Developmental Mathematics Student Motivation: A Mixed-Methods Study

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Failure and attrition are unfortunately common experiences for developmental mathematics students. These students also frequently experience course repetition and redundancy, though these phenomena are less well-understood. In this mixed-methods study, I aimed to investigate how developmental math students' attitudes and motivation are impacted by their experiences with relearning and course repetition. Additionally, I aimed to describe how these experiences influence shifts in motivation, resulting in changes to academic behaviors and, thus, performance. Quantitative analyses, though statistically insignificant, warrant future inquiry regarding the attitudinal impact of course repetition. Qualitative analyses reveal how students' particular aims and learning histories meaningfully mediate shifts in their motivation. The results of this study demonstrate the salience of investigating how *repetition impacts students' motivation, as well as the utility of theories of motivation in the study of developmental math students' perceptions.*

Keywords: Developmental math, motivation, student perceptions

Developmental mathematics education is a unique and complex system at the threshold of postsecondary mathematics education. Courses in this system–typically focused on algebraic topics–aim to ready underprepared students for college-level coursework through remediation and reinforcement of their mathematical knowledge and skills. Discussions regarding the high rates of failure and attrition documented in developmental mathematics education tend to seek remedies and improvements, rather than to more deeply understand the mechanisms and consequences of the outcomes themselves. For instance, the related phenomena of *course repetition*—when a student retakes a course that they previously withdrew from or failed—and *redundancy*—when a college student takes a course at the same or lower level than what they completed in high school—are common, though research is limited regarding these experiences (Ngo, 2020). Bicak and colleagues (2023) found that two-year to four-year institution transfer students who experienced math course repetition had worse outcomes–including lower cumulative GPA, lower rates of degree attainment, and longer time for degree completion–than students who did not experience course repetition. Ngo (2020) found that nearly 40% of community college developmental math students were in a redundant math course. Lastly, Ngo and Velasquez (2023) found that 48% of community college students experienced a math trap, which is "when students never go beyond their highest level of math in high school" (p. 1637). These findings, situated in the context of community colleges and within the broader scope of postsecondary math programs, warrant further inquiry into the influence of course repetition and redundancy with a specific focus on developmental math, its students, and their learning experience.

Ngo (2020) pondered the "psychic costs to redundant math experiences," speculating "implications for college persistence, degree attainment, and STEM participation" (p. 223). Pursuing this line of inquiry, I am interested in unpacking the influence course repetition has on students' attitudes and motivation, which impacts their performance via their academic behaviors. Research documenting developmental math students' perspectives is limited, despite

it yielding rich insight into the learning experience of these students. I use mixed methods to conduct this study and am guided by theories of motivation.

Theoretical Perspective

Amman (2022) defined *relearning* as "the experience of trying to learn content one has learned (or attempted to learn) before" (p. 1). Given the algebraic content of developmental math courses, it is likely that most students have taken an algebra course during their 6-12 math education. Additionally, as a student experiences course repetition, they are further engaging in relearning. Amman's research demonstrated how students' perceptions of relearning meaningfully shaped their learning in their developmental math classes. In this study, relearning is used to frame the unique context of developmental math students' learning experiences.

To guide my inquiry regarding students' motivation, I used Eccles and Wigfield's (2020) expectancy-value theory (EVT) as a foundational theoretical framework. Specifically, I was interested in students' academic self-concept, subjective task values (i.e., relative cost value), and expectation of success as psychological determinants of motivation (PDM), that is, as proximal influences on their "task and activity choice, performance, and engagement" (Eccles & Wigfield, 2020, p. 3). I am interested in leveraging the relearning framework and EVT together because they both acknowledge the salient accumulation of values and perceptions across time.

This mixed-methods study was guided by the following questions:

1. What is the relationship between measures of motivation and degrees of relearning?
2. Why do shifts in students' motivation occur and how do these shifts relate to experiences with relearning or course repetition?

In quantitatively addressing the first question, I hypothesize that positive measures of motivation would negatively correlate with degrees of relearning (e.g., students with more relearning experiences are less likely to agree with positively oriented motivation statements), while negative measures of motivation would positively correlate with degrees of relearning. In qualitatively addressing the second question, other theories of motivation—such as implicit theory (e.g., Yeager & Dweck, 2012), attributional theory (e.g., Graham, 2020), and control-value theory (e.g., Pekrun, 2019)—meaningfully informed my analysis of the interviews.

Methods

Data Collection

For this explanatory sequential mixed-methods (quan → QUAL) study, I conducted two phases of data collection in three consecutive semesters (Spring 2024 and Summer Sessions I and II) at Temple University, a large, urban research university on the East Coast. Because I was interested in students' degree of relearning—reflecting the extent of a student's experience with relearning, repetition, or redundancy—I sought participants enrolled in Temple University's second level developmental mathematics course, College Algebra.

The first phase of data collection involved a quantitative survey instrument with Likert-type items that measured students' mathematical PDM—that is, their academic self-concept (ASC) on a six-point scale, valuation of relative cost (RC; specifically, effort, emotional, and opportunity costs) on a six-point scale, and expectancies of success (ES) on a five-point scale. These scales were adapted from Marsh and O'Neill's (1984) Academic Self-Description Questionnaire III, Gaspard et al.'s (2014) expectancy-value instrument, and Pintrich and DeGroot's (1990) Motivated Strategies for Learning Questionnaire, respectively. The survey had 30 items, 10 ASC items that alternated between positive and negative orientation, 11 negatively oriented RC items, and 9 positively oriented ES items.

The results from the survey were used to identify participants of interest for the second phase of data collection, which involved a semi-structured interview focused on students' prior and current math learning experiences. Across the three semesters of data collection, 32 students consented and completed the survey, and 4 students took part in the interviews (Table 1).

Table 1. Interview Participants

Participant	Year of Study	Degree of Relearning
Samantha (she/her)	Second year[1]	First enrollment in College Algebra
Aniya (she/her)	First year	First enrollment in College Algebra
		One prior enrollment in Intermediate Algebra
Victoria (they/them)	Third year	Third enrollment in College Algebra
		Two prior enrollments in Intermediate Algebra
Robin (he/him)	First year transfer[2]	First enrollment in College Algebra
		One prior enrollment in Intermediate Algebra

[1] Samantha was a junior by credits.
[2] Robin was a sophomore by credits.

Data Analysis

I used R to conduct cluster and correlational analyses to probe the relation between degree of relearning and student motivation from the survey responses. Specifically, I conducted hierarchical clustering using Gower distance and found Spearman's correlations since I was analyzing Likert-type, ordinal data (Islam, 2023). I conducted a cluster analysis to group the participants according to the orientation and degree of their PDM. To analyze the interview data, I first conducted a thematic analysis of each participant's interview, and then conducted a cross-case comparison of these results to draw conclusions regarding the influence of relearning and course repetition on students' attitudes. During the thematic coding, I looked for descriptions of motivated behavior, that is, when participants explained why they behaved in a certain way. It was in this portion of data analysis that I leveraged different theories of motivation to generate a comprehensive understanding of each participants' experience.

Results

Quantitative. Five clusters emerged from the hierarchical cluster analysis. There were strong, statistically significant positive correlations between participants' cluster and their responses on the positive motivation items (ASC: ρ=0.72; ES: ρ=0.70) and strong, statistically significant negative correlations between participants' cluster and their responses on the negative motivation items (ASC: ρ=-0.79; Effort: ρ=-0.87; Emotional: ρ=-0.74; Opportunity: ρ=-0.77). The cluster analysis discerned two clusters of increasingly negative PDM (clust –1, clust –2) and three clusters of increasingly positive PDM (clust 1, clust 2, clust 3); Samantha was in clust –2, Aniya and Victoria were in clust –1, and Robin was in clust 1. There was a significant, moderate negative correlation between the participants' clusters and their degrees of relearning (ρ=-0.35, p=0.051). In terms of the correlations between participants' degrees of relearning and their responses to the motivation items, there were weak negative correlations for positive motivation items (ASC: ρ=-0.21; ES: ρ=-0.05) and moderate, statistically significant positive correlations for negative motivation items (ASC: ρ=0.38, p=0.034; Effort: ρ=0.36, p=0.046; Emotional: ρ=0.21; Opportunity: ρ=0.42, p=0.018).

Qualitative. All four of the interview participants are pursuing STEM majors: Samantha, Aniya, and Victoria need to pass College Algebra as a prerequisite for their major courses, while Robin needs to complete the calculus sequence for his engineering major.

Samantha. When I spoke with Samantha at the end of the spring 2024 semester, she described herself as never having had a good relationship with math and as being "very grade-motivated, extrinsically motivated." That said, in high school, Samantha successfully completed AP Statistics, which she viewed as one of her few positive math experiences. Samantha traced the shift in her feelings toward math back to elementary school when she struggled to learn fractions, saying:

> Everyone was like, 'Oh, you're just not that good at math,' and then I was like, 'Oh, I'm not good at math—why am I gonna try?' So, it was always just the thing where I'd get to math class be like, 'Oh, here we go.'

Thus, Samantha internalized others' conception of her (lack of) math ability and concluded that it was therefore not worth trying. The last part of Samantha's explanation demonstrates her negative fixed mindset regarding her math ability that she brings with her into the classroom.

Samantha's responses also demonstrate the dependency of her motivation on her grades. When asked to describe a time when she felt good in College Algebra, Samantha replied, "On the first quiz, the first quiz I got 100, and I was the only person in the class to get 100. But it's been downhill since then." She went on to say:

> I did well on the first quiz, and then as soon as I tried on the second quiz and didn't do as well, I was so disengaged in class. [...] There's been a lot of times where I've put effort in—like, trying to do the homework, trying to understand—and then I get an average grade back and I feel like I put above average work into this class, which is very frustrating.

This response underscores Samantha's belief in the reciprocity of effort and performance.

Aniya. When I spoke with Aniya at the end of the spring 2024 semester, she identified a drastic shift in her relationship with math that occurred in College Algebra. When reflecting on her prior math experiences, Aniya described herself as being "really good" at math and "extremely confident" in her skills. Therefore, she was surprised when she tested into Intermediate Algebra— Temple University's first level developmental course—because she was "used to a higher math," leading to her having a negative attitude. As a result, Aniya explained that she wasn't paying attention or engaging in class, and therefore initially performed poorly. However, due to this outcome and her instructor's support, Aniya "switched it and turned it positive" by engaging in class, acknowledging that she could use a "refresher." Ultimately, Aniya described Intermediate Algebra as a positive experience that meaningfully reinforced the strength of her mathematical understanding. This positive shift demonstrates Aniya's resilient and positive malleable mindset regarding her math ability.

Aniya's confidence and positive perception of her own math ability shifted toward the negative in College Algebra when she was accused of cheating on the first exam. Following this incident, Aniya said she "completely checked out," explaining that she was disheartened by the nature of the accusation, which, at its core, questioned her mathematical knowledge. When discussing how her survey responses would have "absolutely" been different if she had taken the survey prior to the spring semester, Aniya reflected:

> It is absolutely saddening to me, if I'm being completely honest, because I really used to enjoy math and it was one of my favorite subjects. [...] And, honestly, I can say now that if I could choose to never take a math course again, I would.

While reflecting on her new feeling of annoyance and inadequacy when doing math, Aniya stated, "Now, I don't feel smart anymore when it comes to math."

Victoria. When I spoke with Victoria at the end of summer 2024 session I, they described themselves as an overall anxious learner with particularly inhibiting test-taking anxiety. When asked how they felt about their math skills upon entering college, they said:

> I wasn't terribly excited about it—just because I know math isn't my strong suit—but I didn't expect it to be as hard as it is; I didn't expect to have to take Intermediate Algebra for two semesters, and then this being my third attempt at College Algebra.

The reality of repeating these courses multiple times weighed heavily on Victoria. They later affirmed that their survey responses would have been different prior to the current term, noting, "my answers kind of just progressively went down the more like times I took it." Specifically, they tied the connectedness of their PDM and course repetitions to their STEM major, saying:

> I guess it [(my survey responses)] kind of goes down more because I'm a STEM major. I feel like a lot of stuff I have to do is math stuff and it's like I don't really understand math a lot. Like, I'm doing a bit better, but I'm still having the same issues that I was having, like, not understanding them. It kind of makes me base my self-worth and academics on my math class and I'm not doing good, so it's like my [survey] answers are poorer.

When discussing their current attempt at College Algebra, Victoria described defeating anxiety about the ramifications of not passing including having to reluctantly change major or dropping out of college, "I don't want to have to drop out and then be like, 'Oh my God, I had to drop out because I couldn't pass College Algebra.' So, it's a lot mentally riding on me passing this time."

Robin. When I spoke with Robin at the end of summer 2024 session I, he brought a unique perspective as a non-traditionally aged student, returning to college after over a decade in the workforce to complete his degree, advance at his career, and continue to support his family. As such, Robin's motivations extend beyond academic credit. Prior to enrolling at Temple University, Robin pursued a degree at another local university, completing up through Calculus I after having taken it twice. He noted that he felt frustrated and disinterested in learning math at his previous institution.

After receiving a low score on the placement exam, Robin reported that he "didn't feel confident at all about his math skills" and explained that he was presently enrolled in College Algebra because he "needed to get caught up" to swiftly advance through his engineering math coursework. Speaking of his placement in Intermediate Algebra, Robin explained:

> I'm willing to just start over because I don't want to get to this level and then be stuck because I don't remember any of the basics. It was no big deal for me to just pay the extra money to start over and, you know, learn properly again.

Thus, looking to the future, Robin is motivated to shore up his mathematical fundamentals, knowing he will have to complete the calculus sequence. Furthermore, Robin noted his awareness of his academic financials, explaining his prior reluctance to complete his degree:

> I don't want anything that's going to stress me out: I don't get that [concept], so I have to take [the class] twice. Now, it's wasted money because I have to take it twice or because I failed.

Thus, reflecting on the past, Robin describes his academic behaviors as being motivated by a desire to avoid (the financial consequences of) repeating classes again.

Discussion

Quantitative

In exploring the relationship between measures of motivation and degrees of relearning, I hypothesized that students' motivation would decrease as their degree of relearning increased. Though not all the correlations were statistically significant, the directionality of the negative correlations between the positively oriented motivation items and degrees of relearning and of the positive correlations between the negatively oriented motivation items and degrees of relearning support this hypothesis.

There are two notable limitations to these findings. First, while the survey items used had strong internal validity (Cronbach's alpha = 0.966), the survey's external validity—for measuring the EVT constructs of ASC, RC, and ES in college math students—is questionable given its construction from different extant instruments. Second, this study's sample size is quite small (n=32), further limiting the validity of these analyses. That said, given the limited research focused on understanding the impact course repetition has on students, their non-cognitive factors, and their learning, these results warrant further study.

Qualitative

The conversations I had with my four participants underscored the unique and individual nature of student motivation and its sensitivity to individuals' particular aims and learning histories. For instance, Samantha and Aniya reacted completely differently in response to poor grades, which can be understood by leveraging attribution theory, implicit theory, and control-value theory. On the one hand, Samantha described feeling the demotivating negative emotions of frustration and helplessness when her "above average effort" yielded average grades. In this response, Samantha also expressed her belief that her other classes were "arguably harder" than College Algebra and reported exerting more effort and receiving higher grades in those other classes. Given Samantha's negative and fixed view of her math ability and her grade-based extrinsic motivation, it is likely that this experience, in some way, confirmed the notion that her effort could not compensate for her perceived lack of math ability. On the other hand, Aniya appeared to feel *motivating* negative emotions when she initially received poor grades in Intermediate Algebra, which prompted her to modify her behaviors to be more engaged in class. Implicit theory suggests that Aniya's malleable view of her math ability attributed to her response. While this has less to do with these students' experiences with relearning, the differences between Samantha and Aniya's responses underscore the salience of students' motivational characteristics to their course engagement and performance, as well as the importance of the perspectives they bring with them into the classroom.

Focusing on the influence of relearning and course repetition experiences specifically, Robin and Victoria's responses demonstrate how such experiences influence shifts in motivation. On the one hand, Robin's prior experience with course repetition—and desire to avoid its financial consequences—motivates his current approach to learning math. Specifically, knowing he has to complete the calculus sequence, Robin demonstrates diligence in solidifying his mathematical foundation. On the other hand, reflecting on their second attempt at College Algebra following their two enrollments in Intermediate Algebra, Victoria described being very conscious of their course repetitions, which prompted an adjustment of their behaviors in an effort to avoid future repetitions: "I realized that I can't be anxious to ask for help. Like, I'd rather ask for help than fail my class." Therefore, Robin and Victoria demonstrated how experiences with course repetition can serve as motivators, prompting positive behavioral changes. However, overall, Victoria's experience with multiple course repetitions appears to inhibit, more so than help, their

attitude, motivation, and academic behaviors. Specifically, Victoria described relating their course repetitions to their self-worth via their STEM major because their success on their third attempt at College Algebra would dictate the future of their academic trajectory. This generated a lot of anxiety for Victoria, which increased their test anxiety and likely impacted their memory and performance by depleting their cognitive resources (Ashcraft, 2002; Meinhardt & Pekrun, 2002). Relatedly, Victoria described struggling to remain optimistic about their likelihood of success and ability to continue their desired academic path. Therefore, Victoria's experience demonstrates how experiences with course repetition can accumulate and negatively impact students' attitudes and motivation, underscoring the importance of this investigation.

Lastly, Aniya's experience (i.e., positive prior math attitudes and outlooks, and then a hard shift during a developmental math course) might provide insight into the development of math traps, when students do not go beyond their highest-level high school math course. Though this is not to say that Aniya is or will get stuck in a math trap, it is important to highlight that Aniya proudly described passing Calculus "with flying colors" in high school and that, before College Algebra, she was extremely confident in her math abilities. When discussing her developmental math courses, she described two instances where her prior, more advanced mathematical knowledge caused her instructor to question the strategies she used. While one experience she described fondly as positive reinforcer of her math ability, the other (when she was accused of cheating) left her reluctant to engage with math in the future. I see Aniya's experience as a cautionary example of the negative consequences of redundant math.

This study is a first step in documenting the motivational, non-cognitive impact of course repetition. By capturing the perspective of students, we can better understand *why* and *how* developmental math courses suffer from high rates of failure and attrition. Future research warranted by this study includes a semester-long study of how course retakers' motivation shifts over the course of a semester.

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