the survey; after looking at summary data for the respondents, the review moves into analysis of the open-ended questions for the emergent themes used to create the interview questions. From there, the interviews are considered, with the analysis of the students' responses laying the foundation for the conclusions.
- Chapter 5 presents the conclusions and implications. The chapter outlines the resultant theory for how developmental math students experience their learning. It then describes implications, observing not just what was important for students, but also what did *not* emerge as critical in the students' experiences. Finally, the chapter notes limitations and presents opportunities for future research.

References and appendices are at the end of this report.

Results from the survey indicated *course engagement*, *affective teacher qualities, course structure, and student positionality* as the key themes. After the interviews where students outlined their experiences within each theme, the emergent theory holds that *the students' experiences were impacted by their ability to receive one-on-one help, by their sense of their instructors' willingness to help, and by the extent to which their courses contained supportive structure*. Implications and opportunities for further research include the need to explore the specific types of activities, resources, and interventions that might be particularly beneficial to students, while also observing that factors such as type of postsecondary institution, school setting, developmental math education implementation, and demographics may impact students' experiences as well.

Chapter 2 - Literature Review

The focus of this research is on how developmental math students experience learning in their developmental math coursework. The literature review begins with a discussion of what aspects of developmental math education have been considered in the research. This is followed by a review of how existing studies have regarded what it means to learn developmental math.

What Aspects of Developmental Math Education Have Been Considered?

Much of the research on developmental math has targeted concerns about students' self-efficacy or math anxiety. A great deal of this work was quantitative in nature and utilized instruments designed to measure efficacy and anxiety over large samples of students. A handful of qualitative explorations have been done as well. Since the qualitative research has some methodological overlap with this study, the qualitative work is reviewed in greater detail. Still, these other studies differ from the present investigation in various ways, as also described in this section.

Self-Efficacy

Cordes (2014) conducted a phenomenological study of the experiences of developmental math students. Participating students first responded to a questionnaire where they rated their agreement to various statements regarding math in particular and learning in general. Cordes then sent a formal response questionnaire asking for information about students' current and past math course experience, which was followed by individual interviews in which participants were asked to describe their experiences with math coursework and their feelings on being in developmental education.

In her findings, Cordes (2014) did not find any sense of incorrect course placement among her participants; in fact, all of them felt that their placement was good (p. 157). However, Cordes reported isolation as a problem for the students in terms of wanting to seek help. Additionally, participants reported negative feelings about math—and, connecting to self-efficacy concerns, students expressed concerns about their perceived lack of mathematical ability. Inability to progress through their developmental math coursework, which used a self-paced emporium model, was also an issue. Finally, participants were frustrated by the emporium model itself; they believed they would have been more successful with a traditional class format.

The study by Cordes (2014) described important affective dimensions for her participants. With this said, her study was focused differently than the investigation for this study, in a few significant ways:

- Not one of Cordes's research questions focused explicitly on student learning. Instead, her study explored how students' lives intersected with developmental math and particularly how students reacted. While this dimension is essential to understanding how developmental math students learn, the current research explores their experiences specifically in the context of how the students saw their learning.
- Cordes used a phenomenological approach to capture her students' experiences. The research for the current study sought to develop a framework for how developmental students learn math; grounded theory was selected as the best suited approach for this, as is further explained in the methodology. In particular, Cordes rejected the use of grounded theory, claiming that no research existed to support the use of grounded theory in her study (Cordes, 2014, p. 82).
- Cordes's study took place at "a private, Christian, non-profit, four-year university" (Cordes, 2014, p. 90). In contrast, the current investigation drew students from two public colleges: a community college and a university.

- The participating university in the Cordes study offered developmental math courses only through an emporium model—and furthermore, these courses were taught exclusively by full-time faculty. Of course, many students who take developmental math do so through other course delivery modes (for example, face-to-face, hybrid, and full online). Additionally, developmental courses are frequently taught by adjuncts who often have no regular presence on campus beyond their time in the classroom itself. The research for this study considered students from a range of delivery modes and instructional backgrounds.

Again, Cordes's work offered a critical perspective on developmental math students' experiences. With that said, the current investigation strove to illuminate considerations specific to learning in a traditional setting for developmental math.

Another work closely related to this research is the work by Miller (2018) regarding techniques that developmental math students view as effective for improving their self-efficacy. The participants were seven students at a four-year technical college who self-identified as not believing they could learn math or earn good grades in math. Each respondent completed an individual semi-structured interview where they answered open-ended questions regarding their perceived ability to learn math, their previous and current experiences in math, and their feelings about how well they can learn math in future coursework. Miller used grounded theory (as is also used in this dissertation) to analyze the interviews and to discover themes based on the students' responses.

From the interview analysis, Miller (2018) found the emergent themes of breaking it down/building it up, caring & coaching, creating a safe environment, and enabling small victories (p. 76). She recommended that developmental faculty incorporate technical and affective strategies so that students can feel safe and reflect as they learn (Miller, 2018, p. 85). Miller ultimately asserted that "the key to students' beliefs in their ability to learn math lies in the instructor-student relationship" (Miller, 2018, p. 92).

Miller's (2018) investigation of self-efficacy addressed an essential component of developmental math students' experiences. With this noted, the research for this dissertation differs from Miller's study in a few key aspects:

- Miller's work specifically targeted self-efficacy, whereas the current study is a broader look at student experiences that did not focus on self-efficacy at the outset (although it was considered to the extent that it emerged as a theme from the data).
- Since Miller's study used a tighter focus than the research presented here, Miller was able to develop targeted questions regarding self-efficacy prior to collecting student data. In contrast, this study did not enter with a specific thematic focus for developmental math learning, and thus it relied on a preliminary survey prior to the interviews for data essential for creating questions that reflected students' described experiences.
- Of particular note is that Miller restricted her consideration to students who held at least a grade of C at the midterm. Additionally, the threshold for a C at the college was 75%, which is a bit stricter than the conventional standard of 70% for a C. The current study used no such restriction, as this would eliminate from consideration many students in developmental math—and furthermore, it would neglect the students who need help the most.
- Miller purposefully selected students from classes where the instructor had demonstrated success in teaching developmental math, as identified by administrators

> at the college. In fact, the math department at the college primarily used full-time faculty for these courses in hopes of improving outcomes and retention. The research presented here was open to a range of instructional quality and thus was not subject to any attempt for selecting the "best" faculty. Developmental math students generally do not have the luxury of cherry-picking their learning experience; this study did not do so either.

Again, Miller's work offered insight on these students' self-efficacies. But the current study is a more widely ranging look at developmental math students' learning, and the themes considered here are not based on the researcher's selection; rather, the themes emerged from the students' descriptions of their experiences.

While these studies emphasized student-level considerations, Zientek, Ozel, Fong, and Griffin (2013) investigated both student- and teacher-level variables that predicted success, as measured by course grade, for developmental math students across three community colleges in Texas; this included self-efficacy beliefs. Using hierarchical linear modeling, the research lent empirical support to the premise that self-efficacy is an important consideration, particularly regarding student beliefs on resource management strategies, motivational strategies, self-regulated learning, and meeting other's expectations (Zientek et al., 2013, p. 1003). The authors recommended that instructors address self-efficacy with students across various strategies.

Additionally, based on the modeling, Zientek et al. (2013) found that teacher employment status (full-time versus part-time) and student attendance were significant predictors. The authors argued that their study evidenced the need for better communication between full-time and part-time faculty, attendance policies, regular quizzes, and academic interventions for struggling students (Zientek et al., 2013, p. 1005). Collectively, the theme of these recommendations is greater check-ins on students—here, in the forms of attendance policies, regular quizzes, and help for struggling students. While this theme may not be immediately apparent in the first recommendation for improved communication between faculty and adjuncts, another possible explanation (not offered by the authors) for the significance of employment status is that adjuncts often do not have office space on campus, which would indeed present greater difficulty for these instructors to check up on students without a consistent campus presence.

The above studies focused on students and/or teachers. But research by Morales, Ambrose-Roman, and Perez-Maldonado (2016) worked at the program level, by analyzing a peer mentoring structure that targeted developmental math at a public urban university. Prospective mentees were thoroughly vetted, and they were trained both before and during the first semester of the program (p. 126). For each of the three semesters of the program, 15 students who were on academic probation were mandated to complete the program to remain at the university. All participants were in the same developmental math course and section. The authors used pass rates, end-of-semester individual interviews, and focus groups for their analysis.

Over the life of the program, Morales et al. (2016) found that 72% of the participants (n = 45) passed their coursework, compared to 35% (n = 71) of nonparticipants (p. 129). For the participants, about 80% felt greater self-efficacy, and approximately 70% reported increased social integration and engagement beyond the program itself (Morales et al., 2016, pp. 129-130). Also, mentees experienced less "otherness" and isolation as well as a greater connection between their home and school lives, leading to greater academic engagement (Morales et al., 2016, pp. 131-132). The authors recommended increased mentor training, better working relationships with faculty, and enhanced data collection (Morales et al., 2016, pp. 132-133).

At the same time, the program described by Morales et al. (2016) presented difficulties in terms of implementation that might limit or prohibit replication at other colleges. In particular, the program had financial and personnel resources that might not be available at other colleges. Furthermore, program coordinators were able to tailor the faculty selection to "someone particularly well suited to the population" (Morales et al., 2016, p. 127), which might not be a luxury available to other colleges in implementation, based on existing faculty demands. Morales et al. (2016) observed that the program in fact ended upon exhaustion of the corresponding grant, but they noted that "aspects of it have been institutionalized" (p. 125).

Math Anxiety

Zopp (1999) conducted a study with nontraditional students—all of whom were at least 25—who were enrolled in community college math and also had high scores on the Math Anxiety Rating Scale (MARS). In addition to undergoing a treatment program for math anxiety, the students completed three interviews: one at the start of treatment, another after treatment, and a final interview upon completion of their math course.

All eight participants in Zopp's (1999) study finished with a grade of C or better in their math course. Collectively, they also reported relief in their anxiety, with seven of the eight students also noting that they felt prepared for their next math course. For faculty, Zopp argued that instruction in math courses should include study skills, test-taking strategies, and cooperative learning. She also observed that many adult students are reluctant to enroll in math coursework in the first place, and she recommended that math anxiety treatment be implemented and promoted at the college and community levels (Zopp, 1999, p. 110). A potential barrier Zopp found was that enrollment in math anxiety treatment was low; of the 135 students who took the MARS assessment at the outset of the semester, 66 showed at least a fair amount of anxiety, but only 11 signed up for the treatment.

From a psychological perspective, Schmidt (2005) offered an in-depth look into causes of math anxiety in developmental math students—not just from within their math classes, but over the context of their lives. The researcher interviewed seven female community college students with MARS scores at least one standard deviation above the mean. Using grounded theory, Schmidt asked the participants about their childhood (both school life and homelife), their lifelong experiences with mathematics, and their current views of math (including impact on career choices as well as cultural considerations).

From his analysis, Schmidt (2005) found eight themes:

- Disrespecting/Humiliation and Fear Based Instruction (Math Authority Fear)
- Disbelieving or Abusive Parents (Primarily Fathers)
- Turbulent Home Life and Parental Conflict
- Major Life Transition (Moves, Divorce, Death)
- Math-Me Inadequacy—Negative Self-Appraisal
- Perfectionism (Control/Fear of Failure)
- Cultural and Gender Acceptance to Hate/Flunk Math
- Respectful and Supportive Instruction (Corrective Emotional Experience) (p. 111)

Again, Schmidt operated from a perspective of psychology and not education. As a result, his implications did not deal in specific instructional techniques but rather in attitudes and interactional strategies for teachers and others who encounter students with math anxiety. Schmidt wrote:

A teacher or parent who can sit with the math anxious student without bias or

> judgment, and accept the individual and their experience, has begun to plant the seeds of hope, safety, and confidence. These three pillars are the foundation from which the student can be lifted, out from the depths of anxiety and despair. This study does not advocate tutors and instructors performing psychotherapy with their students, rather, it emphasizes supportive and nonjudgmental assistance. Most of the participants highlighted how important it was to feel unconditional positive regard and sincere interest, without pressure or impatience. An instructor, who was perceived as making a concerted effort at the student's pace, promoted academic learning and growth. This study asserts that teaching and tutoring with empathy and heart, is one of the greatest tools to employ with the math anxious student. (Schmidt, 2005, p. 157)

The researcher asserted that as these students try to learn math, their current negative experiences might evoke memories of prior difficulties in their lives—and, furthermore, that such responses are sometimes "classically or operationally conditioned" (Schmidt, 2005, p. 158).

Summary

Issues of self-efficacy and math anxiety have been prevalent in the literature. Indeed, there have been successes with offering additional supports for students, although many schools might lack the money and personnel to implement such reforms. But an additional wrinkle to consider is what constitutes success in developmental learning; making reforms with no goals in mind is nonsensical. The next section addresses how existing studies have dealt with the question of what it means to learn for students in developmental math.

What Does It Mean to Learn Developmental Math?

Since the research question relates to developmental math learning, a proper review of the literature should at least consider existing studies regarding what it means to learn developmental math. Of course, this study specifically targets how *students* understand their learning. As a result, for the sake of this research, the participants' perspectives of how they learn math—and not the researcher's sense of what it means to learn—were at the center of the analysis.

Even so, the current research on this front should be synthesized. This subsection informs what has already been discovered about how students learn developmental math. It is further worth noting the points of view in existing studies. Current research was regarded with two fundamental questions:

- *How have prior studies operationalized learning?* What was their measure to determine whether students learned developmental math successfully? Did they use course completion or retention? Did they probe students' conceptual understanding? Or, in research where students were asked to describe their own learning, how did the students themselves understand what it means to learn?
- *To what extent do findings reflect students' or instructors' perspectives?* Certainly, it is possible for a student to believe they have learned math while the instructor believes otherwise. The reverse may be the case as well: The instructor might be satisfied that the student has learned, but perhaps the student still does not feel confident in their learning.

To be clear, these questions are not disconnected. For a study where learning was measured through completion or retention, such data could be gathered directly from the institution, which thus removed the need for the perspectives of students and instructors. On the other hand, this type of data was important if learning was evaluated as a function of student or teacher experience.

The following subsections address the different ways in which developmental math learning has been operationalized in existing research. The first subsection deals with learning as measured by completion or retention, which has been a dominant approach in the literature. But some studies have considered aspects of student or teacher experience in evaluating learning, and these are discussed in the second subsection.

Learning as Completion or Retention

Considerations of course completion and retention are extremely common in the literature. Surely one reason is expediency; completion and retention statistics are relatively easy to obtain, compared to attempts to measure students' conceptual understanding. But as the discussions of MDRC and Complete College America in the introduction illustrate, consideration—and especially criticism—of the perceived effectiveness of developmental education is very real, and this also appears to be a factor for using completion and retention as metrics as well.

In previous work (Lawrence, 2016), the researcher noted this phenomenon in several states. Missouri's House Bill 1042, passed in 2012, mandated that public colleges "replicate best practices in remediation" (HB 1042, 2012, p. 3) as determined by a coordinating board. However, the bill required that the board was filled by the governor with senate approval—and the bill further noted that educators and education administrators were expressly *forbidden* from serving (p. 1).

The researcher's prior study (Lawrence, 2016) also observed legislative attempts to eliminate or bypass developmental coursework in Connecticut (PA 12-40, 2012) and Florida (CS/CS/SB 1720, 2013). In the latter case of Florida's SB 1720, where Florida public high school graduates were allowed to bypass developmental coursework and placement testing

(CS/CS/SB 1720, 2013, p. 30), the pass rate for college-level math or intermediate algebra declined from 55.7% to 46.8% as enrollment in those courses increased by about 25% in the wake of the legislation (Smith, 2015). Hunter Boylan, the director of the National Center for Developmental Education, observed:

> This isn't rocket science. If students don't have the skills to complete a college course and you let them take the course, there's a likelihood they'll fail the course. . . . What did they expect? All along this legislation was questioned by experts in the field. (quoted in Smith, 2015)

Some Florida schools developed their own tools for determining whether to suggest developmental coursework for students. But under the law, Florida high school graduates were free to disregard such recommendations—and in the case of St. Petersburg College, students who were suggested a developmental course but opted into the college-level-equivalent course were more likely to fail (Smith, 2015).

Indeed, multiple studies have used completion and/or retention as measures of learning outcomes. As already described, the study by Morales et al. (2016) on a developmental math peer mentoring program used completion rates as a measure of success. Also, the previously described study by Zientek et al. (2013) relied on course grade as its learning metric.

Manning (2018) reviewed the changes in developmental math at a community college in North Carolina. The researcher’s description of North Carolina’s reforms highlights the motivation for the changes:

> The overarching goals of the math reform were to improve the success of developmental students by allowing as many students as possible to bypass developmental math and proceed directly to college-level math, or for those who could not bypass the courses, to

> accelerate their progress through them. Basically, the colleges wanted students to use fewer of their Pell dollars taking developmental courses and to spend fewer terms floundering in developmental education. (Manning, 2018, p. 86)

Beyond the focus on completion, this passage also illustrated a perception of developmental coursework as an obstacle where students are "floundering" like a fish out of water—a term the researcher used later in the article as well (p. 90)—rather than as an asset where students are building understandings that help them become successful in college-level classes.

Furthermore, Manning (2018) observed:

> All student success indicators are improving. Developmental students are enrolling immediately in developmental math, completing it faster and enrolling in college-level math. Multiple measures students are doing well in college-level math and English, and are also accumulating more credits than either students placed into college-level or developmental math. Retention and completion are improving across the college. (pp. 90-91)

Again, the researcher framed success in terms of completion and retention. The study did not indicate any measure of students' conceptual understanding of math.

Related to considerations of completion and retention is where students are placed in a developmental math sequence when they begin such coursework. Melguizo, Bos, Ngo, Mills, and Prather (2016) investigated the effect of placement policies on student success as measured by completion rates. The authors found that students who place in lower courses have lesser completion rates than students who place in higher courses (Melguizo et al., 2016, p. 146).

Discussing their findings on cutoff scores for developmental math placement, Melguizo et al. (2016) argued:

> On average, students at the cut point who are placed in lower-level courses should do better than their peers who are not. If not, then the cut points should be lowered gradually until the costs and benefits of developmental education for these students are in balance. In those colleges where students never catch up, colleges could experiment with lowering placement cutoffs. In those colleges where students do eventually catch up over a longer period of time, colleges can consider ways to decrease the amount of time it takes for students to achieve academic milestones. (p. 148)

The authors recommended setting a placement cutoff by comparing student performance on either side of the proposed line—and if the success rate is the same on each side, then the authors argued for lowering the line. Student comprehension of math is not directly regarded here. It is entirely possible that students on either side of the line might not understand math well at all, in which case lowering the cutoff would take some students from a lower level of math they do not understand, and then put them into a higher level of math they understand even less.

Cox and Britt (2017) investigated the effect of learning styles (via Kolb's Learning Style Inventory) on academic achievement, where the latter was operationalized by final course grade. Additionally, the authors' consideration of existing research focused on studies that measured success by completion. Cox and Britt (2017) ultimately found no statistically significant effect, regardless of course modality (p. 14).

Other examples of completion and retention as measures of learning abound in the literature. Focal points have included completion rates themselves (Okimoto & Heck, 2015), progression (Fong, Melguizo, & Prather, 2015), persistence (Davidson & Petrosko, 2015), course grades (Weisburst, Daugherty, Miller, Martorell, & Cossairt, 2017), and examinations (Ashby, Sadera, & McNary, 2011; Bol, Campbell, Perez, & Yen, 2016). While these considerations are certainly important to teachers, it is reasonable to believe that such a heavy focus on completion and retention somewhat owes to external pressure from politicians, advocacy groups, and business interests, as previously described.

Conceptual Learning and Student/Instructor Perspectives

Regarding student success in terms of completion or retention makes for relatively easy data gathering from institutions. But when the standard is conceptual understanding, how is this measured? And does this information paint a different picture than the one suggested by completion and retention rates?

Quarles and Davis (2017) raised the question of whether developmental math learning—both procedural and conceptual—is actually related to course grades or completion rates. Math students at a community college in Washington State were given an algebraic skills assessment at two points: the beginnings of intermediate algebra coursework, and then college-level math coursework in the following quarter. Procedural and conceptual aptitudes were assessed.

Quarles and Davis (2017) made the following findings:

- Students' procedural scores improved by over 30 percentage points, but their conceptual scores only improved by about 10 percentage points. Furthermore, 26% of students actually showed a *decrease* in conceptual understanding after intermediate algebra coursework. (pp. 41-42)
- Procedural skills were significantly associated with course grades (r = .423, p < .001), but conceptual skills showed no significant association (r = .010, p = .917). (p. 41)
- When only procedural and conceptual skills were used in regression of precalculus grades, both types of skills were significant. However, when prior grades entered the regression, procedural skills were no longer significant. (p. 42)

- Across the three final regression models for course grades in college-level math coursework—precalculus, statistics and liberal arts math, and overall—grades were the most significant predictor across all three models. (p. 43)
- For the three final models, conceptual skills were significant at the $\alpha = .05$ level in the models for statistics/liberal arts and overall ($p < .01$), and conceptual skills were fairly close to significance in the model for precalculus ($p = .108$). (p. 43)
- Students who took at least one term away from math showed significantly lower procedural ability, with a decrease of about 22% on the procedural scale. However, conceptual ability was maintained regardless of the length of time away from math. (p. 43)
- There was "no significant relationship between completion and either conceptual or procedural knowledge" (p. 44).

The results of the work by Quarles and Davis (2017) illustrated a considerable disconnect between conceptual understanding and learning outcomes. Coursework improved *procedural* competence but not *conceptual* understanding—and furthermore, grades rewarded procedural over conceptual as well. Drop-off over time of procedural ability was almost immediate; almost all the decrease occurred within four months to a year, while conceptual understanding showed relatively little drop-off, even after more than two years (Quarles and Davis, 2017, p. 44). This is consistent with the work of Skemp (1987) which showed a notable decrease in rote learning—even after only one day—but showed comparatively little decline in schematic learning (p. 26).

Cox and Dougherty (2019) also examined the distinction between course completion and learning. Addressing reform efforts motivated by low completion rates, the authors argued:

> Such changes include revisions to testing and placement policies, amendments to the intended curriculum, and restructuring of the format and sequencing of courses. However, the measures that have highlighted the inadequacies of developmental math are, in themselves, insufficient for assessing the effectiveness of reforms to developmental math. (p. 245)

Cox and Dougherty (2019) called for measures of the effectiveness of developmental math education other than completion rates (p. 245).

In the research, Cox and Dougherty (2019) investigated the goals of students and instructors in developmental math, the extent to which students felt they had accomplished their goals, and how student perspectives interacted with the use of completion rates in assessing the success of developmental math. Focusing on pre-algebra, the authors collected data through classroom observation, course artifacts, and interviews. Students were asked about their learning, their course experiences, how the course and the instructor compared to others, and how relevant they viewed the course for their lives. Instructors were asked about their professional experiences and teaching philosophies, as well as about classroom activities and interactions observed by the principal investigator.

The faculty in the study consistently equated completion with learning. For the instructors, a passing grade was regarded as sufficient evidence that the student had the skills necessary for later coursework (Cox and Dougherty, p. 253). The instructors also conveyed student goals of increasing students' math confidence and helping students find practical uses for math; both goals were targeted explicitly by instructors in their interactions with students. The authors argued that the faculty's instruction aligned with the National Research Council's productive disposition math competency, and they further claimed, "These goals comprise an essential component of the NRC's conceptualization of mathematical proficiency, they represent an aspect of student learning that can be assessed, yet they are not accounted for in conventional completion measures" (Cox and Dougherty, 2019, p. 254).

The students in the research were interested in completion as well. Perhaps unsurprisingly, they wanted to move through their course sequence as quickly as possible. But at the same time, 18 of the 25 students also sought to *understand* the math; they consistently expressed desire to know why the math works. These students distinguished between procedural and conceptual understanding. They valued detailed explanation and individualized feedback (Cox and Dougherty, 2019, p. 255).

However, the students generally did not view math as relevant. While they did note examples of applications where arithmetic is useful, they found little to no value for higher math in their lives (Cox and Dougherty, 2019, p. 255). Additionally, of the 18 students who wanted greater math understanding, only three actually believed they had gained this by the end of the course. Many of the students were complimentary of the instruction they received but yet did not feel they understood math better as a result; the value they found was in refreshment of procedural competence (Cox and Dougherty, 2019, p. 257).

And for many students, the focus on mere refreshment of procedures was paralleled by frustration. Furthermore, not one of these students felt more confident with math (Cox and Dougherty, 2019, p. 258). This led to angst with placement testing, where students saw difficulties as issues simply with recall, rather than as gaps in their learning. As recounted by the authors, one student's description of her experience emphasized this distinction:

> Clare critiqued the course by saying, "it sucked a lot. I would rather be learning something that I didn't learn, than reviewing something that I learned for four years."

> Clare also acknowledged that the reviewing she accomplished during the course was temporary, noting "if you gave me the final right now I would probably fail." She followed up by explaining, "If you gave me the book and I reviewed for maybe an hour, I could definitely pass the final. It's just the reviewing because I forget so much, and it's just hard remembering every single step." (Cox and Dougherty, 2019, p. 258)

Clare's comments illustrate how developmental math students may simply view their math classes as obstacles rather than opportunities to understand. In Clare's mind, she had already learned the math, but she was stuck taking the course again.

Ultimately, Cox and Dougherty (2019) found a disconnect between completion and learning:

> Not only do students' accounts raise concerns about the effectiveness of the course, they also confound the completion issue: Focusing on students who passed the course handily and listening to what they gained from the course, and how they felt in the subsequent course suggests that completion was not necessarily accompanied by other evidence of learning other than short-term refreshing of procedural rules. The disconnect between completion and learning confirms the need for creating a more comprehensive picture of what is happening inside developmental math classrooms, how that shapes student learning, and the connection (or disconnection) between learning and completion. (p. 259)

As previously noted, the faculty generally viewed completion of their courses as evidence that students had the necessary mathematical skills. Students frequently shared this view—but they applied it to their *prior* coursework and thus were frustrated by repeating math which they believed that they had already learned. While instructors saw course completion as evidence of learning, students often viewed completion simply as a function of recall.

Conceptual understanding as learning also emerged as a theme in the previously described study by Zopp (1999) regarding treatment of math anxiety in nontraditional community college students. Zopp observed:

> An important goal for educators should be to guide students toward an understanding of concepts in contrast to the customary memorization or mechanization of computation skills. [Two participants] reported a lessening of anxiety and a rise in confidence when they concentrated on conceptual understanding instead of rote memorization. . . . The researcher was also an important participant in the study and, based on the findings, realized not only the importance of the Mind Over Math treatment program but confirmed the significance of study skills and an increased emphasis on conceptual understanding instead of rote memorization. (Zopp, 1999, p. 112).

Strictly speaking, this addressed conceptual understanding in the context of math anxiety relief, and it did not *directly* address the issue of what constitutes learning. However, as noted in the prior discussion of this study, all eight participants earned grades of C or better—and furthermore, seven of them felt ready for their next math class.

In the previously described case of Florida and SB 1720, Brower et al. (2018) considered at-risk students in gateway courses who were academically underprepared for college-level studies—particularly in math—in the wake of the legislation. The authors made site visits at 10 Florida colleges. In addition to institutional data, the researchers conducted focus groups with a variety of college personnel. Of the 518 participants across all colleges, 204 (39%) were students, 140 (27%) were faculty, 78 (15%) were administrators, 71 (14%) were academic advisors, and 25 (5%) were support staff (Brower et al., 2018, p. 117). Interview protocols varied depending on whether the focus group members were students, faculty, or so forth.

The participants in the study by Brower et al. (2018) described an array of positive and negative experiences across efforts to scaffold developmental math learning for students. The authors' findings were consistent with those noted in the prior description of the law's aftermath:

> Our study suggests that at-risk students may be poorly served by policy directives allowing them to bypass developmental courses altogether, at least in math. . . . Greater student choice in math course pathways is not necessarily beneficial for some students. (Brower et al., 2018, p. 123)

The authors further advocated for increased integration of support services with classroom instruction (Brower et al., 2018, p. 125). In making these findings, Brower et al. focused not on completion rates as a measure, but rather the perspectives of students, faculty, administrators, academic advisors, and support staff—and in the process, the authors offered a counterpoint to SB 1720's implicit presumption that waiving developmental coursework would facilitate faster math completion for struggling students.

Compared to research that has focused on completion and retention, research where conceptual understanding is the measure has been a bit rarer. But the literature that does exist on this in developmental math contains noteworthy findings. The research has shown that the dominant metrics of completion and retention have roots largely in procedural competence, and less in conceptual knowledge. Additionally, while procedural ability declines relatively quickly, conceptual understanding persists. This distinction makes a fundamental difference in research, as how learning is measured determines what results are found—and, as a result, what reforms are recommended. The contrast between procedural competence and conceptual understanding also offers a lens to understand how developmental math students view their learning, which is the goal of this research.

Chapter 3 - Methodology

This study considers how developmental math students experience their learning in developmental math coursework. The introduction highlighted the need for instructors to gain better understanding of how these students learn. From there, the literature review discussed what is already known about developmental math learning as well as how such learning has been measured in prior studies.

The current chapter outlines the methodology for the current research. It begins with discussion of the participants, followed by an outline of the two phases of data collection. The first phase was an online survey that provided baseline data for what developmental math students regarded as significant in their learning. This data was analyzed as the basis for the individual interviews conducted in the second phase. Grounded theory methodology was used throughout the study.

For the first data collection phase, students received an online survey that asked them for basic demographic information and then prompted them to describe their experiences with developmental math coursework in whatever manner they felt most accurately reflected their perspective. The students' responses were analyzed for emergent themes, which were then used to develop interview questions for the next phase.

For the second phase, some of the students from the first phase participated in individual interviews. These gave the researcher further understanding of the students' interactions with the themes that emerged from the first phase. Audio recordings of the interviews were made with student consent. The interviews were transcribed and analyzed for themes; the results of this analysis produced a final theory for how developmental students might learn effectively. A grounded theory methodology was used to ensure as much as possible that the findings reflected what the students valued in their learning, rather than any preconceived notions the investigator had based on prior experiences as a math student and as community college faculty.

Participants

The participants of this study were students across two postsecondary institutions who had recently completed developmental math coursework. These include a community college and a public university, both in the Midwest. For both phases, most of the respondents were from the university, with these students constituting 27 of the 33 (82%) of the survey participants and six of the eight (75%) interviewees. Relevant characteristics for each institution are briefly noted below.

The community college had a Fall 2018 headcount of approximately 2,600 students and a full-time equivalency (FTE) of about 1,700 students for the same semester. A demographic breakdown of the Fall 2018 cohort is as follows:

- Around 60% of the students identified as female.
- About 92% of the students identified as White.
- The mean student age was 23; the average female age was also 23, while the average male age was 22. Census data for the college aggregated age data within each gender by spans of years (e.g., under 18, 18-19, 20-21, and so forth) thus making exact calculation of median ages impossible—but available data show that for students of known gender, the likely median ages are 19 across the population, just barely 20 for females, and about 19 for males.
- About 46% of the students attended full-time.

Six of the 33 survey participants and two of the eight interviewees attended this school.

The university had a Fall 2018 enrollment of about 11,000 students, of which roughly 9,000 were undergraduates. The FTE for this semester was approximately 9,000. Further details are indicated below:

- Students who identified as females represented 55% of the undergraduate student population and 63% of the graduate student population.
- Approximately 74% of the students identified as White.
- The mean student age was 23.9 years. As with the community college, age data was aggregated within ranges, making precise calculation of the median impossible—but available data indicate that the median age is certainly between 21 and 24, and it is probably a little lower than 22.
- Roughly 70% of the students attended full-time.

Again, 27 of the 33 survey participants and six of the eight interviewees attended the university.

As this research required interaction with students, approval was obtained from the researcher’s appropriate Institutional Review Board (IRB). The IRB application included information about the objective, design, and relevance of the study. Relevant IRB module training was also required. Permissions from the appropriate research offices at both the community college and the university were also obtained. Approvals from faculty were obtained as needed. All permissions were secured before the researcher contacted students for this study.

Phase One: Online Survey

The researcher emailed prospective student participants to solicit their participation in the research. The email included a link to the initial survey and noted that students who completed the survey might be contacted individually by the researcher to request their participation in an individual interview. The initial round of emails was sent to the community college students; in the first of these emails, the researcher indicated positionality as a former community college instructor who returned to graduate school. In the subsequent round of emails to the university students, the researcher noted positionality as a PhD candidate.

The online survey is shown in Appendix A. Students were asked for their age, gender identity, and ethnic identity. They were also asked about their course format (traditional, online, computer lab, and/or other), as well as whether their current attempt in their math class was their first for that class—and, if not, how many previous attempts they had made at the class.

From there, the survey then asked students to describe their experiences in developmental math coursework. This information provided context for each student on their progress through the math sequence as well as the extent to which they have run into difficulties. Students were first asked to rate their current and prior experiences in their math coursework, using the following questions:

- How would you rate your learning experience in your math course this semester? (Students responded on a five-point Likert scale ranging from very negative to very positive.)
- How would you rate your effort to learn in your math course this semester? (This question also used a five-point Likert scale, with this scale ranging from very low to very high.)
- Is this the first semester in which you've taken a college math class? (yes/no)
- (for students not in their first college math course) How would you rate your learning experience across *all your college math courses*? (This used the previously described scale of very negative to very positive.)

- (for students not in their first college math course) How would you rate your effort to learn across *all your college math courses*? (This used the previously described scale of very low to very high.)

Finally, the focus then shifted to open-ended questions that gave students greater opportunities to describe their experiences in their own words:

- Think about the positive learning experiences you have had learning math in college. What made the experiences positive?
- Think about the negative learning experiences you have had learning math in college. What made the experiences negative?
- What do you wish that your math instructors knew about the way that you learn?

For the rating scales and the open-ended questions, the survey noted, “These are personal responses, and so there are not right answers. What is right to you may be different for someone else,” to encourage students to be candid.

Completed surveys were analyzed by coding for themes in the responses. As described by Saldaña (2016), a code “is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data” (p. 4). He defined coding to be both a process of *decoding* (understanding the meaning of data) and *encoding* (attaching a suitable label to a piece of data). Rather that viewing coding as a culmination, Saldaña observed that “coding is the transitional process between data collection and more extensive data analysis” (Saldaña, 2016, p. 5).

Preliminary data analysis for key responses was conducted using in vivo coding. An in vivo code consists of a quotation taken directly from the participant (Saldaña, 2016, p. 4).

Doing so helps the researcher combat the potential to color the analysis with their own perspectives rather than those of the participants. As Stringer (2014) argued:

> To minimize the propensity to conceptualize events through their own interpretive lenses, researchers should, wherever possible, apply the *verbatim principle*, using terms and concepts drawn from the words of the participants themselves. By doing so they are more likely to capture the meanings inherent in people's experience. (p. 140)

As the current study placed a premium on understanding students' learning experiences from their perspectives, in vivo coding is certainly appropriate for this.

The use of in vivo coding ensured that the students' voices remained front and center through the initial analysis. As Charmaz (2014) noted:

> [*In vivo*] codes anchor your analysis in your research participants' worlds. They offer clues about the relative congruence between your interpretation of participants' meanings and actions and their overt statements and actions. *In vivo* codes can provide a crucial check on whether you have grasped what is significant. (p. 135)

By requiring the use of the participants' own language, in vivo coding provided a built-in check for the researcher that the students' perspectives drove the analysis.

Furthermore, Saldaña (2016) observed that in vivo coding is well suited for research that poses ontological questions, including those that ask about the experiences of the population under study (p. 71), as the current study does for the learning experiences of developmental math students. Additionally, Saldaña (2016) noted that in vivo coding is appropriate for research that uses grounded theory (p. 71), which is the case for this study.

The critical passages highlighted in the first round of analysis were then organized through axial coding. As described by Boeije (2010), "Categories and propositions generated in the previous phase [of coding] are tested by confronting them with the new material" (p. 108). Boeije further described the purposes of axial coding:

> The primary purpose of axial coding is to determine which elements in the research are the dominant ones and which are the less important ones. . . . The second purpose of axial coding is to reduce and reorganize the data set: synonyms are crossed out, redundant codes are removed and the best representative codes are selected. (p. 109)

From the existing coding framework, axial coding sorts and clarifies this into an organization of codes that have emerged from the data. Just as with in vivo coding, Saldaña (2016) asserted that axial coding is also appropriate for studies that utilized grounded theory.

Each of the resultant core categories was then processed with focused (or selective) coding. Strauss (1987), using the "selective" version of the term, defined it as "coding *systematically* and concertedly for the core category" (p. 33). Strauss noted that as an investigator focuses on a specific category in selective coding, only codes related to that category are considered. He further stressed related codes should be connected to the core category "in sufficiently significant ways as to be used in a parsimonious theory" (Strauss, 1987, p. 33). Strauss remarked that the core categories should guide subsequent data collection. This was the case for the current research, where these categories shaped the interview script for the second phase of data gathering.

Focused coding prioritized the codes in the researcher's analysis. Charmaz (2014) observed that focused coding forces the researcher to make decisions on which codes best reflect the data, and she noted that this process makes the analysis faster without losing detail (p. 138). For this study, the importance of capturing the students' voices has already been highlighted; preserving student data through the analysis helped the researcher to keep the students' perspectives as focal in the analysis and to let the resultant theory emerge from this data. Indeed, Saldaña (2016) affirmed that focused coding is especially well suited for studies that use grounded theory (p. 240).

Coding is ultimately a subjective process. While this is a seemingly apparent observation, it is essential enough to note explicitly. In a study of developing conceptual categories from children's literary responses, Sipe and Ghiso (2004) objected to treatments of coding "that obscure the role of the researcher and present findings as fixed and infallible" (p. 472). The authors argued that many portrayals of such academic work "idealize the process, ignoring the difficulties and tensions inherent in collecting and analyzing data and in writing accounts of the research" (p. 472).

Furthermore, while the coding process has been presented here sequentially, in the order in which it typically occurred in the analysis, there was some overlap of coding cycles. This was especially true of focused coding. As Charmaz (2014) described:

> Moving to focused coding is not entirely a linear process. Some respondents or events will make explicit what was implicit in earlier statements or events. An 'Aha! Now I understand,' experience may prompt you to study your earlier data afresh. Then you may return to earlier respondents and explore topics that had been glossed over, unstated, or may have been too implicit to discern initially. (p. 141)

Once the core categories were constructed through axial coding, the review for related codes within each category led to the discovery of new relevant codes from the data that were not determined significant in the initial coding. Of course, these were incorporated into the analysis, and the core categories were revisited.

Sipe and Ghiso (2004) further noted the somewhat contradictory nature of using our knowledge as researchers of suitable theoretical frameworks while also not letting our existing perspectives box us into specific interpretations of our data:

> Although ethnographic research at times forefronts the notion of letting data "speak" and categories "emerge," we do not approach sites or data as blank slates, but are influenced by our prior theoretical readings and life experiences. The process is paradoxical: theoretical frameworks are essential to structuring a study and interpreting data, yet the more perspectives we read about, the greater the danger of overdetermining conceptual categories and the ways in which we see the data. . . . Acknowledging and drawing on my prior experiences, I [Sipe] wanted to be wary of overdetermining what I was going to analyze and remain open enough to allow alternative perspectives to emerge. (p. 473)

But the authors ultimately concluded that this conflict has value in the analysis if researchers are open to it:

> Prior knowledge is always in the background, whether consciously or unconsciously, when approaching coding. The more we add to our repertoire of knowledge, the more baggage there is for categorizing data. This tension is intrinsic to ethnographic research, and in embracing the contradictions we can draw on multiple lenses and construct a richer, more complex analysis. (Sipe & Ghiso, 2004, p. 483)

Phase Two: Individual Interviews

From the students who completed the survey, respondents were recruited for individual interviews. Potential participants were contacted using information provided in the survey. Interviews were conducted during Summer 2019. When a student agreed to be interviewed, the student and the researcher worked out a mutually agreeable day and time. For the university students who interviewed, which constituted six of the eight interviewees, this occurred around the end of the semester for their developmental course. The other two interview participants were from the community college and in developmental coursework for Spring 2019, and so their interviews took place roughly a couple months after their class.

Since the researcher lived hundreds of miles from the colleges the students attended, interviews were conducted by phone. Each student was assured confidentiality for their interview, and particularly that any data shared publicly in the study would be done so only through the use of a pseudonym. Interviews were recorded with student consent.

Development of the interview script focused on depth of response rather than sheer quantity of questions. In the first of the researcher’s previous investigations of undergraduate students’ math experiences, which was the brief action project conducted in Spring 2017, the researcher asked the participants eight questions. Other than the final question simply checking if students had anything else to add about their college math studies, the questions were typically narrow in scope. Furthermore, while the questions generally prompted students to elaborate, the researcher often did not encourage the participants when they were reluctant to speak further. For this investigation, the researcher sought more in-depth descriptions of the participants’ experiences.

Knowing this was a concern from the first study, the researcher attempted to rectify this in the semester-long work completed in Spring 2018. Specifically, the researcher attempted to address this by developing a much more extensive set of questions. Compared to the eight questions from the former project, the newer study used 21 questions—again, including a final check if students had further comments. The idea was simple enough: Asking more questions would produce more answers.

And, technically, there were more answers. But even with more data to analyze, the researcher still finished the second study somewhat unsatisfied with the lack of depth in the data. In hindsight, the researcher attributes this to the two factors that were problematic in the first research, but unfortunately were still unresolved entering the second study.

The first factor is that the questions were still somewhat narrowly focused. The researcher asked students about their classroom experiences, assignments, and instructor interactions. In fact, the questions about classroom experiences in the second study were actually reworkings of prompts from the first study that simply asked about learning experiences in general. Of course, this means that in moving to the second project, the questioning actually became *narrower*, in an attempt to get students to describe a particular aspect of their experience.

The second factor that contributed to the lack of depth in the second study's data was the investigator's failure to encourage students to elaborate, just as happened with the first project. As in the previous work, the researcher used follow-ups with several questions in hopes of eliciting greater detail of the students' experiences. But as before, the students frequently did not tell the investigator a great deal, and the investigator did not suitably probe the student's responses for greater depth.

The researcher had no intention of repeating these mistakes with the current study. The former projects would have given greater depth of data had the interviews been conducted more effectively, but they at least offered valuable insight on what *not* to do in future investigations of this nature. While these lessons have been of value in developing this study as a whole, they have been of particular importance in the creation of an interview structure that elicited meaningful data from the participants.

Regarding the narrowness of prior questions, the researcher determined that a grounded theory methodology would address this concern. More information is provided in the following section—but in short, grounded theory is about developing theory from the data. Getting richer responses from the students required interview questions that captured what is important to the students in their math learning, which might not necessarily be what the researcher views as essential to their experiences. The very purpose of the first phase was to get student input for analysis to understand what mattered to them, and then to create interview questions that asked students to elaborate on their ideas and concerns.

As for the other issue of not adequately following up on the students' responses, this was of course a matter of how the questioning was conducted. In the interviews for this research, students were asked to go into further detail on their responses in cases where the investigator felt that more information was necessary. This was facilitated simply by using an interview script with many fewer questions. But at the same time, these questions were much more relevant to the participants because the questions were developed as a result of what the students themselves observed in the survey.

Once the interviews were transcribed, coding was conducted in a similar manner to the survey phase. Again, in vivo coding kept the students' voices at the front of the analysis. Axial coding was then used to organized for themes; for the interviews, the organization was done within questions or related question pairs. Focused coding then refined the results. As with the survey phase, coding cycles sometimes overlapped in this phase as well.

More specifically, coding was done separately from one question or question pair to another. The researcher worked within each question or question pair, using axial and focused coding to produce the key ideas within the given question or question pair and thus describe the most meaningful aspects of the students' experiences. Once this was completed across all questions and question pairs, the researcher analyzed the key ideas across the entire interview analysis to determine the unifying aspects, which led to the resulting theory of how developmental math students experience their learning.

Grounded Theory

In graduate coursework, the researcher completed two investigations on math learning for undergraduate (although not developmental) students. One was as a single class assignment in Spring 2017, and the other was a semester-long project in Spring 2018. Both studies focused on specific elements of students' experiences that the researcher viewed as important; students were asked about their classroom experiences, assignments, and interactions with their instructors.

But as noted in the introduction to the methodology, the researcher wanted to gain the students' perspectives of how *they* experienced their learning. The researcher's goal for this research was not to funnel students through what the researcher valued, but to discover from the students what *they* see as important. A grounded theory methodology was determined to be to most suitable approach for this.

Glaser and Strauss (1967/2006) described grounded theory as "the discovery of theory from data—systematically obtained and analyzed in social research" (p. 1). As the researcher for this study wrote in previous coursework, Glaser and Straus:

> believed that existing theory had not succeeded "at closing the embarrassing gap between theory and empirical research" (p. vii). They argued that while efforts in refining *methods* to test theory had helped close the gap, attempts to address *theory* were less productive. Ultimately, Glaser and Strauss sought "to develop canons more suited to the discovery of theory. These guides, along with associated rules of procedure, can help

> release energies for theorizing that are now frozen by the undue emphasis on verification” (Glaser & Strauss, 1967/2006, p. viii). (Lawrence, 2018, p. 3)

Furthermore, as noted in the current researcher’s work:

> Another difficulty Glaser and Strauss (1967/2006) sought to avoid is what they termed as “exampling” (p. 5)—which, essentially, is confirmation bias. In this context, Glaser and Strauss envisioned a scenario where a researcher develops a theory and then seeks out examples consistent with the theory, noting how in this case, “one receives the image of proof when there is none, and the theory obtains a richness of detail that it did not earn” (p. 5). Of course, grounded theory does not have this dilemma, as the data creation precedes the development of the theory. (Lawrence, 2018, p. 4)

The research for this study emphasizes the students’ perspectives in formulating theory about how they might learn more effectively. The researcher sought with this study to avoid fitting the data into the researcher’s preexisting notions of how these students should learn. Rather, the researcher listened to the students and allowed them to speak for themselves.

Additionally, as noted in the researcher’s prior writing:

> Glaser and Strauss (1967/2006) addressed how a researcher using grounded theory can present their developed theory as credible. In this regard, the first of two problems Glaser and Strauss noted is clarifying the theoretical framework; this was the lesser issue for them, since abstract social science terminology overlaps qualitative and quantitative approaches (Glaser and Strauss, 1967/2006). Rather, Glaser and Strauss (1967/2006) were more concerned about “how to describe the data of the social world studied so vividly that the reader, like the researchers, can almost literally see and hear its people—but always in relation to the theory” (p. 228). (Lawrence, 2018, p. 4).

In presenting the data, the researcher strove to be faithful to the students' experiences, so the reader may see what the researcher saw from the participants.

In this study, the researcher addressed this latter concern in a couple ways. First, transcriptions of the interviews for the second phase were reviewed for accuracy. All transcripts were cross-referenced with notes and interview recordings to guarantee fidelity. Second, quotations from the students are used in the findings whenever possible. As community college faculty, the researcher did not hear from my students nearly as often as the researcher would have liked. The vast majority of students rarely came to office hours despite being urged to do so in class. The researcher further suspects that for many (or perhaps most) of the students who did talk, they often did not share what their real difficulties with the learning actually were, for fear of offending or insulting their instructor.

In that regard, this research afforded a unique opportunity to garner student perspectives in a structure where students could speak freely. The researcher is not the instructor for any of the participating students. Also, the study is not affiliated with the colleges at which the students were enrolled—and in particular, no data was made available to their instructors beyond that which is made publicly available through the use of pseudonyms. The result was a forum where developmental math students could tell the researcher what they are truly thinking, without fear of negative consequences. To this end, the students' views are presented in their own words whenever possible.

In terms of the interpretation of the data, the researcher observed the following in previous work:

> [Glaser and Strauss (1967/2006)] were particularly concerned about the potential for a researcher to misapply existing theory; they observed that such a researcher "uses this

strategy because he has not been trained to generate a theory from the data he is reporting so that it will help interpret or explain the data in a general manner. He does this also because he has been trained only to research and verify his facts, not also to research and generate his explanation of them. The explanation is added afterward" (p. 4). (Lawrence, 2018, pp. 3-4)

Plenty of research exists regarding K-12 math education, but the world of developmental math education is certainly different enough to merit separate consideration. While there is common ground between these two worlds, what is true of K-12 math education is not necessarily true of developmental math education. Such an assumption neglects to provide developmental math learners with evidenced-based educational strategies that have been shown to work specifically for these students.

More precisely, this study used *classical* grounded theory as defined by Glaser and Strauss (1967/2006), rather than *constructivist* grounded theory as popularized by Charmaz (2006) and then further described by Corbin and Strauss (2008); indeed, Corbin herself acknowledged her admiration of Charmaz's work (Corbin and Strauss, 2008, p. 9). Both Charmaz (2006) and Corbin (in Corbin & Strauss, 2008) embrace postpositivism and reject an objective view of the world, instead arguing that the results of grounded theory are interpretations; in fact, Charmaz claimed the existence of multiple realities (Charmaz, 2006, p. 132).

Chapter 4 - Results

This study explores how developmental math students experience their learning. The first two chapters established the need for research with these students as well as what is currently known about how they learn math. The previous chapter then described the methodology, which utilized grounded theory over two data collection phases. The first phase was an online survey to discover the elements of the students' learning experiences that the students viewed as essential. From there, the second phase relied on in-depth interviews with several students who completed the survey, where the interview script was developed based on the key themes and the comments that emerged from the survey. Over both phases, grounded theory ensured that the focus was on what the students themselves viewed as significant in their learning.

The current chapter begins with the results and analysis of the survey, emphasizing the principal themes that were discovered from the students' responses to the open-ended questions. This is followed by a review of the interviews, which used a script developed from the survey analysis. In the discussion of the survey data, the responses are considered within each interview question, or question pair in the case of related questions—for example, when students were asked in separate questions for a positive and negative experience of a particular aspect of their learning. Responses from the students are presented throughout this chapter to provide additional context for how the students viewed their learning.

Phase One: Online Survey

The survey is given in Appendix A. Consideration of the survey data starts with the results from the Likert-scale items (questions 6, 7, 9, and 10), where students were asked to rate their learning experiences. The discussion then moves to an in-depth look at the responses to the open-ended questions (11-13), which framed the themes used to develop the interview questions for the second phase. Each of these themes is highlighted in the review of the open-ended questions. Within each theme, key aspects are noted, drawing heavily on the students' answers to the questions.

Likert-Scale Items

Questions 6, 7, 9, and 10 asked students to rate their math learning experiences and efforts to learn math. In particular, questions 6 and 7 prompted each student to rate for their current math course. Then, if the student took a college math class in a prior semester (as checked by question 8), they were asked to rate across all their college math courses in questions 9 and 10. From the 33 students who answered these items, 23 indicated that they had taken a college math class before the current semester, and thus they received these additional questions.

Table 2 summarizes the results for questions 6 and 7, which were answered by all students. Table 2 then shows the responses for questions 6, 7, 9, and 10, but specifically for the students who previously took a college math class, to facilitate comparison across related question. The latter table is grouped first by the questions on learning experiences (6 and 9) and then by the questions for effort (7 and 10). The scale for the experiences questions ranged from very negative to very positive, while the scale for the effort question ranged from very low to very high. For both tables, averages were computed using point values from 1 to 5 on the scale, as indicated in the table headings.

Table 1: Survey #6, 7, All Students

QUESTION	V. NEG. (1)	NEG. (2)	NEUT. (3)	POS. (4)	V. POS. (5)	AVG.
6. How would you rate your learning experience in your math course this semester?	0 (0%)	5 (15%)	6 (18%)	13 (39%)	9 (27%)	**3.79**
QUESTION	**V. LOW (1)**	**LOW (2)**	**MOD. (3)**	**HIGH (4)**	**V. HIGH (5)**	
7. How would you rate your effort to learn in your math course this semester?	0 (0%)	3 (9%)	8 (24%)	12 (36%)	10 (30%)	**3.88**

Table 2: Survey, #6, 7, 9, 10, Students With Prior College Math Course

QUESTION	V. NEG. (1)	NEG. (2)	NEUT. (3)	POS. (4)	V. POS. (5)	AVG.
6. How would you rate your learning experience in your math course this semester?	0 (0%)	4 (17%)	6 (26%)	8 (35%)	5 (22%)	**3.61**
9. How would you rate your learning experience across *all your college math courses*?	0 (0%)	4 (17%)	8 (35%)	8 (35%)	3 (13%)	**3.43**
QUESTION	**V. LOW (1)**	**LOW (2)**	**MOD. (3)**	**HIGH (4)**	**V. HIGH (5)**	
7. How would you rate your effort to learn in your math course this semester?	0 (0%)	2 (9%)	6 (26%)	8 (35%)	7 (30%)	**3.87**
10. How would you rate your effort to learn across *all your college math courses*?	0 (0%)	0 (0%)	7 (30%)	11 (48%)	5 (22%)	**3.91**

From both tables, the students generally rated their experiences and efforts favorably, particularly with the effort ratings nearly averaging 4, which corresponds to the "high" rating on the effort scale. For students who took college math in an earlier semester,

Table 2 indicates that on average, these students viewed their current math experience slightly more favorably than their general experience across college math (3.61 versus 3.43), although the effort averages were nearly identical (3.87 versus 3.91).

Open-Ended Questions

Questions 11-13 elicited students' perspectives on their experiences and revealed what students saw as important in their math education. These questions were:

11. Think about the positive learning experiences you have had learning math in college. What made the experiences positive?
12. Think about the negative learning experiences you have had learning math in college. What made the experiences negative?
13. What do you wish that your math instructors knew about the way that you learn?

For future reference, these questions will be referred to as the positive, negative, and wish questions, respectively.

Four themes emerged from the analysis of the open-ended questions. This includes three major themes and one minor theme. In order of significance from the data, these themes are:

- course engagement *(major)*
- affective teacher qualities *(major)*
- course structure *(major)*
- student positionality *(minor)*

Each of these is considered in the following subsections.

Course engagement. The most notable theme was the level to which students felt engaged with their class. It is worth noting that in the analysis for this theme, just over half of the codes stemmed from the wish question, which indicates that the students often longed for engagement with the material, but they generally did not feel connected to the course. Three subthemes were identified within course engagement: learning styles, pedagogy, and class interactions. The first two of these were the most prominent in this part of the analysis.

Of particular interest with learning styles is that virtually every code from this theme was produced by the wish question, which suggests a frequent disconnect for the students between how they were taught versus how they believe they learn most effectively. Students particularly longed for multiple examples and active participation:

- “I learn better when I have several different examples and ways shown to me.”
- “I don't do well unless things are explained and I am shown multiple examples.”
- “Practice makes perfect.”
- “Face to face learning and hands on learning.”
- “I learn by repetition and I won't remember how to do things if I don't practice.”

Again, the emergence of this subtheme entirely from the wish question indicates that students did not feel they were being taught in ways that helped them learn.

Pedagogy was a key subtheme under course engagement as well. This emerged almost entirely from the positive and negative questions, and slightly more often from the positive question. Positive comments often noted when the teacher was detailed in their instruction:

- “Instructor explains topics in more than one way and can relate each topic to real life scenarios.”
- “Professors that take the time to explain a number of ways.”
- “The type of teacher that will take the time to go through all the steps.”
- “My instructor explained why and how we did things instead of just doing them.”

Likewise, negative comments commonly arose from lack of depth:

- “Professors that only taught one way to solve.”
- “No teaching.”
- “No teacher explaining to us. Had to teach yourself.”
- “Having to teach myself the whole course and my teacher literally not teaching.”

Generally, the students appreciated detail in their lessons, and they were frustrated when the instructor did not fill in the blanks.

Classroom interactions figured as a subtheme as well. Relevant comments were almost evenly scattered across the positive, negative, and wish questions:

- *(positive)* “Professor . . . actually interacted with the class.”
- *(negative)* “I would ask for help when I was lost and the teacher wouldn't stop to make sure I understood.”
- *(wish)* “More one on one time instead of just doing endless problems on the board.”

The responses here indicated that the students preferred one-on-one interaction with the teacher to help them learn.

Affective teacher qualities. Another emergent theme was the extent to which the students felt that their teachers cared about the students’ learning. Just over half the related codes came from the positive question, with nearly all the rest from the negative question, and almost none from the wish question. But between the two subthemes—wanting students to understand and succeed, as well as commitment—the positive/negative splits differed considerably.

Wanting students to understand and succeed was a largely positive dimension, as the students typically felt that their instructors valued the students’ learning:

- “Having an instructor who cares and wants everyone willing to work for it to pass.”
- “Made me feel motivated and ready to learn.”
- “Teachers that motivate and encourage. Especially those who open themselves to discussion and letting [*sic*] their students know they can come to them.”
- “Professor who was involved.”

- “Professor . . . is very kind, supportive, and never fails to help. She doesn't belittle her students for not knowing.”

While there were a few instances where students reported uncaring teachers, this was generally a positive aspect.

In contrast, responses regarding commitment were mostly negative, with a couple from the wish question as well, and very little positive. The students often did not view their instructor as invested in the students’ education:

- “Not always having someone there to help you.”
- “Very little help from the teacher.”
- “More students than help from the teacher.”
- “Instructors would . . . tell the students to meet with tutors if we have questions.”
- “My professor never responded to emails and just wasn't helpful at all.”

Combining this with the prior subtheme yields a notable dichotomy: While the students believed that their teachers wanted them to learn, they did not believe that their instructors were willing to invest significantly in the process.

Course structure. The final major theme from the survey was the organization of students’ courses. Comments were divided almost evenly between the positive and negative questions—although a few resulted from the wish question, making this a slightly negative theme overall. There were three subthemes here, with pacing being the most prominent, with policies and materials as additional subthemes. Furthermore, the positive/negative splits were relatively even within each subtheme.

Half the comments under this theme regarded pacing. Again, about as many responses were positive as negative, although including the wish responses made this theme a bit more negative. Just over half of these were for self-paced classes where students had freedom to work at their own schedule or ahead of schedule. In other cases, teacher attention to pace helped as well. As one student described, “I gained more knowledge from the one on [*sic*] sessions. They were paced and a speed [*sic*] and he broke down the language in a way that helped me grasp difficult concepts.” Negative and wish comments often indicated that the teacher moved on before the students could understand:

- “Couldn't keep up or understand concepts before the Teacher [*sic*] moved on.”
- “I take a longer time to understand some concepts as I got behind in a few lessons.”
- “It takes a little bit longer for me.”

Both the positive and negative/wish comments suggest that student control of learning activity might be important, as many students responded favorably when they had some level of autonomy, while others were frustrated when they felt at the mercy of the instructor’s pace.

For the subthemes of policies and materials, the positive/negative divide was almost even (policies) or exactly even (materials). Both were relatively minor subthemes with few responses, and neither subtheme had any prominent answer pattern.

Student positionality. In addition to the major themes, how the students felt about their learning emerged as notable as well. But while this was a minor theme, it contained a very notable takeaway: Just over half the related codes stemmed from the negative question, with all remaining codes from the wish question—which means that student positionality was essentially an entirely negative dimension. The sources of frustration varied: lack of confidence, loss of focus, and belief on the given student’s part that the student should be in a higher math class. While none of these was heavily featured in this theme, the fact that student positionality was a fully negative aspect is distinctly a cause for concern.

Phase Two: Individual Interviews

The survey analysis formed the basis for the interview script, which is given in Appendix B. Questions were developed within each of the emergent themes from the survey: course engagement, affective teacher qualities, course structure, and student positionality. More specifically, questions arose from the subthemes as outlined in the previous section. Additionally, within each theme, each student was asked to put themselves in the shoes of their instructor to describe what they would do if they were the teacher, or what they wish their teachers knew. Finally, each interview concluded with a brief wrap-up that echoed the open-ended questions from the survey, where the student was asked to describe both a good and a bad learning experience, as well as what they wished their math teachers knew about their experiences learning math.

Questions within each subtheme were typically paired in terms of describing both a positive and a negative experience. For example, the course structure portion of the interview contained the following question pair:

- Describe experiences where you’ve had course materials and other resources that helped you learn. How did having these materials help you?
- Describe times when you did not have the resources you needed. How did this hurt your learning? What would have helped?

Question pairs are grouped in the interview script, with spacing between separate pairs.

Eight students completed interviews. Six were university students: Alecia (19 years old), Barb (18), Louis (20), Malcolm (19), Rachael (18), and Zane (19). The other two students, Cathleen (29) and Josh (20), were community college students. The interviews were completed by phone. All eight students consented to recording of their interview.

The summary here is sorted by themes, subthemes, and question pairs (or individual questions when unpaired). The organization of the summary parallels the interview script. Critical takeaways are indicated, drawing upon the descriptions offered by the students themselves. While discussion of "If you were the instructor"-type questions appears briefly in this chapter, these notes are largely reserved for the following chapter, as the students' comments on these questions feature suggestions well suited for consideration in the research's implications.

As previously described, coding occurred within each question or question pair. For example, the first pair of questions under course engagement asked students to describe classroom interactions that helped their learning (first question) or that did not help (second question). The responses to this question pair were aggregated across all interviewees. The researcher then coded within this question pair to discover the important ideas, using in vivo coding to preserve the students' words, followed by a combination of axial and focused coding to refine the results. The remaining questions and question pairs were analyzed similarly.

Course Engagement

The review of the course engagement portion is sorted by the question pairs of classroom interactions, learning style, and math content. Also, students were asked what they would do as the instructor. The results present key features of each component.

Classroom interactions. Two ideas were notable within this aspect: one-on-one help and active participation in learning.

One-on-one help. Students noted the importance of individualized attention. Zane remarked:

> If I ever get stuck on a problem, usually anytime I can get one-on-one help with something. . . . I guess I can focus better that way. I don't got to worry about other people around me, just me and the teacher.

Also, Barb described her math class:

> The teacher was actually there, and she would teach the lesson and then go over problems, we worked the problems together. . . . That was probably the most helpful thing I've had during my math college experience. . . . It was one-to-one and they actually worked the problem for you, and you just got to see it, other than just learning off a computer.

And when one-on-one attention was lacking, this was problematic, as Rachael indicated for when new students joined her class:

> When we had maybe newer kids come in and… it was kind of harder for the teacher to pay attention to everybody and help everybody. And sometimes, not all the kids would get the help . . . that they needed in the time period that we had for the class.

Active participation. Whether through involvement with the instructor or with in-class exercises, active participation in the classroom proved important to the respondents as well. Rachael felt that it was valuable:

> when the teacher is very hands-on and actually pays attention to small details about each of your students. What helped me was my math teacher was very hands-on. She paid attention to a lot of… maybe even just small details about how we worked on things. She found easier ways for us to learn better.

Rachael felt that her learning improved when her teacher was focused on how she learned.

It is worth noting Rachael's use of "hands-on," which appears twice in the above passage. Several other interviewees gave this descriptor as well. Grubb and Byrd (1999/2002) observed different uses and misuses of "hands-on" by instructors—where personal interaction, any student activity, or anything other than lecture itself might be deemed hands-on (p. 107). The authors further argued that "group work and worksheets are not necessarily student-centered or constructivist, and to label discussion as 'hands-on' seems to miss the point of the metaphor" (Grubb & Byrd, 1999/2002, p. 107). In this study, the students' usage of "hands-on" was consistent with these misunderstandings of the term, where simply working problems or speaking with the instructor might automatically be regarded as hands-on. For these students, "hands-on" was essentially synonymous with "interactive."

In turn, students did not learn much when they were not involved. Malcolm commented, "I don't believe that just straight reading and regurgitating helped me very much with trying to figure out different questions in my math course." And Alecia noted her own disengagement when the teaching seemed to continue without the students being involved:

> When the teacher just write, just write, don't [*sic*] stop. It wasn't helpful, because it was just, they just talk nonstop. They never . . . stopped to say an example or anything. They just talked and talked and talked. Sometimes, when you move too fast, you don't give enough time for the students to write it down, and then process it.

As with one-on-one attention, students appreciated—or longed for—involvement with the teacher as well as with the content.

Learning style. Of the eight interviewees, three answered in ways indicating that their learning styles were consistent with how they had been taught. Four respondents gave answers in line with inconsistency, while the remaining participant's answer did not suggest a lean in either direction.

Again, active participation in the learning was important here. Cathleen commented:

> I think practice makes perfect, that's kind of my learning style. I just have to keep doing new problems and working them out until I understand the actual subject I was trying to learn. So repetitiveness helps out a lot with my math.

Likewise, Alecia remarked:

> I like to take notes that I can go home and, like, practice. So I think it makes math easier when I write it down multiple times. . . . When you write stuff down, [it] becomes stuck in your brain.

For these students, the value of interaction was in repeated practice. Meanwhile, for Barb, work with her teacher made a difference:

> I have to have someone sit with me and show me what to do, and then I do it. And, I think a lot more math classes now are online-based, and you do the once-a-week meet up, which really doesn't help the way I learn math. I mean, first semester, when she helped was, "Okay, that was better," but second semester, I really struggled, because there was nobody there to actually help me.

In contrast, Malcolm described how teaching approaches with limited interaction worked against his learning style:

> Some math courses have been pretty aversive to my learning style, because it is just equations and stuff slapped up on the board, without a whole lot of explanation. So I have found it very consistent when taking those courses to struggle more often.

In these cases, Malcolm looked for interaction to engage with the material.

Math content. Three topics emerged here: classmate help, teacher help, and boardwork.

Classmate help. The participants often found it easier to learn unfamiliar content when they were able to work with other students in their classes. Barb described a class where students completed test review packets together and went to the board. And Cathleen found much greater value in board practice with other students than in the actual homework:

> Practicing [problems] on the board, I think made it very successful, because you were learning with your class. People asked questions that you didn't think to ask yourself. And just in-class work helped me out a lot more than the homework did at home, because I was able to ask questions and have my classmates or my instructor answer them.

Malcolm also commented on fine-tuning his understanding through group discussions:

> I think a scenario where I was learning pretty well was in a group discussion, almost like a Socratic seminar, just over, and this was in geometry. And talking through the equations, that really helped me a lot with, just talking it through, dissecting it piece by piece.

But at the same time, groupwork was a negative experience for a couple respondents when students were punished for others in the group who did not carry their own weight. For example, Josh described his frustration with group quizzes:

> I ended up getting paired pretty frequently with somebody that thought they, for the most part, knew what was going on but didn't, and I would rather just have my own piece of paper. I think I would've fared a little better just doing it myself rather than trying to argue a point to somebody.

Group interaction had value for students when it was a means of exchanging ideas, and not simply as an assessment novelty.

Teacher help. Students did not like feeling as if they had been left on an island by their instructors. Malcolm expressed frustration with "no explanation to a certain equation or just a question . . . just you answer, straightforward kind of deal, no explanation, no discussion on the question." And Zane noted an exercise where students were expected to teach themselves using a publisher's homework management system:

> We would have assignments where we had to read the [electronic text], the math book, and answer questions based off that, and that was just annoying, cause it was nothing—we weren't doing any problems. We just had to read. And kind of teach ourselves. And that was really annoying, just trying to figure it out on my own.

And Louis lamented being stuck in a cycle of trying to learn but struggling to do so:

> whenever I hit a roadblock on a certain subject that I struggled with. It wasn't very fun in trying to muddle my way through it. . . . It takes a lot more time and effort and everything else, and it's not a lot of fun, sitting there trying to do the same thing over and over, but still not getting it right.

In one form or another, these students felt that they were in positions where they needed instruction but did not get it.

Boardwork. Barb's and Cathleen's positive experiences with board activity were noted in the prior subsection. But even outside the context of group interaction, solving problems at the board was met positively by some respondents. Josh talked about an exercise where students presented a section of the text to their classmates:

> We were each given a different part of the chapter . . . and then we would read the book, learn how to do the problems, and then we all went on the board and showed the class our section of the chapter and what needed to be done there. I kind of liked that. I thought

> that was pretty helpful, because it was kind of a [*sic*] on-your-own, figuring, problem solving, figuring it out.

These students learned by being given the opportunity to present what they had learned to their instructor and classmates.

"If you were the instructor...." Multiple ideas were offered, but a few respondents focused on encouraging or requiring students to take notes. Rachael suggested:

> What I would do to help everyone learn better was I would make sure that everybody is taking notes... because notes really, really make a difference, because you can write them how you understand them. You can write them where you can just make little notes for yourself, or maybe put examples in it, whatever you need to understand the math, you can do on paper.

Josh described the use of a guided note packet. Early in the interview, he was critical of the packet because it was used as an assessment cudgel that became a source of stress. But in response to this prompt, he did encourage its use as an aid, and perhaps for "a little extra credit for you going the extra mile." Barb also advocated for the use of notes, along with working problems over the second half of class.

Affective Teacher Qualities

Consideration of affective teacher qualities is organized by the question pairs of commitment and instructor experiences. As at the end of the previous theme, students were also asked what they would do as the instructor.

Commitment. By far, the dominant aspect regarding commitment was willingness to help, with five of the interviewees citing willingness as key evidence of a teacher's commitment to student learning. Malcolm and Zane both mentioned help beyond class time. For Louis, willingness meant that for the teacher, "They are definitely always willing to help, and . . . they don't leave your side until you understand it."

Additionally, a few participants valued instructors who extended support to struggling students. For Alecia, a teacher could do this "by reaching out to you every chance they can get. So it's if I email, 'Hey, I see you had trouble on this assignment. Is there anything I can do?' You know, really showing that they care, reaching out." Meanwhile, Rachael commented:

> Most of my math teachers that I had this semester were very on top of all of their students. They would make sure that they were emailing students if they had maybe a lower grade on something, or if they thought that they could do better, or if they needed extra credit, or whatever... whatever the student needed, the teacher would always make sure they had.

In these cases, willingness to help inside and outside the classroom was significant.

And when students saw their instructors as unwilling to help, they remarked this as well. Malcolm noted a problem "whenever I have a question, and they just kind of give you the quickest answer that they can, instead of staying there by your side and kind of walking you through each part of whatever question you have." Additionally, Zane described teachers:

> that really just come in and, you can tell when an instructor is not committed by, if they come in and then just teaches [*sic*] stuff, but they're not really making sure that you're retaining it. They just teach it. If you get it, you get it. If you don't, you don't. It's not their problem.

For most of the respondents, how they viewed their teachers' willingness to help was the primary evidence of the teachers' commitment (or lack thereof) to the students' learning.

Instructor experiences. Again, teachers' willingness to assist students dominated this theme. All eight interviewees expressed this as a positive, in one form or another. Alecia, Malcolm, and Rachael mentioned situations where instructors spent additional time outside class to help. As Rachael remarked:

> I've had a lot of teachers that are willing to work with me during other classes and pretty much take time out of their personal time to help me out in math or even right before finals. . . . I was taking a math final, I had one of my math teachers break down on paper, what I was struggling with, which helped me pass my math final. [My teachers] were really committed to making sure I understood all of the things that I need to understand before I moved on to the next math class.

Another indicator of willingness was when teachers proactively contacted struggling students. From Zane:

> I've had instructors reach out to me without me even saying anything. . . . I'm not always the one to ask questions. And so I've had instructors that could tell that I was struggling on something, and they would reach out to me first and just be, "Hey, you know, if you need help with this certain material, I'm available these times. Feel free to come in, ask questions."

For these students, signs that their teachers cared beyond the classroom were meaningful.

At the same time, a couple participants elaborated on how in-class changes indicated instructor willingness. This included changes at the micro level to handle spur-of-the-moment adjustments for student questions, as Cathleen described:

> When an instructor gets on a roll, and they're teaching everything, and you have questions, and the sign that they go back, and they go back without hesitation or being

> annoyed going back a couple steps, and relearning and reteaching the information helps a lot. I think that's a good signal. I've had instructors just be completely annoyed with questions that they've already kind of gone through and passed up. So questions you didn't really have at the time, but then in the future.

But teacher willingness was also reflected at the macro level by adjusting lesson plans, which Josh described in the context of review days:

> Whenever my instructor took a whole different approach to the review of the chapters and started having that more . . . comprehensive review day, I would say that really showed me that they were dedicated to the students wanting to understand it. Because . . . what had been done before the last couple of chapters really wasn't working the best. So having that kind of adaptability and being willing to change what you would normally do, solely on a class to class basis, I think that would be pretty big.

In both cases, the students viewed teacher responsiveness in class as evidence of willingness to help.

"If you were the instructor...." Responses to this item were scattered, and they generally echoed what students had already observed in previous questions. Consistent with the prior responses, teacher availability was noted by a few respondents. A couple participants also remarked on the value in reaching out to students.

Course Structure

The discussion of course structure is sorted by the question pairs for class policies, pacing, and materials/resources. Once again, this section of the interview concluded with asking students what they would do as the instructor for this category.

Class policies. Two ideas emerged regarding policies. The primary takeaway was in terms of having a well-structured course with consistent policies and deadlines. A secondary note on policies involved additional assessment opportunities.

Well-structured course with consistent policies and deadlines. A few of the participants found value when the course was clearly organized with consistent expectations. Louis described importance in deadlines being laid out ahead of time:

> With the classes, they all have deadlines for each assignment, and it's nice to have those deadlines just because you can plan accordingly to meet those deadlines. And also, you can see every single deadline of every single assignment that you're going to have. So there's no surprises or anything like that. So, with that, you can plan accordingly and dedicate time for the class, and also work in your other classes to fit around those times.

And Barb talked about how a regular course routine kept her on track:

> My first-semester math class, so every week, you learn a new chapter. . . . You come to class, learn, and then your homework would be due the Wednesday coming up, cause the class was on Monday. Then that Wednesday, you would have a [*sic*] in-class quiz, but you couldn't take the quiz unless you finished all the homework. And then that Friday, you'll have a test. And I liked it like that, cause it didn't really allow you to fall behind, and if you did fall behind, you just have to catch up over the weekend, cause you didn't want to fall behind on the next chapter coming up.

For these students, consistency helped them stay on top of the material.

Additionally, a couple students found their teachers' in-class expectations to be helpful in maintaining the students' dedication and attention in the classroom. Zane valued strictness in terms of tardiness, noting this "always helps get students into the classroom." He also mentioned how a no-phone policy kept him from being distracted. Alecia also reflected on the value of a no-phone rule:

> That was amazing for me, because I'm young, so I have a problem texting and social media. So my one teacher, she did not allow phones at all. And I feel like it really, really helped me to focus. And I really learned, without having to look at a text every 30 seconds or social media.

Instructor expectations for classroom conduct gave these students additional structure which kept them on track.

Additional assessment opportunities. Two of the students considered class policies in the context of whether they had further chances to show what they had learned. Alecia and Rachael lamented a lack of such opportunities. But as a positive, Rachael noted how retakes on quizzes gave her greater ability to improve in one of her classes:

> If we were there every day in math classes, we were never absent, we were always there for that section that we learned that we would test over, the teacher would always give us a retake. . . . With quizzes . . . if you needed to retake it, you could retake it as many times as you needed to, up unto the next section started. So that was really helpful. . . . It was just kind of like we always had a second chance to do better in math class.

The students here valued getting more than one window to demonstrate their knowledge.

Pacing. As was the case with class policies, consistency in structure was important for pacing as well. Far and away, this was the dominant idea here, and it surfaced on both the positive and negative sides of this question pair. Again, Alecia and Rachael gave similar responses in terms of having enough time for information across concepts. And Josh saw the consistency of having one or two concepts in each unit as good preparation for college-level math.

On the negative side, having too much material to cover was a recurring concern. Cathleen discussed her experience with a math class:

> Each day, there was a new section, new subject, sometimes even two sections that you had to get to, because there was [*sic*] more sections than actual class days. So having to blow through those and just to get through the material . . . was not beneficial at all, because it was leaving out several people behind [*sic*], as far as understanding goes, and having to go home and complete the amount of homework as practice was just infuriating. I spent more time in that class than I would've a full-time job probably on just homework alone.

For his six-week summer course, Zane noted how the issue could be compounded when pacing problems had to be rectified at the end of the class:

> Everything kind of got jammed on together. And so we were taking three quizzes and a test, in the same week with homework every single night. Just trying to cram in everything before the class ended. . . . And instructors usually just kind of cram everything in last-minute that they weren't able to get to or if something was the way they weren't able to do, a few labs or something like that, trying to catch everything up.
>
> Then usually, they just cram everything on top of you, "I hope you get it"- type deal.

Issues with pace arose both from having too much content as well as inconsistency in the rate of coverage.

Materials and resources. Responses ranged from student to student, with not a great deal of overlap. But there was some level of commonality across the participants on publisher software tools and alternative resources (that is, beyond the publisher's materials).

Publisher software tools. A couple students benefitted from additional homework practice afforded from the text publisher's online platform. Cathleen noted that when working a given problem, being able to work similar problems helped her grade. Josh found use for this feature combined with built-in tutorial videos as a convenient way to learn:

> If you were struggling with the problem, you could hit the help button, and there was a video you could watch of how to solve that kind of particular equation, not the exact one that you had, but that form of. And then you could also go through the step-by-step breakdown of how to solve that exact problem, and then after you went through the step-by-step learning of it . . . you would get a new problem, and it'd start you over. So I always felt like that was super helpful, because if I ever got stuck, I had automatically two resources right there on my computer screen, ready to help me through it.

Between these two students, extra practice and ease of use were offered as helpful aspects of publisher software tools.

Alternative resources. Josh's response above indicated how the publisher's videos were useful to him. But he also noted instances where he thought he might have gained from other tutorials. Malcolm discussed external videos "if the instructor isn't conveying the message in the way I need" as well as being able to ask other teachers for help, again to get another point of view. Louis described this as well, also noting value in consulting other texts as well as classmates:

> I’ve been able to have help from other students. And then also outside textbooks. . . . And then also, [video website] is a big help as well. . . . Just seeing it from a different perspective and hearing it from a different person. Sometimes, that can put it in better words than the instructor or the book I’m assigned. . . . So just seeing it in a different way, that sometimes helped me.

In cases where these participants were not able to connect with the material as it was originally presented, they were helped by other presentations of the content.

“As the instructor....” Again, the students’ answers spanned a fairly wide spectrum. But consistent with previous responses, recurring themes included instructor availability, one-on-one help, and additional resources.

Student Positionality

Unlike the other major themes, questioning for student positionality did not occur in pairs. The participants were asked separate questions about their ability to learn math, how they knew they had learned, their math background relative to their coursework, and their teachers’ understanding of the students’ preparation. This section of the interview concluded by asking what the respondents wished their teachers knew about the students’ background and preparation.

As noted in the discussion below on ability to learn math, there was a fairly even mix of positive and negative responses. As a result, there were few heavily unifying elements across the participants, as the students who felt better about math tended to describe their positionality differently than the students who were not as optimistic. Still, there were some aspects that occurred with a fair amount of consistency.

Ability to learn math. Among the eight interviewees, three felt good about their ability to learn, four felt bad, and the remaining student rated their ability as average. While responses were scattered, a pair of key ideas from this section were one-on-one help and a sense of helplessness in math.

One-on-one help. Consistent with prior answers, individualized assistance factored into consideration for a couple students. This was certainly true for Zane, who lacked confidence in his ability:

> Anytime I can get one-on-one help, whether it's with an instructor or a tutor, one of my friends that's way smarter than me or something. And I know that's always the most beneficial for me is whenever I can get one-on-one help with someone about it.

Alecia, who rated her ability positively, indicated, "[If] I have someone there that I can ask questions, I'll be fine." Again, one-on-one help was a recurring idea connected with ability to learn math.

Sense of helplessness in math. A couple students who viewed their ability as bad expressed a feeling of not quite being in control of their learning. Although neither participant used the word "helpless" or "helplessness," both seemed to give a sense that learning math was not quite within their grasp. As Louis noted about his ability:

> It's always been pretty poor throughout school. . . . It's always been my weakest subject. And I know that going into it, so that probably doesn't help my state of mind going into it. . . . I tend to be poor at learning at math for whatever reason. . . . It's always been a struggle of mine. And I've tried to get better at it, and it's just always slow to me.

Meanwhile, Barb viewed herself at the mercy of her instructor:

> I just really need a good teacher, because math is all about the type of teacher you have. . . . Because the way you learn math, it really just depends on the type of teacher you have. So, if your teacher is not really helpful, then . . . I can't learn.

In different ways, both Louis and Barb described not having firm command of their learning.

Knowing they have learned. Again, responses were fairly mixed. But key points for this topic included successful recall, use in applications, and better grades.

Successful recall. One student indicator of knowledge was being able to remember what they had learned. Alecia and Barb both found evidence of their learning when they could complete the work without looking up the material. Zane elaborated on how he felt during assessments:

> We'd do quizzes and then we'd take a test, and I could always tell when I took the test, "Yeah, I learned that a few weeks ago." But it's right there, I don't even have to think about how to do that. I just kind of bust it out. I was kind of surprising myself, honestly, cause I noticed I wasn't using my calculator as much. I wasn't having to look at equations. I just was remembering them.

Being able to solve problems without consulting a reference was proof for these students that they had learned.

Use in applications. Extending their coursework beyond the classroom was another sign for respondents that they gained understanding. Louis mentioned using his knowledge "in projects in real life." Meanwhile, Josh referenced paramedic work, specifically "calculating drip rates on IVs and in changing kilograms to pounds for medication doses." For both students, fruitful application of their coursework showed that their understanding had improved.

Better grades. Just before his description of paramedics, Josh indicated that his success on the final exam was proof of his learning. Rachael noted how her grades improved after a previous unsuccessful attempt. In these cases, positive evaluation of the students' work contributed to a belief that they knew the material.

Math background relative to course. Of the eight participants, three were overprepared, while four either were moderately prepared or expressed a mix of preparedness levels. Only one was underprepared.

Once more, responses ranged considerably. Both Alecia and Josh indicated some level of preparedness from high school. But beyond this, answers across the interviewees had little in common.

Teacher understanding of student preparation. Four of the eight students felt that their teacher understood their preparation level. Two participants said that their instructor did not know the students' preparation level, while two students gave mixed responses.

The key takeaway from this question was one-on-one help, which again proved notable. In fact, for all four students who felt that their teacher understood their preparation, each student highlighted individual attention as a factor. This was typically in the context of the instructors' expressed interest in helping their students. As Rachael described, "My teacher . . . knew each individual personally. She would always take time to pull each student aside to kind of work with them and talk to them, to kind of get a feel of what kind of student they are." As before, students valued one-on-one assistance.

"What do you wish your teachers knew...." Answers to this item exhibited a range. A couple students suggested that their instructors might have benefitted from knowing the students' high school math background. Two other participants simply indicated that they needed more help than what they felt was typical or apparent.

Wrap-Up

The final portion of the interview consisted of three questions. The students were asked to describe first what a good learning experience looks like, and then likewise for a bad experience. With the final question, the participants were asked what they wished their math teachers knew about the students' experiences learning math.

Good and bad learning experiences. Three areas of focus emerged as significant from this question pair: grades, retention/application, and one-on-one help.

Grades. Students frequently saw their success in terms of the marks they received. While this is perhaps unsurprising, an important caveat is that these students did not see grades as the *only* measure of their experience, but as confirmation of their learning (or lack of it) in conjunction with other parts of their experiences. For example, Rachael cited positive student attitude as being beneficial along with good grades—and, likewise, her idea of a bad experience was not only failing, but also not caring about failing. Alecia's positive view combined good grades with her being able to reteach the material that she had been taught. While grades were important to these students, the grades were not the sole indicator of their learning.

Additionally, Malcolm described improvement in his homework grades as key in knowing that his understanding had increased:

> Something . . . that's helped me as well is having harder homework than the questions on the quizzes, and then being able to succeed on that, that homework prior to the quiz or a test, seeing my improvement in math. . . . Say if I have three different pieces of homework before a quiz. I think I've learned more when I scored a 0 out of 10 on the

> first assignment and then . . . by the third assignment, I scored . . . 8 out of 10. I feel like . . . that's helped me learn and helped me prepare better for that quiz or a test.

In Malcolm's case, it was the score progress that confirmed he was learning successfully.

Retention/application. Some of the participants discussed their experiences in terms of retaining and applying the material. Alecia's experience of being able to reteach content was noted in the prior subsection. Cathleen said that being able to complete the material on her own, as well as in front of her class, signified a good experience. Both students found value in working through the content and presenting it to others.

Additionally, Zane indicated retention as important when discussing both good and bad experiences. On the negative side, he framed the issue in terms of homework:

> You get caught one day on how to do something, you go home and do the homework, and you don't remember anything about what you just learned. And so, I've had times where I just look at my notes, and I have all my notes there, but I just… I just can't piece together how I go about doing a certain problem. And so that's whenever I can tell I'm not retaining it the best that I can.

Zane's marker of a bad experience was the disconnect between what he was able to do in class versus what he was unable to complete away from the classroom.

One-on-one help. Yet again, individualized attention was important for some of the students. Barb cited this as the primary indicator of a good experience. Louis also commented on the importance of having an instructor who would help him through material when he struggled.

In terms of negative experiences, Barb and Louis both noted that the lack of a helpful teacher was problematic, either because the course was structured so that students largely taught themselves (Barb), or because the instructor was unwilling to help (Louis). Additionally, Josh framed the problem as a lack of in-class engagement:

> Math classes for me have always kind of instructed the same way where I would just come in, sit down, listen, and/or pay-attention-and-watch kind of deal. . . . It's pretty dry. . . . Just sitting there, having to religiously following [*sic*] along with the notes, and watch as problem after problem gets worked, as opposed to getting your own hands-on experience of either (1) come up to the board and try to work it yourself, or (2) . . . "Here's this material, read over it, see if you can work these problems and understand them."

Josh longed for opportunities to engage with the material, and his learning experiences were soured by not getting these chances.

"What do you wish your math teachers knew...." Participant responses suggested three important ideas: one-on-one help, student background, and student gratitude for instructional help.

One-on-one help. The importance of targeted assistance surfaced yet again. At this stage, the respondents who noted one-on-one help did not elaborate much, likely because they had already talked about this aspect at multiple times over the course of the interview.

Student background. A couple students commented that more information on their math experience might be useful for their instructors. Malcolm suggested "transparency with my history in math, what courses I have taken, and what manner I've taken them, and when I took them." Another alternative, as recommended by Cathleen, was a student-created profile:

> I wish that they could know how much preparation it takes to get into a math class at the level I was in. And personal experience, I had to work very hard to even test to the level

> I needed to, to get into the class I needed to be in, that was required. So I wish there was more of a background, like a profile or something that you can write your experiences with math and stuff like that, the teacher can review and see where you're coming from, kind of help with your learning style.

Cathleen's suggestion would add a student perspective to the typical prerequisite checks in understanding a student's math background.

Student gratitude for instructional help. Two of the students discussed how thankful they were for their teachers' assistance. And both students indicated that they did not receive the opportunity to say this to their instructors. Rachael noted, "I wish those kind of math teachers knew how much they were appreciated." Meanwhile, Josh detailed his experience:

> I wish that my instructor knew just how genuinely thankful I was for them. . . . I really, really enjoyed my instructor. I enjoyed the way the class was structured. I think she did a terrific job, never, never left anybody who needed the help in the dark, was always willing to go the extra mile for the students. And I just, I wish that she could know just how truly appreciative of her time I was.

Both students appreciated the assistance of their teachers, but the students felt that their instructors might not realize how grateful the students were for that help.

Interview Summary

The interviews were organized by the primary themes of course engagement, affective teacher qualities, course structure, and student positionality. Every interview concluded with a short wrap-up where the participants described their ideas of good and bad experiences. Each section of the interview, including the wrap-up, ended with a question where the students were essentially asked to put themselves in the shoes of their instructors.

Table 3 gives a brief outline listing the themes and corresponding subthemes, as presented in the results above:

Table 3: Interview Summary

Course Engagement	Affective Teacher Qualities	Course Structure
classroom interactions • one-on-one help • active participation learning style • active participation math content • classmate help • teacher help • boardwork as the instructor • taking notes	commitment • willingness to help instructor experiences • willingness to help as the instructor • teacher availability • reaching out to students	class policies • well-structured with consistent policies and deadlines • additional assessment opportunities pacing • consistency materials/resources • publisher software tools • alternative resources as the instructor • instructor availability • one-on-one help • additional resources
Student Positionality	**Wrap-Up**	
ability to learn math • one-on-one help • sense of helplessness knowing they had learned • successful recall • use in applications • better grades math background • preparedness from high school teacher understanding • one-on-one help wished that teachers knew • high school math background • needed more help	good/bad experiences • grades • retention/application • one-on-one help wished that teachers knew • one-on-one help • student background • student gratitude for instructional help	

With this data in hand, the following chapter presents the resulting framework for how developmental math students experience their learning, as generated by grounded theory. Implications and avenues for future research are discussed in the next chapter as well.

Chapter 5 - Conclusions and Implications

The research question for this study is: *How do developmental math students experience learning in their developmental math coursework?* The previous chapter outlined the results, first from the online survey and then from the individual interviews. This chapter first presents the conclusions of the study, using grounded theory to generate a framework for how these students experienced their math education, and noting what was meaningful for them. Implications are then discussed in detail, drawing heavily on how the students viewed their learning. Included with the implications is an "anti-conclusion," which observes what was *not* found to be significant—and, in the process, lends greater perspective to what students actually value. Finally, limitations and opportunities for future research are considered.

Conclusions

This section begins by recalling the original themes determined from the survey to be important: course engagement, affective teacher qualities, course structure, and student positionality. From here, an overarching view of the most important aspects of the students' experiences is outlined, where each of these is connected to the original themes, based on the results.

The following aspects were found to be key in understanding how the students experienced their developmental math learning, in order of importance:

1. The students' experiences were shaped by their ability to receive *one-on-one help*. This applied not only to the amount of such help that the students received, but also to the quality of the help.

2. The students' viewed *instructor willingness to help* (or lack thereof) as an important part of their learning. This particularly included the extent to which the students believed that their teachers wanted to assist them.
3. The students appreciated courses that provided a *supportive structure* to organize the learning. This meant clear schedules and deadlines, as well as activities and assessments that provided opportunities for the students to develop their understanding and to demonstrate what they learned.

Of course, these three aspects hardly live separately; there is certainly considerable overlap. Even so, each is important enough to merit consideration in its own right. The following subsections contain further discussion of each aspect, with an additional subsection to observe what did *not* emerge as key to the students' experiences, again to grant perspective to what was actually important for the students.

One-On-One Help

Even a cursory look at Table 1Table 3 indicates the importance of individualized assistance. One-on-one help appeared under four of the five interview sections (three of the themes, plus the wrap-up). The only interview portion where one-on-one help did not appear is under affective teacher qualities, where willingness to help dominated. And since willingness to work with students was very much connected to spending one-on-one time working with them, it is reasonable to say that the importance of individualized help surfaced throughout the interviews.

Instructor Willingness to Help

Again, this idea appeared throughout the theme for affective teacher qualities. In one form or another, it was also evident under student positionality and the wrap-up. And as noted above, willingness is attached to one-on-one teaching with students. Obviously, instructor willingness is fundamentally connected to *everything* a teacher does. An unwilling instructor will not spend significant time working with students individually, nor will such a teacher invest the time and energy to develop a supportive structure that helps students learn. But the students in this research consistently indicated that it was important for them to see overt gestures that their teachers wanted to help.

Supportive Structure

In the course structure portion of the interviews, the participants described how they benefitted from well-organized courses that had consistency in expectations, plenty of resources, and additional opportunities for students to show what they knew. Comments in the interview portions on student positionality and the wrap-up suggested that students did not always feel great about their background, and that they could use a little more help anyway. Combined with the responses under course structure, the students sent a message that having a solidly structured class kept them on track and gave them the help that they needed.

Implications

The conclusion summarized the key aspects of one-on-one help, instructor willingness to help, and supportive structure. In this section, potential implications are described. As with the conclusions, the implications are rooted in the students' responses.

One-On-One Help

For individualized assistance, the data suggest that developmental math students might benefit specifically from:

- responsive instruction
- feedback from other students

- discovering student background

Each of these is described below.

Responsive instruction. The interview results for affective teacher qualities included Josh's remarks about how his teacher made changes for review days in response to what was not working. And noting what she wished her teachers knew about her positionality, Alecia commented:

> I wish that they knew... that I'm pretty good in math. I just have to really apply myself, and actually sit down and try. Because I do try, but . . . I wish they knew that I need more than what it looks like.

The key feature was not simply that each student received attention from the instructor. Instead, it was that the instruction changed as a result of the student's progress or struggle.

Feedback from other students. Alecia also indicated that she benefitted from additional tutoring from other students who had completed the course she was taking. And Cathleen talked about her own experience working with classmates for review:

> [The instructor] had us each learn a section with a partner on review day and then teach that particular section to the class. And that was—that really helped out a lot. A lot of people actually in the class said that helped a lot, and I enjoyed that. Interactions . . . doing problems on the board seemed to help. You could have people kind of help you through them. So it's more interactive than doing work on your own. I guess it's helpful in math, is a team effort.

These students found value in learning from other students. While individualized instruction was important, it did not always have to come from the teacher.

Discovering student background. While not universal across the interview participants, some of them believed that their instructors might gain from understanding more about the students' background. Cathleen's idea of a student-created profile has already been noted. For Malcolm and Louis, this included simply having more information about the students' prior coursework. These students felt at least some level of disconnect in terms of their background, and they felt that their instructors might have benefitted from further information about each student's prior experiences with math.

Instructor Willingness to Help

Notable implications for instructor willingness to help regard:

- student perception of availability
- reaching out to struggling students
- providing additional resources

These are discussed in the following subsections.

Student perception of availability. College faculty make themselves available to students by holding office hours and answering questions. But for the interviewees, being available typically meant much more than doing the bare minimum. In the affective teacher qualities results discussion, Rachael described teachers who committed additional time to help her. And Louis elaborated on availability at an individual level, where the instructor:

> instead of just walking off after the one question's answered, make sure the student doesn't have any further questions on those types of problems. And make sure that the student does have a solid understanding of it. And then you also reassure them that, "If you need me on the next one, just let me know." So, yeah, just reassure them that it's no big deal if they call right me back over.

The interview participants frequently noted their views of teacher availability. And they repeatedly indicated that overt signs of availability were important signs of instructor willingness to help.

Reaching out to struggling students. As also outlined in the affective teacher qualities results, a few participants appreciated teachers who were proactive in helping struggling students. Alecia, Rachael, and Zane mentioned instructors who contacted their students at signs of trouble. A forward-thinking approach on behalf of the teachers contributed to these students' beliefs that their teachers were willing to help them.

Providing additional resources. The students benefitted from having further means for help beyond the text and the instructor. Various aids were suggested, including handouts, worksheets, external videos, and additional texts. But regardless of the form, additional resources were connected to instructor willingness.

Supportive Structure

Implications connected to supportive structure include:

- routines and policies to foster good student habits
- deadlines and schedules
- meaningful activities and assessments

Each of these is considered below.

Routines and policies to foster good student habits. Instructors might sometimes be reluctant to impose seemingly strict routines and policies, for fear of restricting their students' freedom or otherwise micromanaging the students. But on the contrary, some of the interview participants expressed support for certain rules when they saw the benefits. The course structure results noted how Alecia and Zane appreciated the no-phone policy in their classes, as well as how Barb valued having a regular routine in her class. Of course, the interviewees discussed bad policy encounters as well, as one of the interview questions specifically asked them to do. But certainly, the students did not feel that all rules were bad. For the students, the difference between good and bad policies was whether they were able to view a given policy as helpful for their learning.

Deadlines and schedules. Related to the above idea—but still worthy of note in its own right—is the idea of having deadlines and schedules. Louis's take on this in terms of planning was outlined in the course structure results. And while describing a different learning experience where the class was self-paced, Barb commented, "I just feel like there should be a guideline of when you should have this done or just deadlines, because then that just allows you to fall behind, especially if your time management skills aren't 100%." As with the previous subsection, the students wanted deadlines because they saw how it aided their learning.

Meaningful activities and assessments. The interview participants described activities and assessments in various forms that helped them learn. They frequently cited the importance of active participation, and they described boardwork, developing review questions, and group activities as being useful. But at the same time, not *all* activities were productive for the students, as shown in the course engagement results with Josh's example of the guided note packet that he saw as stressful when it was a required part of his grade. Once again, the students generally were not opposed to additional structure, so long as they saw its value.

Limitations

Simply put, the primary limitation of this study is that it is unclear to what extent the results can be generalized beyond the participants in this research. To be clear, this was expected entering the study. The goal was to gain a more thorough understanding of the learning experiences of developmental math students, and a qualitative approach afforded opportunities to listen to such students discuss at length different aspects of their learning. While sacrificing breadth cut against the ability to generalize, the additional depth from focusing on a handful of participants contributed to a more complete theory of the students' experiences.

It is worth noting that the interviewees ranged reasonably on gender identity (four female and four male) and ethnic identity (four white, three black, and one who identified as "mixed race"), which gives reason to believe that the conclusions may hold across gender and racial lines. On the other hand, there was little variability on age, as seven of the eight participants were 20 or younger. And from the survey, the students generally rated their learning experiences and effort fairly positively (see Table 1 and Table 2), which certainly may not always be the case for other students. Also, six of the eight respondents were university students, which leaves the question of to what extent the conclusions apply at the community college level. Still, it is worth noting that the experiences of the two community college participants were not unlike the experiences of the university interviewees, which suggests some level of commonality for developmental math students in general, regardless of the type of postsecondary institution they attend.

Opportunities for Future Research

The data from the respondents led to the generation of a theory that describes these students' experiences and hopefully informs perspectives of how these students learn. The resulting theory warrants further investigation regarding not only generalizability, but also the specific types of learning experiences that are beneficial to developmental math students. From the implications for the conclusion themes of one-on-one help, instructor willingness to help, and supportive structure, the questions in the next sections present opportunities for further study.

One-on-One Help

Implications for one-on-one help included responsive instruction, feedback from other students, and discovering student background. Among the possible directions for additional research are the following:

- **Responsive instruction:** *What indicators might suggest that students are struggling with the course material?* (A downturn in grades would of course be a sign, but this might come too late for the instructor to deliver meaningful help.) *What indicators might suggest that students feel helpless in their ability to learn? What interventions, inside and outside the classroom, are beneficial?*
- **Feedback from other students:** *What in-class activities with other students help their learning? To what extent do students benefit from tutoring by other students who have completed the course successfully, and does this offer different benefits than when a student works with their teacher?*
- **Discovering student background:** *What elements of students' backgrounds do the students wish their instructors knew? What do instructors want to know about students' backgrounds? To what extent is there a gap between the students' experiences and college-level expectations?*

Instructor Willingness to Help

The implications here noted student perception of availability, reaching out to struggling students, and providing additional resources.

- **Student perception of availability:** *What signs do students perceive which suggest their teachers are unwilling to help? In what ways can instructors effectively communicate that they want to work with students?*

- **Reaching out to struggling students:** *What indicators might suggest that students are struggling with the course material?* (This question was noted with responsive instruction, but it is appropriate here as well.) *What forms of instructor intervention are effective in helping these students? How can instructors build student self-efficacy and help students overcome feelings of helplessness in their learning?*
- **Providing additional resources:** *What types of instructor-supplied resources (handouts, worksheets, and so forth) assist with student learning? What further course materials (such as videos and other websites) are useful for students?*

Supportive Structure

The implications for support structure covered routines and policies to foster good student habits, deadlines and schedules, and meaningful activities and assessments.

- **Routines and policies to foster good student habits:** *What types of routines and policies help students develop good habits? Which routines and policies build student self-efficacy? How can instructors distinguish which routines and policies are beneficial, versus those which simply impose rules without benefit?*
- **Deadlines and schedules:** *In what ways does providing a clear schedule and deadlines help (or harm) students? How can teachers assist students who get behind schedule?*
- **Meaningful activities and assessments:** *What activities and assessments are most effective in helping students learn? How do instructors use the results of assessments? How can teachers implement useful activities and assessments while also being aware of when an activity or assessment is not working? What*

interventions and professional development support teachers in implementing best practices?

Additional Note on Further Questions

The above questions present an array of options for subsequent research. Of course, these are not the only possible questions, and the reader is invited to pursue other relevant avenues not mentioned here. Furthermore, even within a given question, the results may very well depend on factors such as:

- type of postsecondary institution (community college, public university, or private university)
- school setting (urban, suburban, or rural)
- developmental math education implementation (which can be particularly impacted by state law)
- demographics

This research does not establish the extent to which these factors might make a difference. But it is certainly possible that they could, and this opens even more directions for future consideration.

Research Summary

The study explored how developmental math students experience their learning. The researcher sought to understand the students' experiences using grounded theory methodology, first with a survey to discover the themes that were important to the students themselves, and then with individual interviews based on these themes to gain an in-depth understanding of how the students viewed their learning. The survey results indicated the key themes of course engagement, affective teacher qualities, course structure, and student positionality. After the interviews explored these ideas further with students, the resulting theory suggested that one-on-

one help, instructor willingness to help, and supportive structure were essential components of the students' experiences.

From the implications, the emergent theory suggests the following:

- Within the dimension of one-on-one help, students benefit from responsive instruction, feedback from other students, and discovering student background.
- For instructor willingness to help, students value a sense that their instructor is available for assistance, they appreciate when their instructor reaches out to them when they are struggling, and they like receiving additional resources from the instructor.
- On supportive structure, students appreciate routines and policies that foster good student habits, deadlines and schedules that keep students on track, and meaningful activities and assessments.

Limitations and opportunities for future research were noted as well. More study is warranted to determine the extent to which the results might generalize, as well as to explore the role of factors like the type of postsecondary institution, the school setting, the implementation of developmental math education, and demographics.

As observed in the introduction, teachers of developmental education need additional understanding of how our students learn. This study hopefully contributes to such understanding and encourages greater exploration of the needs of the students and how instructors might respond to these needs. This work does not offer any statistically significant conclusions, although it was never intended to do so. But what this study does offer are paths for further research in developmental math education. For those of us who teach these students, it is of the utmost importance that we continue to investigate these questions and to find effective teaching strategies, so we can give our students the greatest opportunity to succeed in their learning.

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Appendix A - Phase One Online Survey

Please complete the following demographic information.

1. Please enter your age: ___________

2. Please select your gender identity:

   ◯ Female

   ◯ Male

   ◯ Other (please enter) ____

3. Please select your ethnic identity:

   ◯ Asian

   ◯ Black/African American

   ◯ Hispanic/Latino

   ◯ Native American

   ◯ White

   ◯ Other (please enter) ____

4. What is the format for your math class? (Please select all that apply.)

- ☐ Traditional (face-to-face)
- ☐ Online
- ☐ Computer lab
- ☐ Other (please enter) ____

5. For the math course you're currently taking, is this your first attempt to complete it? (If not, please enter how many times you've tried to complete the class before this semester.)

- ○ Yes, this is my first attempt at this class.
- ○ No, I've attempted this class before. (Please enter number of prior attempts.) __________

Please use the following questions to describe your college math experiences. These are personal responses, and so there are not right answers. What is right to you may be different for someone else.

6. How would you rate your learning experience in your math course this semester?

	Very negative	Negative	Neutral	Positive	Very positive
Learning experience in your math course this semester	○	○	○	○	○

7. How would you rate your effort to learn in your math course this semester?

	Very low	Low	Moderate	High	Very high
Effort to learn in your math course this semester	○	○	○	○	○

8. Is this the first semester in which you've taken a college math class?

○ Yes

○ No

[Questions 9 and 10 were only displayed if the student answered "No" to question 8.]

9. How would you rate your learning experience across *all your college math courses*?

	Very negative	Negative	Neutral	Positive	Very positive
Learning experience across all your college math courses	○	○	○	○	○

10. How would you rate your effort to learn across *all your college math courses*?

	Very low	Low	Moderate	High	Very high
Effort to learn in your math course this semester	○	○	○	○	○

11. Think about the positive learning experiences you have had learning math in college. What made the experiences positive?

____

____

____

____

____

12. Think about the negative learning experiences you have had learning math in college. What made the experiences negative?

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____

____

13. What do you wish that your math instructors knew about the way that you learn?

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____

____

____

Appendix B - Phase Two Individual Interview Script

In this interview, I will ask you questions about your experiences learning math at the college level. Please feel free to be honest and thorough in your responses. Your confidentiality will be maintained; no personally identifiable information will be shared with your instructors.

course engagement

What classroom interactions have you experienced that have helped your math learning?

Why were these experiences helpful?

What classroom interactions were not helpful in your math learning? Why were these experiences not helpful?

How do you believe that your learning style figures into your experiences learning math?

To what extent do you think that your learning style is consistent or inconsistent with how you have been taught math? Why do you feel this way?

Describe ways that you experienced math content where you felt like you were learning successfully. Why were these useful?

Describe ways that you experienced math content where these did not help you learn. Why were these bad experiences?

If you were the instructor, how would you structure the course in ways that help students learn better? What would you avoid doing?

affective teacher qualities

How do your instructors demonstrate their commitment to your learning?

What do instructors do, or fail to do, that signals they aren't committed to your learning?

What experiences have you had with instructors that have shown you that they want you to understand the material and be successful?

What instructor experiences have signaled that your instructor does not care if you understand or succeed?

If you were the instructor, how would your students know that you are committed to their learning and that you want them to understand and succeed?

course structure

Describe your course experiences where the class policies were structured in ways that helped you learn. Why were these policies beneficial?

At what times did class policies work against your learning? Why were these policies bad experiences?

Describe classes which you thought were well paced. What was it about the pacing of these courses that made for a positive learning experience?

What about courses that were paced badly? What were these experiences like, and how did they impact your learning?

Describe experiences where you've had course materials and other resources that helped you learn. How did having these materials help you?

Describe times when you did not have the resources you needed. How did this hurt your learning? What would have helped?

As the instructor, how would you structure a course to help your students learn?

student positionality

How do you feel about your ability to learn math?

How do you know that you've learned?

In general, how would you describe your math background compared to the level of your coursework? That is, did you feel underprepared or overprepared, and how did you know?

How well do you believe that your teachers understand your preparation level? Why do you believe this?

What do you wish your teachers knew about your background and preparation level?

wrap-up

What does a good learning experience in math look like?

What does a bad learning experience in math look like?

What do you wish your math teachers knew about your experiences learning math?