Examining the Effects of Self-Regulated Learning and Growth Mindset Instruction for Underprepared Students in Corequisite College Algebra

by

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ABSTRACT

The shift across developmental education from prerequisite to corequisite remediation has left students underprepared for college-level mathematics in need of additional support. Typically, this support takes the form of content remediation, but what happens when this extra help is reframed in terms of student learning skills and confidence? Taking place across four sections of College Algebra at a large community college in Texas, this mixed methods, quasi-experiment examined the academic and affective outcomes between students given the usual, content-centered remediation versus an intervention grounded in the theories of self-regulated learning and growth mindset. This intervention included explicit instruction on cognitive and metacognitive learning strategies and growth mindset principles, weekly reflective student learning journal writing prompts, and a reworking of formative assessments. No statistically significant differences were found between the two groups, but higher exam scores by the intervention group indicate possible practical significance. Qualitative differences also emerged between the two groups with the intervention group self-reporting a wider variety and more frequent use of metacognitive learning strategies, demonstrating a higher degree of self-experimentation and strategic planning, and experiencing greater increases in external locus of control and self-confidence. Although many interesting avenues remain to be studied the incorporation of self-regulated learning and growth mindset principles may help students enrolled in corequisite algebra-based courses become more effective learners.

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Chapter 1

Introduction

Many people at some point in their lives have had a negative experience with mathematics such as failing an assignment, being made to feel inadequate by an impatient teacher, or becoming frustrated with their child's homework. Sometimes it may be something less obvious, such as a multiplication drill that emphasized speed, "real life" word problems that did not have anything to do with real life, or boring questions that required more memorization than understanding. When people have one of these experiences they might start to believe all sorts of unconstructive things: maybe they are just "bad" at math; maybe math will always feel foreign and difficult and there is not much they can do about it; maybe mathematical thinking is not something that can worked on and improved, someone either "has it" or they do not.

Unfortunately, sometimes mathematics teachers perpetuate some of these same negative ideas even if they do not realize it. Mathematics at the college level is rife with language (such as remedial, developmental, underprepared, at risk) that lends itself to blaming students for shortcomings, failing to recognize their potential, and absolving the instructor from responsibility for lack of learning. A label such as "underprepared" often takes on inherent qualities the student lacks. A more constructive framing may help challenge teachers to explore their students' past experiences and find a productive way forward.

In this action research dissertation study, I focus on the issue of improving mathematics education for underprepared mathematics learners within a new model of developmental mathematics teaching and learning. I will use the term "underprepared" because it is ubiquitous throughout the literature on mathematics developmental education. However, I try not to wield this term as a weapon against students, as such terms often are. I use “underprepared” to indicate that something in the students’ past experiences has failed them as learners, not that they are incapable of learning college-level mathematics. It is these students who most point to the need for reframing college-level mathematics—from who gets to take the course to how it is taught and assessed.

These issues are front and center in this study, which examines the type of support college-level math teachers provide to underprepared students. Schools around the country, including my institution’s state of Texas, are being asked to redesign their developmental education sequences by pulling students out of traditional, prerequisite developmental math classes and instead enrolling them in college-level math classes supplemented with remediation. In this action research study, I consider what kind of remediation support may be the most helpful for underprepared students taking a College Algebra course at my institution.

Is Traditional Developmental Education Working?

In the postsecondary context, a distinction exists between developmental and college-level (or credit-bearing) course work. The former is typically intended for content remediation taken prior to a college-level course and does not count towards the credit hours needed for a degree. To this end, developmental education (DE) around the United States is undergoing a crisis of identity. Historically, mathematics DE was designed for students needing remediation before taking a calculus course, but today fewer than five percent of students attending two-year institutions will ever take calculus (Hastings et al., 2006) while significantly more than this are assigned to some sort of math remediation.

In September 2016, an analysis published by the U.S. Department of Education (DOE) reported that nationally, over 59% of incoming students at two-year institutions took at least one remedial math course (Chen, 2016). Unfortunately, discouraging data on DE completion rates, as well as lack of subsequent success in a college-level course, college persistence, and credit hour accumulation have left policy makers, educators, and students questioning the utility of the traditional, prerequisite structure of DE.

Only about 50% of students starting in a mathematics developmental course at a two-year institution successfully complete their DE sequence (Bailey et al., 2010; Chen, 2016). Of those who complete, nearly 62% go on to earn credit in a college-level math course, compared to 48% who do not enroll in any remediation (Chen, 2016). On the other hand, students starting in DE who complete only some or none of their remedial courses earn a college-level credit only 36% and 18% of the time, respectively (Chen, 2016). These DOE numbers coincide with the Bailey, et al. (2010) study that claims only 20% of students referred to DE successfully complete a corresponding college-level course within three years.

The numbers are also low for transfer and graduation rates of students needing remediation at 2-year institutions. Students who complete only some or none of their DE sequence are less likely to transfer to a 4-year institution and more likely to have dropped out of college altogether within six years of initial enrollment (Chen, 2016). They also accumulate fewer hours than their counterparts who either completed their remedial classes or forwent DE altogether (Chen, 2016). Taken together, these disappointing results suggest that instead of serving as stepping stones, remedial classes act more as hurdles.

Yet most of the statistics presenting DE in an unflattering light compare disparate populations—students deemed prepared for college versus students deemed underprepared. For a more valid discussion of DE, we must instead look at studies that compare the effects of DE on similar populations. A number of studies have utilized regression discontinuity designs to compare students slightly across either side of the college placement cutoff at their respective institutions, with varied results.

Bettinger and Long (2009) found that remediation has an overall positive effect on student persistence; this positive effect also extended to degree completion. Studies controlling for mediating variables such as socioeconomic status and past academic experience have found that students at two-year institutions who complete their DE sequence are more likely than comparable students who never took DE to graduate (Atwell et al., 2006) and just as likely as the rest of their cohort (including students who did not need remediation) to graduate or transfer to a four-year institution (Bahr, 2010).

However, several studies found students who placed just under the college-level cutoff and subsequently enrolled in DE experienced a neutral effect (Calcagno & Long, 2008; Martorell & McFarlin, 2011; Scott-Clayton & Rodriguez, 2015) to slight disadvantage (Boatman & Long, 2018) from taking DE. Borderline students who took a DE math class before enrolling in a college-level course did not show an increased likelihood of taking college credits or completing a degree (Calcagno & Long, 2008; Martorell & McFarlin, 2011; Scott-Clayton & Rodriguez, 2015), but neither did they show a decreased effect. Advocates of DE point to these results and argue that DE is accomplishing its intention—to give underprepared students the same (not necessarily better) chance at completing college-level coursework and graduating (Goudas & Boylan, 2012).

However, detractors of DE point to these same results and claim that while DE itself does not appear to be detrimental to students, the economic burden, both to the state and to students themselves, of enrolling in additional DE classes is not worth the additional time and money (Bailey et al., 2013). The answer—whether DE causes benefit or harm to underprepared students—is important because it holds crucial implications regarding how best to help incoming students traditionally deemed underprepared for college-level mathematics. If eliminating DE as we currently know it is the solution, are there still elements of DE that should be integrated into our new models?

Legislators, school administrators, and educators alike see the lower retention, completion, and graduation rates of students who start in DE and agree that change is necessary. The key question then becomes, what kind of change? Recent decades have seen programs around the country implement reforms such as course acceleration, tutoring labs, emporium models, and modular classes, each with varying degrees of success. In January 2017, the DOE released its report *Developmental Education: Challenges and Strategies* in which several recommendations were made for DE reform, including early interventions for at-risk secondary students, using multiple college-level placement measures, providing extensive and system institution support, compressing or accelerating DE sequences, and using corequisite remediation (Schak et al., 2017).

The Corequisite Model

The term *corequisite* in education has been in literature since at least the 1990s, used by actors in the California Community Colleges system (Academic Senate for

California Community Colleges, 2010). As defined by the California Code of Regulations, Title 5, "'Corequisite' means a condition of enrollment consisting of a course that a student is required to take simultaneously in order to enroll in another course" (CA 5 CCR §55000). The corequisite (coreq) model is a paradigm shift because it eliminates the concept of DE as a prerequisite to entering a college-level course. Instead, students who are deemed underprepared, by whatever the system's standard of measure, are enrolled straightaway into a credit-earning class accompanied by some sort of additional, remedial support course.

State policy makers have started to turn towards a coreq remediation model in an attempt to address the shortcomings of the traditional DE model discussed above. Promoters of the coreq model argue it benefits students starting at the DE level but who do not need an entire semester of remediation before attempting a college-level course. Instead, the remediation is targeted specifically to the college-level course material, also referred to as "just in time" tutoring. It also is intended to increase student retention since it eliminates the potential loss of students between semesters that occurs under the traditional DE model (Atkins & Beggs, 2017; Belfield et al., 2016; Kashyap & Mathew, 2017; TBR, 2009).

The model has been tested by public and private schools, community colleges and universities, through small pilots and large-scale enactment across entire states such as Tennessee and Florida. Schools and systems that have completely abolished traditional remediation and require all students needing remediation to enroll in a coreq course have seen a large increase in the percentage of students needing remediation successfully completing a college-level math course when compared with DE cohorts from previous years (Belfield et al., 2016; Royer & Baker, 2018; TBR, 2009). In places where the coreq model was one of multiple options, students who registered for the coreq model were more successful than those who enrolled in a college-level class without coreq support (Anderson & Foxley, 2016; Park et al., 2017), passed a college-level math class at higher rates than students who took the traditional remediation route (Kashyap & Mathew, 2017), and had a lower noncompletion rate than students enrolled in a traditional DE course (Campbell & Cintron, 2018). Researchers declared the coreq model a success even when there was no statistically significant difference in college-level course completion rates between those taking a coreq versus a prerequisite DE course, because students in the coreq course spent less time and money those in the traditional DE course to complete their college-level math course (Atkins & Beggs, 2017; Campbell & Cintron, 2018).

However, many of these positive results have been produced by coreq models enrolling only students at the borderline of the college-level cut-off, and thus do not account for higher need students. Furthermore, the existing research fails to address the significant proportion of students, often upwards of 50%, who are not experiencing success in the coreq model. And finally, the coreq support discussed in the literature focuses primarily on providing students with content exposure, with little to nothing said regarding helping students actually *learn how to learn* all of this additional content. As an educator at an institution that the state of Texas now requires to transition the majority of developmental math students to a coreq model, I am sharply aware for the critical need to understand and address these gaps as we seek opportunities for success for our most vulnerable students.

Texas Legislation and HB 2223

For years, Texas policy makers have been attempting to address the achievement gap experienced by students needing remediation through eliminating and accelerating the DE sequence. Their most recent legislation requires colleges to move to the coreq model. Signed into law in 2017, Texas House Bill 2223 (TX HB 2223) requires public colleges and universities across Texas to phase out traditional prerequisite DE courses in favor of coreq courses.

During Fall 2018, schools were required to enroll at least 25% of their DE population into a coreq course, meaning students enrolled straightaway in a college-level math course while taking some sort of DE support concurrently (TX HB 2223). In Fall 2019, this requirement was raised to at least 50% of the DE population in a coreq course, and by Fall 2020, the state required that 75% of your DE population enrolled in the coreq model (TX HB 2223). It is within this shifting context that this action research study occured.

However, the percentage requirements are nearly the only stipulation of the bill. The state did not dictate to schools how many credit hours of additional support to add, which courses or students to target, or (perhaps most importantly) curriculum requirements for these newly created DE support courses. This leaves the door open for schools to develop what they determine to be the best fit for their student population. Many are choosing to simply put students on a computer learning program for an additional hour every week, in hopes that students will “catch up” on the DE material they do not know yet. As a mathematics educator who has worked for years with DE math students, I question whether these students will be able to “boot strap” themselves up to the college-level standards of the class. Will it help to simply throw even more content at students who are already likely to feel inadequate with mathematics? How might college mathematics instructors design learning opportunities to better serve these students? These questions emerge within the situated context that I work within, driving the focus of this study.

Situated Context

I began my career as a lecturer in the mathematics department at Texas A&M University in College Station. For three years, I taught mostly to lecture halls of 100+ students, most of whom graduated in the top 10% of their high school class. In Fall 2009 I took my current teaching position at Northwest Vista College (NVC), a large (over 15,000 students) community college in the northwest corner of San Antonio, Texas, designated as a Hispanic-serving Institution. The math department serves over 3,000 students every semester, over 60% of whom place into developmental education (DE; J. Pace, personal communication, August 7, 2018). At NVC, I have been involved in a number of DE initiatives, from flipping the classroom and accelerated courses to content creation and advising.

Recognizing a need to differentiate between the algebra needs of Science, Technology, Engineering, and Mathematics (STEM) majors and non-STEM majors, starting Fall 2010 the NVC math department split our College Algebra course into two tracks – one for STEM majors and another for non-STEM majors. I have been active in the creation and progress of both courses. Due to my knowledge of the coreq model and experience with non-STEM College Algebra course, I co-created NVC's coreq non-STEM College Algebra during the spring of 2018. That summer I began training other faculty, and implementation of the course began Fall 2018. According to NVC's most recently available internal data, the success rate (percentage of student who earn a grade of A, B, or C in the course) of NVC students enrolled in coreq non-STEM College Algebra during Fall 2018 and Spring 2019 was approximately 72% and 69%, respectively.

While success rates hovering around 70% are reasonable, up until Fall 2020 the students taking a coreq College Algebra course at NVC were still the 'borderline' students, those who just missed the college-level cut-off score or who have already taken one level of DE mathematics. However, starting Fall 2020 the HB 2223 requirement increased to 75% of students needing remediation who must be enrolled in a coreq model. This increase necessitated reaching into the student population of our entry level DE course and placing students well below the cut-off into college-level courses.

Problem of Practice

At NVC, failing a coreq course pairing has more severe consequences than failing a DE course. For DE courses, NVC has an 'In Progress' (IP) final grade that is given instead of a D. The IP grade has no effect on the student's GPA. Since the coreq course involves a college-level class, receiving a D negatively affects GPA, thus potentially affecting financial aid and transfer opportunities. Even if the final grade is an F the DE course counts for fewer hours than the coreq course and thus GPA is less negatively impacted. Furthermore, withdrawing from a DE course does not count towards the state's 6 Drop Rule (only six withdrawals allowed throughout one's Texas public college education), but withdrawing from a coreq course does. Another consequence involves Texas's Excess Credit Hours rule by which students must begin paying out of state tuition after 150 attempted credit hours; DE courses do not count towards the 150-hour total, but coreq courses do.

Thus, the stakes are much higher for underprepared students enrolled in a corequisite course, and this population continues to increase. As of Fall 2019, the corequisite requirement at NVC applied only to ‘borderline’ non-STEM College Algebra students who were already being served by an NVC course acceleration previously. But by Fall 2020, the state’s mandated phase-in of the coreq model meant that the coreq population was extended to students who tested into college at a lower level and thus were at a higher risk for failing their college-level course. Given that underprepared students are some of our most vulnerable in terms of academic outcomes, these heightened consequences place an even greater importance on finding ways to support their learning in college-level courses. We must find a way to meet these students where they are in order to provide them the best opportunity to pass their college-level math course on their first attempt.

However, most of the current coreq literature includes only borderline students and states very clearly that the results may not generalize to higher need students. Furthermore, there is a lack of research addressing the significant numbers (often at least 50%) of students failing their corequisite course. Therefore, NVC must look beyond the coreq literature to address the issue of underprepared students enrolled in a college-level algebra course. Such students clearly are in need of additional learning support and it is critical to explore ways to ensure that they develop as effective learners of mathematics. Given the need to help underprepared math students develop strategies that support them as individual learners and promote confidence in their ability to learn math, self-regulated learning offers a promising area of intervention. This is particularly true when combined with mindset theory.

Theories Behind the Intervention

Self-regulated learning (SRL) takes on a variety of forms in the literature, but the definitions and components discussed are variations of the same construct with key underlying commonalities. In ideal situations, people learn in a cyclical feedback loop. Initial plans, thoughts, and feelings surrounding the subject matter all influence learner strategies and performance; performance then produces outcomes on which the learner can reflect and self-assess, thus providing a chance to iterate and make changes in their plans and strategies if need be (Zimmerman, 2000). It is a complex and multi-faceted process people often employ without conscious effort. However, for many students this cyclical process of learning does not come naturally in an academic setting. Students often need help acknowledging their thoughts and feelings around mathematics, and support with metacognitive processes such as employing appropriate strategies and learning how to self-evaluate. For students who are underprepared for college-level work, providing SRL instruction and support may be particularly important (Zimmerman et al., 2011).

Also of import is Dweck's (2008) mindset theory. People with fixed mindsets tend to believe their abilities are predetermined (for example, this can be seen in the often-heard comment, "I am not good at math"), but people with a growth mindset believe they can improve through hard work and practice. Dweck (2014) encourages us to think of the difference between the two as arising in the simple addition of the word "yet". For instance, the phrase "I am not good at math" (fixed mindset) as opposed to, "I am not good at math…*yet*" (growth mindset). The addition of this simple word can make a substantial difference in the learning potential of my students.

Mindset theory shares commonalities with the planning phase of SRL, which deals with emotive components of learning, but it also fundamentally affects other elements of SRL such as performance, strategies, self-evaluation, and adaptation. Students with a fixed mindset towards mathematics will not be as likely as those with a growth mindset to believe that their mathematical ability can be developed by improving their learning process. Therefore, an intervention aiming to improve students' SRL ability must also take into account their mindset. To this end, I developed an instructional intervention I have titled GEAR. GEAR stands for *Growth: Emotions, Actions, and Reflections*, signifying the goal of progression in each of the three phases of SRL.

However, in my research around SRL and mindset interventions, I have realized it is not helpful (and perhaps even counter-productive) to place the burden of improvement solely on the backs of students. Boaler (2016) reasons that students' underdeveloped study habits and fixed mindset beliefs result partly from years spent in an academic system that simultaneously reinforces shallow study skills and hinders growth mindset practices. If my aim is to help students shift towards more productive thoughts and practices, I realized I needed to start with my *own* thoughts and practices. This realization and resulting reflection comprise an element of action research Noffke (2012) refers to as the personal dimension of action research, "making personal beliefs more congruent with practices" (p. 6). Discovering my own role within the SRL/mindsets intervention has required a thoughtful, critical reflection of my own planning, strategies, and self-evaluation, thus mirroring my students' own journeys through the SRL process.

Research Purpose and Questions

By design, students entering NVC's non-STEM College Algebra coreq course are underprepared for college-level math and require additional support in order to succeed. NVC is already utilizing conventional interventions in place at other institutions for coreq courses, such as advising students towards non-algebra-based courses, incorporating active and collaborative learning, and providing additional tutoring. Therefore, we need an original innovation. As I will explore in the theoretical foundations of chapter 2, research indicates that helping underprepared students become better self-regulated learners and develop a growth mindset can increase their chance of academic success. But successfully implementing an intervention such as GEAR requires the teacher to contemplate and adjust their own practices.

In my research I am attempting to determine how closely the academic success of students in NVC's coreq College Algebra class is related to their SRL abilities and mindset beliefs. Furthermore, I want to find out if employing the GEAR intervention can improve students' abilities and beliefs in these areas, as compared to using class time solely for additional math remediation. And finally, I am interested in exploring how students' perceptions of themselves as mathematical learners might be changed by such the GEAR intervention.

RQ1) Compared to a group receiving additional mathematics remediation, what impact does GEAR have on students' academic achievement in corequisite non-STEM College Algebra?

RQ2) What impact does GEAR have on students'

a) SRL ability?

b) Growth mindset regarding math?

RQ3) How do students' perceptions of themselves as mathematical learners change during implementation of GEAR?

Chapter 2

In my large and local context chapter, I present the current situation of developmental education, introducing the corequisite (coreq) model of remediation and discussing the ramifications for students who are placed in a coreq non-STEM College Algebra course at my institution. In this chapter, I will explore the theoretical perspectives and studies that inform my action research project by examining self-regulated learning (SRL) and implicit theories of intelligence, also referred to as mindsets. I will discuss the relationships between students' SRL skills, mindsets, and their academic achievement as well as consider research which demonstrates that educators can foster SRL skills and growth mindsets in a classroom setting. Researchers have studied a range of interventions across primary, secondary, and post-secondary classrooms, and while specific results fluctuate, the overall trend for the impact of SRL and mindset instruction on student success is promising. In this action research dissertation study, I develop an intervention informed by SRL and mindset frameworks and examine its influence on underprepared students within the new coreq model of developmental math education.

Self-Regulated Learning

An interest in metacognition, or one's awareness and understanding of one's own thought processes, led me to SRL. I want to encourage students to think about their thinking, which is one of the central components of SRL. Additionally, the attention that SRL pays to the affective domain is also crucial, given the range of trepidation, lack of interest, and anxiety many math students confront. While math content is obviously the defining element of a math class, I believe spending more class time on content instruction will not benefit students if they do not know how or are afraid to learn the content. My ultimate goal utilizing an SRL intervention is to help students learn how to learn by showing them tools and strategies with which to accomplish this.

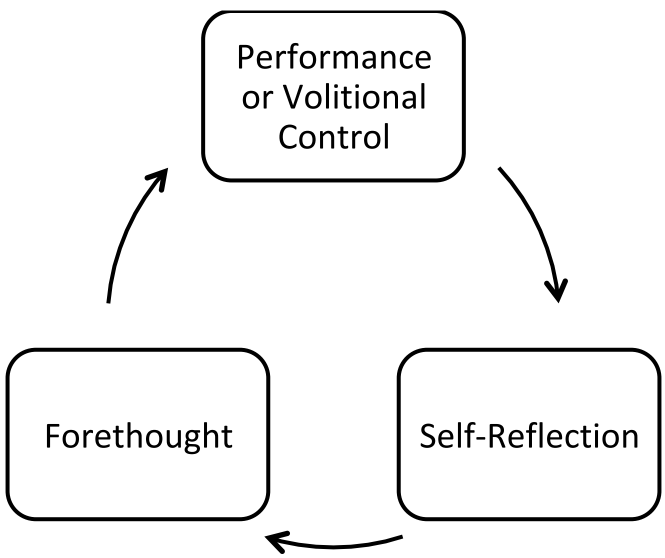
Introduction to Self-Regulated Learning

As the field of educational psychology expanded beyond behaviorism and early cognitive models in the mid-twentieth century, focus began to shift towards empowering students to exert control over their own learning. Self-regulated learning developed as a branch of self-regulation theory, fathered by Albert Bandura. By the late twentieth century, most major constructs of SRL had been widely explored in educational psychology, such as: self-efficacy (Bandura, 1977; Schunk, 1981; Schunk, 1984), goal setting (Locke et al., 1981; Schunk, 1985), implicit self-beliefs (Dweck & Leggett, 1988), intrinsic motivation (Bandura & Schunk, 1981; Zimmerman, 1985), cognitive strategies (Corno & Mandinach, 1983; Schunk & Rice, 1984), self-monitoring (Schunk, 1982; Shapiro, 1984), and metacognition (Kurtz & Borkowski, 1984; Paris et al., 1984; Pressley et al., 1987). In the late 1980s, these ideas were formally blended together in the first SRL handbook, edited by Zimmerman and Schunk (1989), forming the basis for the strategic learning cycle now recognized as SRL theory.

Early influences of the SRL model include Bandura's (1986) representation of self-regulation as a triadic reciprocity between personal, behavioral, and environmental factors and strategies, and the framework Carver and Scheier (1982) developed. They envisioned self-control as a self-regulated feedback loop and likened it to the setting, operating, and monitoring tasks of a thermostat (as cited in Burnette et al., 2013). So while the extensive body of SRL literature presents the framework in a variety of ways, an underlying commonality between representations is the distinct but related categories of thoughts and strategies believed to take place before, during, and after learning, and their reciprocal interplay. For example, Pintrich (1989, 2002), discussed SRL metacognitive strategies as occurring during *planning*, *monitoring*, and *regulating* phases, while Zimmerman's (1998, 2000) formulation presents the phases as *forethought*, *learner performance* (or *volitional control*), and *self-reflection* (see Figure 1). I will use the latter's terminology throughout this paper.

Figure 1

Self-Fulfilling Cycles of Academic Regulation



Note: A visual depiction of the cyclical nature of self-regulated learning phases (Zimmerman, 1998, p. 3).

Learners can proceed through the cycle with adaptive, mastery-oriented thoughts and strategies or maladaptive, self-handicapping beliefs and behaviors (eg. DeCastella & Byrne, 2015; Doron et al., 2009; Schneider & Preckel, 2017). In the mastery-oriented case, a student believes they are capable of and interested in learning the topic at hand, sets positive learning goals for themselves, uses effective learning strategies, successfully monitors progress towards their goals, views feedback constructively, and makes helpful adjustments to the process if necessary. Thus, the cycle becomes a positive feedback loop. However, the opposite can also occur. If a student is performance-oriented they might set goals out of fear and view feedback negatively. Such student may be likely to utilize ineffective or, even worse, self-handicapping strategies, leading to poor results and thus confirming negative self-beliefs. So their maladaptive beliefs and actions are likely to be perpetuated.

The Phases of Self-Regulated Learning

If SRL was a car, the forethought phase would be the steering wheel. It involves the thoughts and feelings that occur before the learner takes action and thus points them in the direction they will ultimately travel: mastery or maladaptation. This phase is when the crucial steps of goal setting and strategic planning occur, which Zimmerman (2002) groups together as task analysis. The forethought phase also includes affective components related to self-motivation (Zimmerman, 2002) such as self-efficacy, learner interest, learner's perceived control, and goal orientation (Cleary et al., 2008; DiFrancesca et al., 2016; Zimmerman, 2000).

Goal setting involves the strategy of creating manageable, short-term goals that are easy to monitor (e.g., "I will spend 2 hours every day studying") as opposed to longer-term, nebulous goals that are difficult to measure (e.g., "I want to pass the class"). Goal orientation has less to do with strategy and more with motivation. A learning-oriented goal will be motivated by *increasing* how much you know, but a performance-oriented goal will be driven by *showing* how much you know. Goals are also powered by approach or avoid motivations (Grant & Dweck, 2003). Another important sub-construct of the forethought phrase is the learner's perceived control, which is crucially tied to implicit theories (Dweck & Leggett, 1988); whether or not a student believes they are capable of improving their learning will influence the subsequent behaviors and strategies they are willing to adopt.

Continuing the car analogy, the performance stage may be considered the engine of SRL; it is what makes the whole thing go. This stage is comprised of the processes that drive present learning opportunities and is when learners are actively employing cognitive strategies (whether useful or maladaptive) planned for and motivated during the forethought phase. These strategies fall into one of two classes: self-control and self-observation (Zimmerman, 2002). Self-control strategies include self-instruction, concentration and attention tactics, and task specific cognitive strategies, while self-observation involves concomitant evaluation and adjustment of actions (Butler et al., 2005; Cleary et al., 2008; Zimmerman, 2000, 2002).

Students employing successful cognitive processes during the performance phase are employing a variety of effective learning strategies while avoiding distractions. They do this all while self-monitoring to check that they are meeting the learning goals they set for themselves and making adjustments if not. However, learners who have adopted maladaptive strategies likely find themselves wasting time on an ineffective or purposeless learning activities, having difficulty staying focused, failing to notice when their practice is fruitless, and perhaps even engaging in self-handicapping behavior such as skipping class or ignoring homework assignments.

Finally, the self-reflection phase that follows is the transmission of the car. When running properly, it serves to make the most effective use out of the learning produced in the performance stage and to change gears when necessary. In the self-judgment class of processes students employ self-evaluation and assign explanations for their results (Zimmerman, 2002), while self-reaction processes are students' emotive responses to their performance, which can be self-satisfying if positive and destructive if not (Zimmerman, 2002). During this phase students make use of self-evaluative assessment and external feedback (Cleary et al., 2017; Zimmerman, 2000; Zimmerman et al., 2011) to judge their performance and make applicable adjustments to their goals, attitudes, and strategies, thus starting the cycle over again.

Self-evaluation is used to measure one's performance against some sort of standard set by the teacher, themselves, peers, or some combination of the three. Consciously or not, learners then assign reasons for their successes and failures, also known as causal attribution. A student who credits success or failures to effort (or lack thereof) will have more cause to re-engage meaningfully with the SRL cycle than a student who attributes outcomes to external or uncontrollable forces. The positive or negative emotions experienced by learners during this phase will also play a role in their adoption of mastery versus helpless attitudes and actions. Does failure feel like a positive opportunity to learn from, or a negative result to avoid?

SRL and Connections to Academic Achievement

Over the past few decades, an abundance of research has shown that students' SRL skills relate to their academic achievement across a variety of age levels, from primary and secondary students (e.g. Dent & Koenka, 2016; Dignath et al., 2008; Fuchs et al., 2003a; Wolters, 2004; Zimmerman & Kitsantas, 2014) to college undergraduates (e.g. Cohen, 2012; Schneider & Preckel, 2017). Indeed, the relationships between academic outcomes and the three phases of SRL may even be stronger than those between outcomes and demographic or personality qualities (Schneider & Preckel, 2017).

Within the self-motivation class of the forethought phase, students who are higher achievers tend to have greater self-efficacy and higher achievement motivation (Blackwell, Trzesniewski, & Dweck, 2007; DiFrancesca, Nietfeld, & Cao, 2016; Schneider & Preckel, 2017). They set more mastery and achievement-oriented goals (Aditomo, 2015; DeCastella & Byrne, 2015; Grant & Dweck, 2003), and they are more likely to believe that intelligence is malleable (e.g.. Burnette et al., 2013; DeCastella & Byrne, 2015). Task analysis may be just as important. Two recent large-scale meta-analysis of the relationship between SRL sub-constructs and academic outcomes found moderate to strong relationships between achievement and effort regulation (Schneider & Preckel, 2017) and task planning, in particular (Dent & Koenka, 2016; Schneider & Preckel, 2017).

Cognitive strategies also play a role, as lower or superficial learning strategies are associated with poorer outcomes (Dent & Koenka, 2016; DiFrancesca et al., 2016; Schneider & Preckel, 2017), whereas students who use higher order strategies such as retrieval practice (retrieving information from memory, Lyle & Crawford, 2011), elaboration (connecting ideas to prior knowledge and contiguous information, Dent & Koenka, 2016; Schneider & Preckel, 2017), concept maps (visual connections of concepts and themes, Schneider & Preckel, 2017), or self-checking (Dent & Koenka, 2016) tend to achieve at higher levels. A detailed path analysis performed by Burnette et al. (2013) found mastery-oriented cognitive strategies have a strong effect on goal achievement. Self-control processes are also important. Higher achieving students employ more control strategies such as attention focusing, class attendance, and resource management (Schneider & Preckel, 2017) whereas lower performing students are more apt to engage in self-handicapping behavior such as cutting class, disengagement, and procrastination (DeCastella & Byrne, 2015; Schneider & Preckel, 2017).

Finally, the metacognitive approaches utilized by students during the self-reflective stage are particularly critical to learning and achievement (Dent & Koenka, 2016; DiFrancesca et al., 2016; Dignath & Büettner, 2008; Zimmerman et al., 2011). The more accurate a student's self-evaluations, the better their outcomes (DiFrancesca et al., 2016). Causal attributions play a role as well. Students who attribute setbacks to something controllable, such as lack of effort or use of inefficient strategies, are more likely on subsequent academic tasks to outperform students who make helpless attributions (Aditomo, 2015; DeCastella & Byrne, 2015; Hong et al., 1999; Wilson & Linville, 1985). The emotions involved in self-reaction processes also matter. Aditomo (2015) found that effort attribution, or crediting outcomes to effort related causes, served as a kind of buffer against demotivation, which in turn led to higher final exam grades. This kind of affective reaction has been confirmed by meta-analyses that find significant relationships between students' self-satisfaction, positive expectations, or negative emotions and their subsequent achievement (Burnette et al., 2013; Schneider & Preckel, 2017). Students' reasoning and reactions from the self-reflection phase then feed back into their forethought and play a role in determining whether students will make productive or maladaptive adjustments to their strategic plan (Zimmerman, 2000).

SRL Interventions

Educators interested in helping their students improve their learning should understand that adaptive SRL attitudes and skills are not dependent on intelligence or past capability (Zimmerman, 2001); they are teachable and can be fostered in a classroom environment (Brown & Harris, 2014; De Corte et al., 2011; Fuchs et al., 2003b; Pintrich, 2002; Zimmerman, 2001). Classroom interventions centered around SRL are able to develop a wide variety of students' motivational factors, cognitive strategies, and metacognitive processes (e,g. Vasquez Mireles et al., 2011), which in turn can improve academic outcomes (Donker et al., 2014).

In the forethought phase, interventions can address students' task analysis processes by incorporating aspects such as goal setting (Cleary et al., 2008; Cleary et al., 2017) and strategic planning (Donker et al., 2014; Semana & Santos, 2018). The Self-Regulation Empowerment Program (SREP), developed by Cleary and Zimmerman (2004) has students consider their maladaptive behaviors, analyze appropriate learning tasks, set short- and long-term goals for the class, and create a study plan (Cleary et al., 2008). In studies with high-risk middle school math students and high school biology students, the treatment group saw substantially higher gains on their test scores (Cleary et al, 2008; Cleary et al., 2017). In a study conducted by Semana and Santos (2018), students in a Portuguese middle school math class took part in discussions over assessment criteria, thus strategically planning for their learning. Over the course of the two-year program, students showed significant improvement in their ability to understand the criteria and take appropriate goal-directed actions (Semana & Santos, 2018).

Students must also feel motivated to engage productively with the SRL cycle. Interventions can intervene successfully with a variety of motivational factors such as self-efficacy (Cleary et al., 2008; Butler et al., 2005), anxiety (Vasquez Mireles et al., 2011), and task value (Donker et al., 2014). Students' perceived control over their learning, which is a crucial driver of the motivational processes, can be influenced through general SRL instruction (Cleary et al., 2008) as well as interventions designed to specifically target their beliefs (e.g. Blackwell et al., 2007; Paunesku et al, 2015; Yeager et al., 2019). As another way to motivate deeper learning, educators have found success by introducing and discussing Bloom's taxonomy with college students (Vasquez Mireles et al., 2011; Cook, Kennedy, & McGuire, 2013).

Once students believe they can improve and are motivated to do so, the types of cognitive strategies available to them matters. Higher achieving students employ more effective learning strategies such as regularly reviewing lecture notes, giving themselves plenty of time to study for exams, eliminating distractions in their learning environment, and using deeper processing strategies such as self-monitoring, retrieval practice, and paraphrasing (Cleary et al., 2008; DiFrancesca et al., 2016; Cook et al., 2013) - strategies that might be obvious to educators as tools to improve one's learning but are not always obvious to students.

Explicit teaching of cognitive and metacognitive strategies can raise course grades (Cleary et al., 2008; Cook et al., 2013; Montague et al., 2014), improve content-specific learning (Applegate et al., 1994; Butler et al., 2005; Montague et al., 2014), and increase students' use of appropriate SRL strategies (Applegate et al., 1994; Butler et al., 2005; Cleary et al., 2008; Cook et al., 2013). These interventions emphasize instruction of higher-order cognitive strategies, such as creating concept maps (Applegate et al., 1994; Cook et al., 2008; Vasquez Mireles et al., 2011), identifying main ideas or concepts (Applegate et al., 1994; Vasquez Mireles et al., 2011), activating prior knowledge (Applegate et al., 1994; Cook et al., 2008), using domain-specific problem solving strategies (Butler et al., 2005; Montague et al., 2005), retrieval practice (Cook et al., 2013; Lyle & Crawford, 2011), and self-assessing their effort and progress (Cook et al., 2013; Semana & Santos, 2018; Vasquez Mireles et al., 2011).

For example, a fifty-minute learning strategies presentation developed by McGuire (2015) has students self-assess their current approach to the class, introduces the concept of metacognition and Bloom's taxonomy, teaches students explicitly about specific higher-order learning strategies, and asks students commit in writing to the use of at least one new learning strategy. Implementation in undergraduate chemistry courses has seen students increase their use of successful SRL strategies and improved course averages by a full letter grade or more (Cook et al., 2013; McGuire, 2015).

The metacognitive approaches students use during the self-reflection stage play a vital role in their learning and achievement (DiFrancesca et al., 2016; Zimmerman et al., 2011), as self-evaluation and self-reaction processes cycle back into the forethought phase and determine how students will adjust their strategic plan (Zimmerman, 2000). Addressing students' self-reflection processes can be accomplished through written reflection journals (Semana & Santos, 2018), explicit instruction (Cleary et al., 2008; Cleary et al., 2017), holding conversations about causal attributions (Cleary et al., 2017; Wilson & Linville, 1985), and having students correct and reflect on graded assignments (Cleary et al., 2008; Cleary et al., 2017; Montague et al., 2014; Zimmerman et al., 2011).

This latter intervention can be particularly helpful, as frequent external feedback on formative assessments that allow students additional opportunities to demonstrate mastery learning aids in students' self-judgment capabilities and academic achievement (Montague et al., 2014; Zimmerman et al., 2011).

Another tactic taken by SRL interventions in the self-reflection phase is to address students' self-reactions by tackling the difference between constructive, positive judgments as opposed to helpless, defensive reactions. The implications for students' feelings in the self-reflection phase are important, as a meta-analysis conducted by Burnette et al. (2013) found moderate to large effects of students' emotional reactions, positive or negative, on their ultimate academic achievement. Use of the SRL instructional modules developed for the SREP can lead to students' increased confidence in their self-regulatory processes (Cleary et al., 2008) and adaptive inferences after a poor performance, such as concluding they need to change their study strategies (Cleary et al., 2017). Students who participate in quiz self-reflections are also more likely to respond positively to academic setbacks (Zimmerman et al., 2011).

Strengths and Limitations of SRL Interventions. Across a variety of developmental stages and diverse subject matter, researchers have found several features of SRL interventions that carry particular importance. Factors such as content, instruction, duration, domain, whether the intervention facilitator was an outside researcher or the classroom teacher, and the type of instruments used to collect SRL data all influence the results of SRL interventions (Dignath & Büettner, 2008; Dignath et al., 2008).

The most successful self-regulation instruction is based on socio-cognitive theories, metacognitive theories, or a blend of the two (Dignath & Büettner, 2008; Dignath et al., 2008). Effectiveness increases when the intervention addresses all three phases of the SRL cycle (Dignath et al., 2008), although there are certain aspects of SRL found to be particularly helpful. For example, interventions fair better when they include explicit instruction on and modeling of general metacognitive knowledge (Dignath et al., 2008; Donker et al., 2014; Tanner, 2012; Schraw, 1998). Regarding more specific task strategies, the cognitive strategy of elaboration (Dignath et al., 2008; Donker et al., 2014), and the metacognitive strategies of planning (Dignath et al., 2008; Donker et al., 2014) and reflection (Dignath & Büettner, 2008; Tanner, 2012; Schraw, 1998) relate significantly to SRL intervention efficacy.

Perhaps not surprisingly, the longer the duration of the intervention, the greater its effectiveness (Dignath & Büettner, 2008). Importantly for the students in this study, SRL interventions can have a particularly strong effect on mathematics performance (Dignath & Büettner, 2008; Dignath et al., 2008). Formative assessments and constructive feedback on students' learning strategies also play a helpful role in developing students' metacognitive ability (Clark, 2012; Dignath et al., 2008).

However, classroom SRL interventions are not without their limitations. Dignath and Büettner (2008) found at both the primary and secondary levels that SRL effects on student achievement were higher when a researcher rather than a teacher conducted the intervention. Unfortunately, teachers often lack the belief system or knowledge to effectively incorporate SRL instruction into their classrooms (Dignath-van Ewijk & ven der Werf, 2012). Even when integrated into the existing curriculum, SRL interventions require extensive training, often meeting regularly with trainers throughout the program (Cleary et al., 2008; Cleary et al., 2017; Montague et al., 2014; Semana & Santos, 2018) which may not be feasible in all educational environments.

Further complicating SRL studies is the unreliable nature of SRL self-reported questionnaires (Dignath et al., 2008). Several studies have found no significant self-reported differences in SRL skills between high and low performing students, even though SRL differences were observed and performance impacted (eg. Cleary et al., 2017; DiFrancesca et al., 2016; Zimmerman et al., 2011). These researchers recommend a more reliable means of measuring SRL than self-reporting, such as observations, interviews, or student work.

However, despite potential limitations, an intervention steeped with SRL principles and instruction hold promise for the students entering NVC's non-STEM College Algebra corequisite course who are underprepared for college-level math and require additional support in order to succeed. NVC is already utilizing conventional interventions in place for corequisite courses at other institutions, such as advising students towards non-algebra-based courses, incorporating active and collaborative learning, and providing additional tutoring. I am therefore adding to my department's innovative spirit by planning an original intervention to directly influence students' metacognition and mindset toward becoming more effective math learners. Decades of research indicate that helping underserved students become better self-regulated learners can increase their chance of academic success. The next step is to help students towards the belief they are capable of learning math.

Implicit Theories of Intelligence

Underlying the cognitive, affective, and behavioral aspects of SRL are the fundamental psychological processes and beliefs people use to interpret their environment (Dweck & Leggett, 1988; Molden & Dweck, 2006). Whether or not students adopt productive self-regulating views and actions will be influenced by whether or not they believe such actions to be beneficial (Dweck & Yeager, 2019). For an example, assume there are two students with a comparable prior mathematics background who both failed the first exam in their freshman math class. However, one student thinks that they will be able to improve their math skills while the other supposes their math ability is fixed and they cannot do much to change it. Due to this difference in their fundamental views regarding mathematics intelligence, these students are likely to employ aspects of the SRL cycle very differently (Burnette et al., 2013; Molden & Dweck, 2006).

Introduction to Implicit Theories of Intelligence

Dweck and Leggett (1988) developed a theoretical social-cognitive framework to describe the differing personal beliefs held about intelligence and their ensuing motivational responses—called *implicit theories*, or sometimes referred to as *lay theories* (Molden & Dweck, 2006). Implicit theories propose that people hold either *incremental* or *entity* beliefs regarding intelligence. People with incremental beliefs regard intelligence as something that is malleable and can be improved; those with entity beliefs see intelligence as fixed and stable. A large and varied body of research has demonstrated that the orientation of a person's implicit beliefs about intelligence is related to a wide variety of self-regulating mechanisms such as self-efficacy, goal orientation, self-control, strategy adaptation, affective response, and causal attributions, as well as achievement (e.g., Blackwell et al., 2007; Burnette et al., 2013; DeCastella & Byrne, 2015; Robins & Pals, 2002). More recently, the terminology of implicit theories has been replaced with *mindsets*. The literature now popularly refers to holding incremental versus entity beliefs as having a *growth* or *fixed mindset*, respectively (Dweck, 2006; Yeager & Dweck, 2012). However, the terminology is essentially interchangeable (Dweck & Yeager, 2019). I will primarily use implicit theories vocabulary here but will also use growth and fixed mindset, particularly when discussing specific literature employing the latter labels.

There a few important characteristics, born through studies conducted in a wide variety of contexts, of implicit theories. People generally favor one or the other, so that incremental and entity views do not often overlap, and each orientation is roughly as commonly held. Implicit theories are independent of educational and ability level. Although people's implicit views are generally stable over time, they can be manipulated (Dweck, 1999; Molden & Dweck, 2006). And implicit theories are domain-specific, i.e., the same person can believe that athletic or musical ability may be improved with practice (incremental) but intelligence cannot (entity). Due to the context of this study's problem of practice, research questions, and intervention, all of the literature I discuss here stems from the academic domain, though similar results hold for non-academic domains as well (Burnette et al., 2013).

The original framework offered by Dweck and Leggett (1988) proposes that implicit theories of intelligence influence goal orientation, either learning or performance-based. People who set learning goals are concerned with *improving* their capability; people with performance goals focus on *demonstrating* their capability. In turn, one's goal orientation then relates to adoption of either mastery or helpless emotions and behaviors within the self-regulatory feedback loop (Dweck & Leggett, 1988).

Connections Between Implicit Theories, SRL, and Achievement

Dweck and Leggett's (1988) original proposal hypothesized that goal orientation, an element of the forethought phase of SRL, plays a key role in the relationship between implicit theories and engaging in either mastery or helpless strategies. However, more recent research suggests that implicit beliefs may be more regularly predictive of self-regulation constructs such as causal attribution (Hong et al., 1999), avoid or approach strategies (De Castella & Byrne, 2015; Rhodewalt, 1994), and even achievement (Burnette et al., 2013; Stipek & Gralinksi, 1996). So research exists which establishes relationships between implicit theories and cognitive, affective, and behavioral patterns such as those mentioned above, as well as between implicit theories and achievement, without depending on facilitation by goal orientation.

Incremental beliefs about intelligence are related to a host of adaptive SRL responses and abilities. As has already been mentioned, incremental theorists are more likely to set learning-oriented goals over performance-based ones (Aditomo, 2015; Blackwell et al., 2007; Burnette et al., 2013; Rhodewalt, 1994; Robins & Pals, 2002). For example, a student holding incremental views of intelligence might place a higher value on learning than achieving a certain grade. They are also more likely to hold positive views of effort (Blackwell et al., 2007; Rhodewalt, 1994), which Hong et al. (1999) attributed to incremental theorists' belief that effort and ability are positively related. In other words, exerting effort is a positive sign of ability and vice versa. Moving into the performance phase of SRL, students holding incremental views are also more likely to make use of positive learning and academic strategies (Blackwell et al., 2007; Burnette et al., 2018; Corradi et al., 2019; Doron et al., 2009; Hong et al., 1999; Shively & Carey, 2013).

In response to negative feedback, a belief in malleable intelligence seems to buffer students from making attributions based on the notion that they are helpless or that results are dictated by innate qualities they cannot control (Blackwell et al., 2007; Robins & Pals, 2002); instead, students are more likely to attribute setbacks to a lack of effort (Hong et al., 1999). They are also more likely to credit effort and study skills (Aditomo, 2015; Robins & Pals, 2002) for positive results. Furthermore, incremental theory beliefs are related to positive affective responses such as determination, enthusiasm, and excitement (Robins & Pal, 2002), having optimistic expectations (Burnette et al., 2018), engagement (Bostwick et al., 2017), and increased self-efficacy (Davis et al., 2011).

On the other hand, students holding entity beliefs are less likely to set mastery-based goals, instead favoring performance goals (De Castella & Byrne, 2015; Rhodewalt, 1994; Robins & Pals, 2002), such as avoiding failing a class. Perhaps even more insidious, they also believe effort and ability are inversely related—the more effort one exercises, the less ability they possess (Hong et al.,1999). Unfortunately, entity theorists are also more likely to engage in maladaptive practices such as self-handicapping, disengagement, and truancy (Aronson et al., 2002; De Castella & Byrne, 2015; Doron et al., 2009; Rhodewalt, 1994). Their lack of success then becomes a self-fulfilling prophecy.

Regarding causal attribution, entity theorists are more likely to blame results on uncontrollable or external factors (De Castella & Byrne, 2015; Hong et al., 1999; Robins

& Pals, 2002). And belief that intelligence is fixed also generates negative affective responses such as distress and shame (Robins & Pals, 2002), loss of perceived control (Doron et al., 2009), and helplessness (Davis et al., 2011).

In addition to their relationships with components of SRL, students' implicit theories directly predict academic outcomes. Researchers have demonstrated these associations over a range of developmental stages: middle school (e.g., Bostick et al., 2017), high school (e.g., Claro et al., 2016), and college (e.g., Aditomo, 2015). Furthermore, two independent meta-analyses conducted over implicit theories revealed a low-to-moderate association of implicit theories to academic achievement (Burnette et al., 2013; Costa & Faria, 2018). Although Costa and Faria (2018) found the overall impact of entity beliefs on academic achievement was insignificant, they were negatively correlated with achievement when considering only the studies conducted in North America ($k = 4$, $r = -0.22$; 95% CI = -0.35, -0.10; $p < 0.001$, Costa & Faria, 2018). For example, two studies conducted stateside found a negative correlation between holding entity views and grades in both high school and college (De Castella & Byrne, 2015; Shively & Ryan, 2013).

Conversely, incremental beliefs correlate positively with academic outcomes (Burnette et al., 2013; Costa & Faria, 2018). Incremental beliefs have been linked to higher standardized test scores (Claro et al., 2007; Good et al., 2003), subject-specific test scores such as statistics and mathematics (Aditomo, 2015; Bostwick et al, 2017), and overall grades (e.g., Aronson et al., 2002; Blackwell et al., 2007; Romero et al., 2014). In an impressive nation-wide study of Chilean tenth graders, growth mindset even predicted academic achievement as strongly as socioeconomic factors and appears to provide a buffer for the deleterious effects of poverty (Claro et al., 2016). Furthermore, there is evidence to suggest this relationship is causal (e.g., Blackwell et al., 2007), which I will discuss in the next section.

Mindset Interventions

People's beliefs about the fundamental nature of intelligence and whether it is malleable or fixed are related to a host of self-regulatory behaviors and emotions, as well as to academic achievement itself. But in order to develop an effective intervention to affect positive change with my coreq College Algebra students, there are important questions to ask and answer. Can students' mindsets be *changed*? And if so, does a change in mindset predicate an improvement in SRL and academic outcomes? And if so, then what do those successful mindset interventions look like? In this section, I explore the answers to these questions in order to begin solidifying details of my intervention.

Can Students' Mindsets Be Changed? Research has shown that people with entity beliefs can be influenced towards an incremental view. This has occurred across a variety of contexts, such as the laboratory (Hong et al., 1999), small-scale field experiments (e.g., Burnette et al., 2018), and large-scale randomized control trials (Yeager et al., 2019). A successful shift to growth mindset has also been induced across different developmental stages, particularly during educational transitional periods to junior high (e.g., Blackwell et al., 2007), high school (Paunesku et al., 2015; Schmidt et al., 2017), and college (Aronson et al., 2002; Hussein, 2018).

Although many of these studies took place at the intermediate or secondary school level, in an attempt to combat minority stereotypes at a highly competitive private university, Aronson et al. (2002) conducted one of the earliest experiments utilizing an implicit theories intervention. Participants in the intervention condition were given explicit information regarding the malleability of intelligence and then asked to write letters to an "at risk" middle school student offering encouragement and advice. This information and subsequent letter writing appeared to significantly increase the incremental beliefs of the African-American students assigned to the intervention over their counterparts in the control group. Furthermore, these results held over a longer term (several months), as the difference in incremental beliefs actually increased between the intervention and control groups (Aronson et al., 2002).

In another influential study, researchers developed and administered eight, weekly, face-to-face, 25-minute sessions to seventh-grade public school students in New York City. The sessions covered incremental theory topics such as the malleability of intelligence and how learning makes you smarter (Blackwell et at., 2007). After completion of the workshop, during which the control group received similar messages without the emphasis on intelligence malleability, the intervention participants supported an incremental theory more strongly than those in the control, including after controlling for pre-test scores (Blackwell et al., 2007).

A group of researchers out of Stanford University then later refined, abbreviated, and digitalized the intervention used above in the Blackwell et al. (2007) study. This improved and streamlined intervention has since become the basis for a suite of intervention studies conducted with incoming ninth graders to determine if a growth mindset intervention can be brought successfully to scale (DeBacker et al., 2018; Paunesku et al., 2015; Yeager et al., 2016, 2019).

In its original form, Paunesku et al. (2015) reported that two 45-minute, online sessions, which included an article on growth mindset and accompanying writing exercises, increased students' malleable views of intelligence in the intervention group over the control. Using a similar article and writing assignment, as well as incorporating a comprehension check, DeBacker et al. (2018) corroborated these results and also found that the increase in growth mindset was sustained over time (one year later). Interested in replication feasibility, Yeager et al. (2016) submitted the original intervention to A/B testing among its target users and found that the revised version did slightly increase the shift in participants' incremental views; they confirmed these results in a larger, randomized control trial (Yeager et al., 2019). This revised version, called the Mindset Kit, was developed for the Project for Education Research that Scales (PERTS) and is freely available for secondary and post-secondary educators at the PERTS website, https://www.perts.net/resources.

Does a Mindset Change Improve SRL Ability and Academic Outcomes? If students' entity beliefs of intelligence can be nudged towards incremental views, and if these growth mindset views are related to all sorts of SRL abilities and academic achievement, then it makes sense that employing an intervention that changes students' minds about the nature of intelligence will also result in more positive self-regulation and academic outcomes. Indeed, this does seem to occur.

In the area of goal setting, a growth mindset intervention seems to be able to reduce students' performance-based goals, particularly performance avoidance (e.g., avoid appearing dumb; DeBacker et al., 2018). Such interventions can also impact important affective components of SRL such as enjoyment (Aronson et al., 2002;

Blackwell et al., 2007), motivation (Aronson et al., 2002; Blackwell et al., 2007; Rhew et al., 2018), and learner interest (Schmidt et al., 2017). Growth mindset interventions have also been found to predict learning self-efficacy (Burnette et al., 2018).

Within the self-reflection stage of SRL, causal attributions play a vital role. Students who blame a lack of success on external or uncontrollable factors are less likely to continue engaging with the SRL cycle in a productive way, since they do not view results as under their control. However, manipulating college students' mindsets in a laboratory setting demonstrated among people receiving low-performance feedback those with incremental views of intelligence are more likely to attribute lack of effort than inherent ability than those led to hold entity views (Hong et al., 1999). This same study also demonstrated that when experiencing negative outcomes, the incremental theorists were also more likely to engage in task pursuit instead of avoidance by choosing to take a remedial tutorial. And in fact, effort attribution was found to mediate this remedial action response (Hong et al., 1999).

Given the emphasis our current educational culture places on the academic "bottom line" of test scores and grades, perhaps most significant effect that mindset interventions can cause is the improvement of academic outcomes. Studies have found that mindset interventions can increase standardized math test scores (Good et al., 2003), hold students' grades steady when they are expected to decline (Blackwell et al., 2007; Schmidt et al., 2017), or even increase students' grades (Mills & Mills, 2018).

In Aronson et al.'s (2002) research with minority college students, those experiencing the mindset intervention went on to earn higher grades than those in the control groups. Furthermore, while African American students (the primary target population of the intervention) demonstrated the largest difference in grades, the authors were surprised to find that *all* participants' grades were improved by the intervention condition. Hussein (2018) found in a qualitative study that reflective journaling by college students in a nutrition course was associated with increased growth mindset and learning of course material. And the studies conducted on the PERTS Mindset Kit have reliably shown to improve the GPAs of at-risk ninth graders as well as reduce the overall failure rate for classes (Paunesku et al., 2015; Yeager et al., 2016, 2019).

What Do Successful Mindset Interventions Do? However, not all interventions are created equal, and they do not all see the same promising results. Even interventions that experienced success for the treatment group in one area may have found no effect in others. Burnette et al. (2018) conducted an online growth mindset intervention with rural high school girls that improved their growth mindset but not their course grades. An intervention run with middle school students enrolled in special education saw a significant change in motivation but not self-efficacy (Rhew et al., 2018). And in a study with a population similar to my own (college math students in a developmental course) Mills and Mills (2018) found a near statistically signification relationship between the intervention and passing the course but no correlation between the intervention and student retention.

Other successful interventions found that gains initially achieved were temporary (Orosz et al., 2017), or what worked for one age group failed to work for another (Schmidt et al., 2017). One study, manipulating the mindset of Chinese children in a laboratory setting, found that while scores on a post-failure test increased, mindset had no effect on a variety of SRL components such as goal orientation, task persistence, enjoyment, or causal attributions (Li & Bates, 2019). A meta-analysis of 29 mindset interventions across a total sample size of 57,155 students found most effect sizes (86%) to be insignificant and only 12% to be significantly different from zero and positive (Sisk et al., 2018). Therefore, it is important to examine common qualities of interventions that have reported success, both in increasing students' growth mindset and also their academic achievement. Two of these common qualities are the nature of how the message is framed and writing exercises to reinforce the messages. A third factor, considering the role played by grades and feedback within the classroom, is increasingly endorsed by researchers in the field.

Most mindset interventions include standard explicit growth mindset messages such as, "You can grow your intelligence". But it turns out that how such messages are conveyed may be important (Yeager et al., 2016). Successful interventions also share the neuroscience-backed research linking learning, creation of neuronal connections, and brain plasticity, and reinforce the material through activities (Blackwell et al., 2007), video (Aronson et al., 2002), or interactive graphics (Yeager et al., 2016, 2019). Including testimonials from other students (Walton & Cohen, 2001) or celebrities (Yeager et al., 2016) may potentially further strengthen the message. In A/B testing of the wording of their intervention, Yeager et al. (2016) found additional characteristics that improved effectiveness of the message: indirect instead of direct framing (asking participants to evaluate content of the intervention rather than telling them the intervention was intended to help them), presenting only the incremental view (rather than also refuting entity beliefs), and explaining why a growth mindset maybe beneficial.

Changing people's attitudes can be notoriously difficult, but promising work has been conducted in the area of self-perception theory (that is, behavior determining attitudes instead of vice versa), particularly when people are asked to convey a message persuasively using their own words. The "saying is believing" effect (Higgins & Rholes, 1978), reveals how adopting an advocacy position can influence people to examine their own behaviors and increase the likelihood of embracing the new position (Aronson et al., 2002). Several successful mindset interventions have accomplished this through writing exercises, such as the middle school pen pals used by Aronson et al. (2002), similar letter-writing and video-filming employed by Walton and Cohen (2011), creation of original web content (Good et al., 2003), and self-reflective journaling (Hussein, 2018). The Paunesku et al. (2015) study and its derivatives also employed this technique in their interventions, asking students to use what they had just learned and write a letter containing encouragement and advice to a hypothetical struggling student.

A common refrain for those conducting mindset research is the importance of the overall context within which the intervention takes place (Dweck & Yeager, 2019; Sisk et al., 2018; Yeager, & Walton, 2011). Results from mindset interventions are moderated by peer and school norms (Yeager et al., 2019) which includes classroom norms such as assessment and feedback (Campbell et al., 2020; DeBacker et al., 2018). Masters (2013) argued that how teachers choose to assess can "send powerful messages to students not only about their own learning, but also about the nature of learning itself" (p. 1) and that standard grading practices, in addition to being demotivating, often fail to help students make the connection between learning and effort (Masters, 2013; Schinske & Tanner, 2014). Instead, educators should incorporate more effort-based and low-stakes grading into their classes (Brame & Biel, 2015; Rhew et al., 2018; Schinske & Tanner, 2014; Swinton, 2010).

An intriguing set of studies regarding feedback suggests that students' motivation and performance both benefit from formative comments but not standard grades (numerical or letter). Elawar and Corno (1985) found that providing middle school math students with consistent, informative, and encouraging written comments increased students' math achievement and positive attitudes towards math, regardless of initial ability. The difference between constructive comments and standard grades is thrown further into contrast when considering a pair of studies by Butler and Nisan (1986) and Butler (1988). These studies found that not only was providing constructive comments superior to no feedback or grades only (increased student performance and motivation), but students receiving constructive comments and grades did not perform any better than students receiving just grades. Only the group receiving comments improved. Similar results reveal a relationship between feedback modality and goal orientation; students who receive grades, even if the grade is accompanied by comments, show an increase in their performance-avoidance goals, a relationship mediated by a decrease in motivation (Pulfrey et al., 2011). These results led Jo Boaler (2016), a leading researcher in the intersection of growth mindset and mathematics education, to suggest that in order to "eliminate the fixed mindset message of a grade" (p. 143) math teachers should move away from grades and towards diagnostic comments, thus promoting growth mindset in mathematics classrooms.

Criticisms and Responses

Concerns Regarding Efficacy. Research worth discussing should be subjected to continuous, lively academic debate, and growth mindset is no exception. Critics have questioned the effectiveness of Dweck's mindset framework for a variety of reasons, primarily on the basis of short-term, null, or even negative results (e.g., Li & Bates, 2019) and small effect sizes (Sisk et al., 2018). Proponents have responded by pointing out the importance of context (e.g., Dweck & Yeager, 2019) and the potentially misleading nature of effect sizes (e.g., Yeager et al., 2019).

Researchers across a variety of contexts have been unable to reproduce some of the most promising growth mindset findings. Bahnik & Vranka (2017) found growth mindset to be negatively correlated to academic outcomes for university students in the Czech Republic, a finding duplicated by college students in Beligum (Corradi et al., 2019). Others have found results that vary from positive to null depending on the explicit mindset construct (e.g., academic ability versus general intelligence; Aditomo, 2015), the age of students (Schmidt et al., 2017), or the time lapsed post-intervention (Orosz et al., 2017). Respectively, these studies took place with undergraduates in Indonesia (Aditomo, 2015), middle school students and high school freshman in the American Midwest (Schmidt et al., 2017), and high school students in Hungary (Orosz et al., 2017). In a large-scale implementation of growth mindset instruction across United Kingdom Year 6 classes, Foliano et al. (2019) found "no evidence of an impact" (p. 4) on students' non-cognitive skills (such as self-efficacy and test anxiety) or standardized test results in literacy or numeracy. And in a laboratory manipulation similar to the one conducted by Muller and Dweck (1998), researchers found null to negative effects of growth mindset on motivation or attribution in Chinese children (Li & Bates, 2019).

The meta-analysis performed by Sisk et al. (2018) on the effect of 29 growth mindset interventions on academic achievement corroborates all of these results. Of the 43 effect sizes analyzed by their model, most were ineffective at producing the desired results; 37 of the 43 (86%) effect sizes were not significantly different from zero, and one effect size that was significantly different from zero was negative (Sisk et al., 2018). Only 5 out of 43 (12%) of reported effect sizes were significantly different from zero and positive, and these positive effect sizes were small as defined by Cohen's (1988) conventions. Such results have resulted in questioning the cost efficiency of mindset training and implementation, its scalability, and overall effectiveness (Foliano et al., 2019; Li & Bates, 2019).

Response to Efficacy Concerns Within the Literature. Those arguing for continued efforts into growth mindset interventions stress the importance of context and point out that results are likely to vary across systems, cultures, and conditions. Yeager and Walton (2011) stress that social-psychological interventions are "not silver bullets" (p. 268) and must be considered as only part of system-wide solution. Indeed, others have argued that instructional content, teacher beliefs, strength of the intervention, school norms, and classroom practices all mediate the impact of mindset interventions (Burnette et al., 2018; Canning et al., 2019; Sun, 2018; Yeager et al., 2019). Dweck and Yeager (2019) warn of a "false growth mindset" (p. 490) in which an educator may espouse growth mindset ideals but classrooms norms perpetuate fixed mindsets. Clearly, mindset results should not be interpreted independently from their educational context; this makes mindset theory an excellent fit for action research, which is grounded in context and concerned with issues of transferability over generalizability.

Additionally, many of the studies that found null or negative results occurred outside of the United States such as Europe (Bahnik & Vranka, 2017; Corradi et al., 2019; Foliano et al., 2019; Orosz et al., 2018) and Asia (Aditomo, 2015; Li & Bates, 2019), suggesting that cultural differences in the way intelligence is framed (Aditomo, 2015; Corradi et al., 2019) or the use of adapted or translated measurements (Costa & Faria, 2018) moderates the link between students' implicit theories and their academic success. Finally, Burnette et al. (2013) uncovered in their meta-analysis that the presence of an ego threat strongly mediated the association between incremental beliefs, goal orientation, and strategy adoption. In other words, the condition of experiencing failure or setback might be necessary to see the full impact of mindset interventions (Aditomo, 2015; Burnette et al., 2018; Corradi et al., 2019).

Regarding the issue of small effect sizes, the instruments and design of growth mindset research vary wildly, and it is meaningless to compare effect sizes of studies utilizing different methodologies (McGough & Faraone, 2009). Furthermore, nearly every study uses some version of a Likert scale to measure students' mindsets and other academic attitudes, then converts this ordinal scale into an interval scale to run statistical analysis. This places another limitation on the interpretation of statistical results (Edmondson et al., 2012; Jamieson, 2004). And in fields such as medicine and education in which many potentially confounding variables exist, statistical significance can be misleading. So, it is advisable to instead consider substantive significance, for which context plays a large role (Kelley & Preacher, 2012; Powers & Glass, 2014). Defenders of growth mindset seize upon this last point in particular, arguing that long-held conventions regarding the interpretation of results, developed when psychological experiments still took place primarily in controlled laboratory settings, are outdated in the age of field and heterogeneity testing (Dweck & Yeager, 2019; Miller, 2019; Yeager et al., 2016).

Philosophical Concerns within Popular Education Discourse. In addition to the efficacy debate over growth mindset theory and interventions, educators and equity scholars have recently raised critiques connecting growth mindset to a deficit orientation. While the relative newness of this line of criticism means it has not yet fully played out in academic research, the concerns raised within the current popular educational discourse merit recognition and response here.

Gorski (2011) defines holding a deficit perspective in education as “approaching students based upon our perceptions of their weaknesses rather than their strengths” (p. 152). He argues that this ideology is pervasive throughout the United States’ educational system and causes harm by blaming students for achievement gaps, disregarding differences between learners, and ignoring larger social, political, and economic contexts (Gorski, 2011). Recently, educational scholars have denounced growth mindset along with grit, Duckworth’s (2016) concept of persistence, as guilty of falling under a deficit perspective and thus hurting students (Tewell, 2020).

Such reproaches are multidimensional and center on viewing the weaknesses in our educational system as caused by individuals versus systemic flaws. Critics maintain that theories such as growth mindset exist to maintain the inequality of our current system and thus fail, intentionally or not, to address the root causes of achievement gaps (Kohn, 2015; Perry, 2016; Tewell, 2020). Blaming students instead of educators or the system is one of the primary ways in which a deficit perspective fails students (Perry, 2016;

Tewell, 2020). Those who hold a deficit perspective will typically fail to search for potential improvements or interrogate the status quo pedagogy, curriculum, or assessment (Kohn, 2015). This in turn places an incommensurate burden on students who are already historically marginalized (Tewell, 2020). In a 2016 interview with *The Atlantic* Dweck herself warned against the inherent dangers in weaponizing growth mindset and automatically assuming the label of fixed mindset for lower achieving students (Gross-Loh, 2016).

Applicability to My Research Context and Personal Response. Despite the potential concerns regarding growth mindset interventions there are several aspects to implicit theories of intelligence that make such as intervention a potential fit for my context and problem of practice. Recall from Chapter 1 that students enrolled in coreq College Algebra are academically underprepared for college-level mathematics. Implicit theories of intelligence and resultant interventions are particularly applicable in situations in which students are part of an underserved population, are likely to experience possible setbacks, in need of remediation help, and in mathematics classes. Furthermore, to combat a tendency towards a deficit orientation I can use my own awareness and reflexivity to shifts my lens inwards, away from wielding growth mindset as a pathological tool and towards what I might do instead to help struggling students.

Researchers conducted the earliest implicit theories interventions in a successful attempt to lessen stereotype threats (fear of confirming a negative stereotype about one's social group) for threatened populations, such as minorities or women in mathematics, and narrow subsequent achievement gaps (Aronson et al., 2002; Good et al., 2003). They conclude that encouraging students to view obstacles as surmountable "can meaningfully increase student achievement, especially for those students who face negative stereotypes about their abilities" (Good et al., 2003, p. 658). Canning et al. (2019) extended this work by discovering the impact that teachers' personal mindsets have on stigmatized students in science and mathematics-based courses, including women, Black, Latinx, and first-generation students. Furthermore, growth mindset buffers the detrimental effects of lower socioeconomic status (Claro et al., 2016; Yeager et al., 2016), and challenging school transitions (Blackwell et al., 2007; Molden & Dweck, 2006; Yeager & Dweck, 2012). In particular, Dar-Nimrod and Heine (2006) found women in mathematics classes may benefit from mindset interventions, a result confirmed a year later by Good, Rattan, and Dweck (as cited in Dweck, 2008). Given the population of students in my institution (Hispanic, female, first generation, and first time in college) the above results are promising and offer hope.

Dweck (2006, 2008) emphasizes that the full impact of having a growth versus fixed mindset is not realized until students experience a challenge or failure, a claim supported by meta-analysis results showing that the relationships between mindsets and goal orientation as well as strategy adoption are moderated by the presence of an ego threat (Burnette et al., 2013). In causal quasi-experiments the presence of a failure, whether realized or just a threat, strengthened the causal pathways between mindsets and math self-efficacy, helplessness (Davis et al., 2010) and mastery goals, causal attribution, motivation, and academic success (Aditomo, 2015). Given the underserved status of corequisite students, it is likely that many of them will experience a setback in their college-level class, making their mindset all the more important in their ultimate success or failure in the course.

Additionally, corequisite students must be willing to seek remediation they may need in the course content. Students holding entity beliefs are more likely to exhibit a helpless response to struggle (Robins & Pals, 2002). However, students holding incremental beliefs are more likely to seek help and support (Doron et al., 2009; Shively & Ryan, 2012); this response is likely mediated by their greater inclination to attribute outcomes to effort rather than innate ability (Hong et al., 1999). When students' mindsets were manipulated in a laboratory setting, Nussbaum and Dweck (2008) established the causal role that mindsets play in students' willingness to seek remedial action after failure.

With regards to mathematics specifically, incremental views of intelligence are associated with engagement and higher academic outcomes (Bostwick et al., 2017; Romero et al., 2014; Shively & Ryan, 2012). Blackwell et al.'s (2007) influential results of a growth mindset positively affecting academic performance took place in seventh grade mathematics classrooms. At the college level, interventions have also been found to increase the math outcomes of DE mathematics students (Mills & Mills, 2018; Silva & White, 2013).

Unfortunately, in the United States, mathematicians are the second-most likely to rate ability within their field as dependent on inherent intelligence (Leslie et al., 2015). Given the potential impact that teachers' views of intelligence can have on their students' mindsets (Canning et al., 2019), it is perhaps not then surprising that a world-wide meta-analysis of implicit intelligence theory studies revealed North America to be the only region in which entity beliefs were negatively correlated with academic achievement, particularly in quantitative fields (Costa & Faria, 2018). Thus, it becomes crucial for math teachers in particular to encourage growth mindset within their classroom practices, such as incorporating explicit messaging and thoughtful feedback (Sun, 2018). This latter perspective, that it falls on teachers to create a classroom environment that fosters growth mindset, contrasts with the deficit orientation of criticizing students for shortcomings.

Assuming responsibility as the teacher to create a productive learning environment for all students is one measure I can take to reduce my own deficit orientation tendencies. Another preventive measure I can take is engaging regularly in reflective critical thinking, a vital component for the health of both my action research (Mertler, 2017; Schön, 1995) and my teaching practice (Larrivee, 2010).

Awareness of potential problems, willingness to wrestle with dissonance between one's teaching philosophy versus their actions, and keeping a reflective journal are important components to what Larrivee (2010) deems "critical reflection" (p. 294). Such critical reflection encourages teachers to take ownership of students' classroom experiences, question conventional wisdom, and check their own potential biases (Larrivee, 2010). Furthermore, critical reflection can help teachers reframe adverse outcomes and instead help them "[seize] the opportunity to discover the potential positive in a situation…[looking] for openings to extend and learn in any situation" (Larrivee, 2020, p. 299). Put another way, when students struggle I need to consistently orientate my reaction around what I can do to help rather than what they need to "fix" about themselves as students. Essentially, to avoid the potential lure of deficit thinking I must cultivate a growth mindset within myself as well.

Conclusion

Due to a variety of personal factors and past experiences, students at NVC entering the coreq non-STEM College Algebra class are at a higher risk for failing the course, the consequences for which are heavier than the traditional prerequisite remediation sequence. Thus, we are in need of a course innovation to intervene within students' first semester of attempting the class. Research indicates that addressing students' SRL processes and abilities can positively influence a range of student outcomes, including academic achievement. One crucial motivational element of SRL involves students' mindsets—their implicit beliefs regarding the control they are able to exert over their learning. I believe these corequisite students will benefit from an intervention that helps students learn how to think about their thinking, convince them they are capable of learning mathematics, and give them tools with which to accomplish this.

Chapter 3

In Chapter 2, I discussed the theoretical perspectives underlying my intervention and dissertation study. In Chapter 3 I will discuss the methods and methodological foundations of this study. I begin with a brief overview of the purpose and design of this study within the action research context of the EdD program at the Mary Lou Fulton Teachers College. From there, I describe in detail the *Growth: Emotions, Actions, Reflections* (GEAR) intervention for my coreq non-STEM College Algebra students as well as the methods I used to measure its efficacy. I will introduce my institution's setting and participants and discuss my dual insider/outsider role as practitioner and researcher. I will also describe the data sources and analyses I used, including a timeline for the procedure. Finally, I will address issues of validity, trustworthiness, and ethics as they apply in a mixed-methods, action research project.

Introduction

The purpose of this action research study is to determine how an intervention grounded in principles of self-regulated learning and growth mindset might influence corequisite College Algebra students' academic achievement in the course as well as perceptions of themselves as mathematical learners.

As its name indicates, action research is driven by taking action. Rather than passively examining the effect the corequisite model is having on students at my school, action research dictates that the research itself motivates an effect. Thus, the researcher is compelled not only to identify a problem of practice (PoP), but also to develop a theory-informed solution addressing the PoP and to study the effectiveness of this solution (Creswell & Guetterman, 2019; Mertler, 2017). It is practical in nature, using quantitative and/or qualitative data gathered from the researcher and participants' immediate environment in search for real-time solutions, but it is also theory-driven. In this way, action research lives in the intersection of educational practice and philosophy.

Because educational problems can never truly be solved, action research is an on-going, recurring experiment utilizing small, sensible steps to solve complex issues, the types of problems Rittel and Webber (1973) refer to as "wicked" (p. 155). Thus, action research is iterative—a cyclical process of observing, learning, evaluating, and improving with each cycle building on the previous, but never fully complete (Mertler, 2017). Within my own study, I initially explored my PoP with other faculty and reviewed the literature; this led to introducing student reflective journals in my coreq classes. After another cycle of reading the current research and holding conversations with faculty, I changed the way I grade formative assessments. And in my most recent cycle I began implementing more formalized instruction of SRL and growth mindset principles. Along the way, I have been continually refining my GEAR intervention.

Furthermore, because the researcher is an integrated part of the study context, reflexivity is a crucial element of conducting action research. In this way, action research is not just a practice used to improve upon a local environment or empower participants, but it also serves as a form of individualized professional development for the researcher themselves (Mertler, 2017; Noffke, 2012). This combination of environmental and personal improvement makes action research an incredibly powerful tool for educators. All along my study, I have continually become a better teacher.

To address my research purpose, I conducted a mixed-methods, quasi-experimental study in which one group received additional mathematics remediation and the other group was taught SRL and growth mindset principles through the GEAR intervention. Utilizing a mixed methods procedure gives the researcher tools to address both the depth and breadth of a study topic more fully than using only a quantitative or qualitative approach on its own (Creswell & Guetterman, 2019; Johnson & Onwuegbuzie, 2004; Teddlie & Yu, 2007). Therefore, in order to best triangulate results I concurrently gathered and analyzed both quantitative and qualitative data to address my research questions:

RQ1) Compared to a group receiving additional mathematics remediation, what impact does GEAR have on students' academic achievement in corequisite non-STEM College Algebra?

RQ2) What impact does GEAR have on students'

a) SRL ability?

b) Growth mindset regarding math?

RQ3) How do students' perceptions of themselves as mathematical learners change during implementation of GEAR?

Setting

This study took place at Northwest Vista College (NVC), a large community college with over 17,000 students in San Antonio, Texas, where I am an Assistant Professor of Mathematics. Enrollment numbers for the 2020-2021 academic year are currently unavailable, but in Fall 2019, the student body at NVC was 56.7% female and 43.3% male. Just under three quarters (73.7%) of our students are part-time, and less than a fifth (18.4%) are first time in college students (FTIC). With a study body that is 62.8% Hispanic, NVC is designated as an official Hispanic-serving Institution; the remainder of the student body is 21.9% White, 6.0% Black, 3.4% Asian, and 6.0% multi-racial or other, which closely mirrors the racial demographics of San Antonio itself. Approximately 60% of our students require some sort of developmental mathematics support.

Participants

Participants of this study were students enrolled across four sections our coreq non-STEM College Algebra course. Two of the four sections received additional class instruction on remedial content (i.e., the "RC intervention"), and the other two sections instead received the GEAR intervention. The students in both the RC and GEAR groups were students needing non-STEM College Algebra for their degree plan who either scored just below the "college level" cutoff on the Texas Success Initiative (TSI) exam or successfully passed the DE-level Elementary Algebra class.

As discussed in Chapter 1, students who start in DE mathematics are indeed at greater risk of starting college but never finishing. In my experience, these students are more afraid of the subject, having experienced failure in the past. And while they are ready and willing to put effort into the class, their effort is often misguided as they spend their time using the same sort of inefficient learning strategies that landed them in a DE math class to begin with. Again, it is these students who are in the greatest need of rethinking how we provide support for a college-level math course.

I assigned classes a status (RC or GEAR) as a unit. I held the RC courses every Monday and Wednesday from 9:00-10:40am and again from 1:00-2:40pm; the GEAR courses met every Tuesday and Thursday during the same time periods. Students registered themselves for the classes (albeit without knowing its status). Thus, I used cluster sampling (Teddlie & Yu, 2007) with non-random assignment (Smith & Glass, 1987); this is a convenience practice commonly used in educational quasi-experiments. Participation in the study was completely voluntary and students were able withdraw their consent to participate at any time, as indicated in the Recruit Consent Form (See Appendix A). None of the students were younger than age 18.

Initial total enrollment across both RC sections was 49 students, 41 of who consented to participate in the study. Initial total enrollment across both GEAR sections was 48 students, 45 of who consented to participate in the study. Prior to the start of the intervention, 2 students from each group dropped the course, bringing the RC group size to $n = 39$ (25.6% male, 74.4% female) and the GEAR group size to $n = 43$ (30.2% male, 69.8% female). Of these, 36 students in RC group and 42 students in GEAR group consented to collection of their student history. In the RC group, 13.9% of students were FTIC, 16.7% had earned 1-15 hours of college credit, 38.9% had earned 16-30 hours, 19.4% had earned 31-45 hours, and 11.1% had earned over 45 hours of college credit. In the GEAR group, 44.4% of students were FTIC, 38.9% had earned 1-15 hours of college credit, 25.0% had earned 16-30 hours, 5.6% had earned 31-45 hours, and 2.8% had earned over 45 hours of college credit. I collected additional self-reported demographic data on race at the conclusion of the study.

Due to course withdrawals by the conclusion of the study $n = 28$ students in the RC group and $n = 33$ students in the GEAR group took the course final exam, the final outcome measurement. Of the 28 students in the RC group who completed the course 25% were male and 75% were female. Of the 33 students in the GEAR group who completed the course 30.3% were male and 69.7% were female. Furthermore, of the students who took the final exam 27 RC participants and 29 GEAR participants self-reported additional demographic data of race. In the RC group, 55.6% identified as Hispanic/Latino, 22.2% as White/Caucasian, 14.8% as Black/African American, 3.7% as Native American, 3.7% preferred not to say. In the GEAR group, 82.8% identified as Hispanic/Latino, 13.8% as White/Caucasian, and 3.4% as Black/African American.

Role of the Researcher

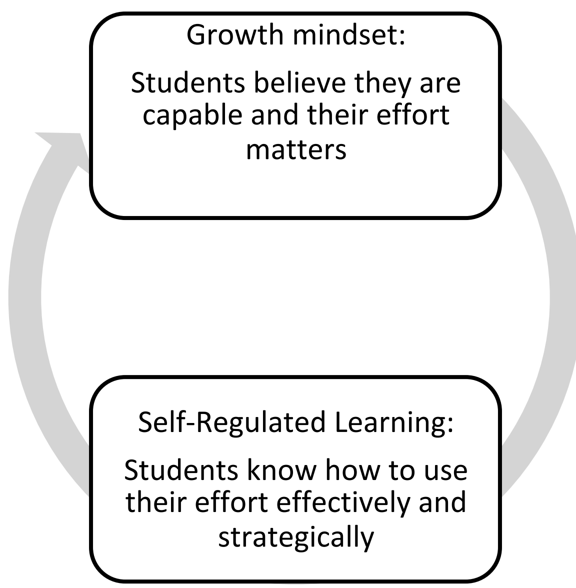
In order to control for the influence of the instructor as much as possible, I taught all four sections (RC and GEAR interventions) of the coreq College Algebra classes. This role as teacher placed me as an insider within the study, whereas my role as a researcher also made me an outsider. This dual positionality is not uncommon in action research; in fact, it is a strength of action research as it ties my research more directly to improving educational practice (Mertler, 2017). However, it does require sensitivity to the different purposes of my insider and outsider roles and reflexivity to notice if these roles come into conflict with one another. My primary purpose as teacher was to offer support and instruction, whether in remedial math or SRL topics, to all my students as they pursue their goals for the class. My primary purpose as researcher was to collect data from multiple sources, both quantitative and qualitative data, and then analyze that data to judge the efficacy of the intervention.

GEAR Intervention

In their exploration of the psychological history of teaching and learning, Schallert and Martin (2002) talk about "learning as an intentional, strategical act" (p. 38) and discuss the importance of metacognition. In their analysis, I recognized the roots of teaching practices I was already using with my own students, and this led me to the self-regulated learning framework. Once I began examining the sub-constructs of SRL, I noticed how influential students' beliefs about their abilities are on the entire learning process, and so I decided to include growth mindset in my intervention as well. The objective of my intervention was two-fold: first, to convince students that they are capable of learning mathematics and second, to then help them learn to use the kinds of cognitive and metacognitive strategies that will aid this learning. Both are important because if they do not believe they are able, they will not be motivated to change or use new learning strategies. However, optimism alone is not enough; once they believe they are capable, they need to have appropriate and efficient learning strategies available to them as well. In this way, these objectives are cyclical and feed back into one another. (See Figure 2.)

Figure 2

The Driving Principles Behind My Corequisite Intervention



As discussed in chapter 2, prior research has shown aspects of SRL and mindset interventions to be impactful. These characteristics influenced my own intervention in a number of ways. My intervention addressed all three phases of SRL (forethought, performance, and self-reflection) and lasted for the duration of the semester. I offered explicit instruction on both growth mindset and metacognitive knowledge as well as other SRL skills shown to make a difference in learning such as planning, elaboration, and reflection. Students were be prompted to write thoughtfully about the intervention topics we discussed together, and I reworked the role played by grades and feedback on formative assessments.

Explicit Instruction

The DE support for NVC's corequisite College Algebra class takes the form of an additional fifty minutes of class time every week. In the RC treatment group, I used this additional class time to cover remedial math content. In the GEAR treatment group, I used this time for class instruction and discussion regarding growth mindset and SRL skills. My GEAR intervention focused on two presentations in particular, one addressing metacognitive approaches to learning and the other growth mindset principles. However, additional class time was spent further elaborating on topics such as goal setting, time management, learning strategies, the role of emotions, and adaptive inferences. (See Table 1.)

During the class period following the first exam I led a 100-minute class discussion adapted from the presentation developed by McGuire (2015); a free template of this presentation is available at https://styluspub.presswarehouse.com/Titles/TeachStudentsHowtoLearn.aspx. While McGuire's (2015) presentation focuses on specific cognitive and metacognitive strategies students can use to improve their learning and therefore course outcomes, it incorporates multiple elements of all three phases of SRL such as motivation, goal orientation, causal attributions, and self-evaluation.

Table 1

Summary of Supplemental Topics for Both GEAR and RC Intervention Groups

Weeks	GEAR	RC
1 - 2	Pre-intervention measurements, pre-course reflection, and math autobiography	Pre-intervention measurements, pre-course reflection, and math autobiography
3 - 4	Metacognitive article about learning and McGuire's (2015) SRL presentation	Content review follow-up for Exam 1a
5 - 6	PERTS growth mindset modules, SMART goal setting, metacognitive study sessions	RC for linear graphs, function notation, and linear applications
7 - 8	Exam reflection and Causal attributions; Self-affirmation	Exam reflection and RC for quadratic graphs & applications
9 - 10	Procrastination and motivation; Strategy evaluation & adjustment	RC for solving quadratics & factoring
11	Exam reflection	Exam reflection
12 - 13	Non-cognitive strategies to deal with wellness issues; Revisiting past journal topics	Additional content for inverse, exponential, and logarithm functions
14 - 15	Post-intervention measurements and reflection	Post-intervention measurements and reflection

In the fifth week of class students in the GEAR group went through the online growth mindset module developed by Yeager et al. (2016). Access is available for schools to sign up for no cost at the PERTS website, https://www.perts.net/orientation/cg. The module is presented to participants as an opportunity to help their college improve the experiences for other students. It first has them answer some survey questions, then presents growth mindset philosophy, including brain plasticity and the importance of challenging yourself, in the form of research results and student testimonials. Participants are also asked to complete follow up writing exercises throughout the module, reflecting on how their own experiences may relate to the new information presented in the module.

Student Learning Journals

In addition to class instruction, student learning journals provided students with more opportunities to practice thinking about their thinking by encouraging them to reflect on their learning, set and evaluate goals, and personalize the SRL and mindset topics covered in class. Students submitted entries pertaining to the topics we discussed that week through the free platform Edublogs (https://edublogs.org/) or on a discussion board in Canvas, our learning management system. For example, the week we held the discussion based on McGuire's (2015) SRL presentation I asked students to commit in writing to one or two of the new strategies reviewed. In addition to McGuire's (2015) presentation, I drew inspiration for the structured journal prompts from Nilson's (2013) book on fostering students' SRL skills and Howington and Sieve's (2018) conference presentation on non-cognitive skills for corequisite math students. For a complete list of the learning journal prompts, see Appendix B.

Formative Assessment Grades and Feedback

Unfortunately, many students have likely experienced math homework and quizzes as punitive, summative assessments, thus making it less likely that they will view them as learning opportunities. After reviewing the literature describing how formal grades can potentially harm students' mindsets and motivation to learn, I decided to experiment with how I handle formative assessments. First, I re-branded formative assessments, such as homework and quizzes, labeling them "learning opportunities" and "learning checks", respectively. Second, on these formative assessments I offered diagnostic comments rather than assignment standard numerical grades, which is in line with the recommendations made by Boaler (2016) to foster growth mindset in mathematics classes. I used a “check plus” or “check” to distinguish complete learning opportunities from those that needed more attention. Students from both groups were allowed to correct and resubmit any assignment.

Summative assessments (i.e., exams) were still assigned a numerical grade. However, written feedback on the exam itself included only diagnostic comments via Canvas SpeedGrader. Point totals for each problem were added on a separate piece of paper and attached as a comment to the exam submission. Both treatment groups were allowed to work on exam corrections for a percentage of their points back.

Data Sources

In this mixed methods design, I gathered data from both quantitative and qualitative sources. Quantitative data included student history, pre- and post-surveys, and course performance measures. I collected qualitative data from open-ended questions on the surveys, student learning journal entries, student interviews, and researcher reflective notes.

Quantitative

Student History. Students’ previous academic outcomes are generally reliable predictors of future academic performance (DiFrancesca et al., 2016). In order to compare baseline performance between my RC and GEAR groups, I collected students’ scores on the math portion of the Texas Success Initiative (TSI) Assessment, the primary tool used by my institution to determine DE or college-level placement. I also gathered students’ college GPA and previous grades in math classes taken in college when applicable. Since this is considered private academic information, I obtained separate consent from participants to gather their student history. Of the 39 participating RC students, 36 consented for me to look up their student history. Of the 43 participating GEAR students, 42 consented for me to look up their student history. I waited to look up this data until after final grades were submitted and stored it on a password-protected computer to which only I have access as the researcher. I present results from this academic baseline data in Chapter 4.

Motivated Strategies for Learning Questionnaire (MSLQ). To measure students' SRL skills I administered a pre- and post-survey to both groups via Qualtrics. Developed by Pintrich et al. (1991), the MSLQ is an exhaustive instrument containing scales to measure fifteen different sub-constructs of motivation and SRL, totaling over 80 items. In the original version participants answered using a seven-point Likert-type scale, from 1 "not very true of me" to 7 "very true of me", with the answer choices 2 – 6 unlabeled. Pintrich et al. (1991) designed each scale to be used as an individual module, so I administered the scale that measures metacognitive self-regulation. This scale focuses on the planning, monitoring, and regulating cycle of metacognition and contains twelve items, two of which are reverse-scored (items 1 and 8). See Appendix C for the original version of the metacognitive self-regulation scale. This scale has a reported alpha value of .79 (Pintrich et al., 1991), meaning it is a reliably internally consistent tool (Field, 2016).

I used this scale with a few minor adaptations. First, for clarity I converted the answer choices to a standard seven-point Likert scale, from 1 "Strongly Disagree" to 7 "Strongly Agree"; this also required slightly rewording the instructions. Second, because our math class did not involve much reading, I substituted "studying" for "reading" where it appears. Third, in the pre-survey I altered the instructions asking students to answer the following based on their experiences in previous math courses (rather than the current class). See Appendix D for my adapted version. Pre-intervention, 80 of my participants completed this slightly modified MSLQ scale, which had a reasonable level of internal consistency as determined by an alpha value of .763. This result is also in line with the research results shared above.

Self-Oriented Implicit Theories of Intelligence Survey (SOITIS). Most growth mindset studies use or base their instrument off of Dweck's (1999) original 8-item Implicit Theories of Intelligence Survey, which measures general beliefs about intelligence. De Castella and Byrne (2015) found that rewording the items to use a first-person point of view resulted in an instrument that better predicted academic achievement and motivation. This version of the instrument has an alpha value of .90 (De Castella & Byrne, 2015), indicating an excellent degree of internal consistently (Field, 2016). To measure students' growth mindset, I administered a pre- and post-SOITIS to both the RC and GEAR treatment groups. This instrument contained eight items, half measuring personal entity beliefs and half incremental beliefs. Participants answered using a seven-point Likert scale, with the entity items reversed scored.

I adapted De Castella and Byrne's (2015) instrument in one important way. Since research indicates that there are domain-specific differences in people's beliefs regarding the malleability of intelligence (Aditomo, 2015; Costa & Faria, 2018; Dweck, 2008), I added the word "mathematical" before the word "intelligence" on the instrument. By doing this, I hope to better isolate students' beliefs about their mathematical intelligence rather than their general intelligence. (See Appendix E.) Pre-intervention, 81 of my participants completed this slightly modified SOITIS scale, which had a high level of internal consistency as determined by an alpha value of .933. This result is also in line with the research results shared above.

Course Performance Measures. Finally, I used students' summative assessment scores to track the impact of the intervention on students' course performance. The first exam occurred very early in the semester, so I am using it as a baseline measurement. There were then four subsequent unit exams and a cumulative final exam. Furthermore, I am interested in potential differences between the pass, fail, and withdrawal rates between the treatment groups. Passing the course entails earning a final course average of 69.5% or higher. Earning lower than 69.5% results in a failing grade (D or F), and students who drop the course are considered to have withdrawn.

Qualitative

Open Ended Survey Questions. Qualitative data was collected by including an open-ended prompt at the end of an otherwise quantitative survey. At the end of the SOITIS instrument, I included a sentence prompting, "Briefly discuss your thoughts or reasoning for choosing your answers above". I followed up the MSLQ items regarding metacognitive self-regulation strategies by asking students to, "Include any other strategies you have used in your past (or current) math class." I collected responses to these open-ended questions on both the pre- and post-measures from both treatment groups and analyzed all responses.

Student Learning Journals. While functioning primarily as a class assignment for the GEAR group to foster SRL, students' journal entries also provided a rich source of data. From their journals, I was able to observe how they talked about themselves as learners, how they set and evaluated goals for the class, their perceptions of learning mathematics, and the strategies they used to do so. Furthermore, even though self-report survey results can be skewed due to participants offering the answers they think sound "right" rather than what is true for them, the language they use in discussing their math experiences, both past and present, may better reveal whether they exhibit a fixed or growth mindsets towards mathematics. GEAR students completed one entry per week throughout the semester for a total of 14 entries. RC students completed two entries prior to the course performance baseline measure, the two exam reflection discussions, and the post course reflection, for a total of five entries. Any student who opted out of the study was still required to complete the journal entries, but I excluded their data from my collection. Of the 43 participating GEAR students, 40 consented for me to use their student journal entries for my study.

It would have been overwhelming to analyze the entirety of my data set (over 600 entries), so I purposively sampled the journal entries for typical cases. I purposively sampled entries from each of the RC and GEAR groups representing students who did not pass our course, students who might have experienced some struggle but still passed, and students who earned high marks consistently. After coding the journal entries of four students from each of the groups (eight in total) I reached saturation of new codes and ideas.

Student Exit Interviews. I conducted short, semi-structured interviews with students from both groups after the courses ended to inquire about their perspective on the experience. I purposively sampled for typical cases representing different student outcomes, intending to talk with at least one student from each group who (1) did not pass the class, (2) performed average in the class, and (3) excelled in the class. I was able to talk with four students from the GEAR group who represented all three categories. However, I was only able to get two students from the RC group to respond to my interview request; one high performance student and one average. I also attempted to set up interviews with two students who dropped the class, but while both initially agreed to an interview neither responded to my emails once the semester ended. So, in total I conducted six interviews (four with GEAR students, two with RC students). I ran each interview by asking the same set of seven questions, plus a question for GEAR students regarding their journal entries (See Appendix F). When applicable, follow up questions for each participant varied based upon their answers.

Researcher Self-Reflection Journal. Due to the unique position held by the practitioner researcher, practicing reflexivity is a crucial element of action research (Mertler, 2017). Thus, I maintained a personal reflection journal, which accomplished several important purposes. First, it helped to highlight areas of potential improvement for future research cycles. Second, keeping track of my thoughts throughout this process provided invaluable data enabling me to discuss results within the context of the study. As the course instructor, conducting formal class observations was unfortunately not feasible. However, I kept record of informal observations in my reflection journal, and these informal observations can inform the interpretation of results. Furthermore, since it is not possible (or desirable, really) to separate the practitioner from the researcher in action research, maintaining awareness regarding a potential crossover of instructional strategies between the RC and GEAR groups was a strength rather than a weakness of my study.

See Table 2 for a summary of the data sources I used to address each of my research questions. Note that research question 1, regarding student achievement in the course, is answered solely with quantitative data, whereas the questions about the GEAR intervention's impact on students' SRL ability and growth mindset were explored simultaneously by both quantitative and qualitative data.

Table 2

Summary of Data Sources Used to Answer Each Research Question

Research Question	Data Source
RQ1. Compared to a group receiving additional mathematics remediation, what impact does GEAR have on students' academic achievement in corequisite non-STEM College Algebra?	TSI scores, College GPA, previous grade(s) in college math class, summative assessment scores, course pass/fail/withdrawal rates
RQ2. What impact does GEAR have on students' (a) SRL ability and (b) growth mindset regarding math?	Pre- and post-surveys (SOITIS and MSLQ) with open ended prompts, sample of the five student learning journal entries RC and GEAR groups both completed, student interviews
RQ3. How do students' perceptions of themselves as mathematical learners change during implementation of GEAR?	GEAR Pre- and post-SOITIS survey results with open ended prompt, sample of GEAR student learning journal entries, GEAR student interviews

Procedures and Timeline

Because I was solely responsible for implementation of the intervention, data collection, and data analysis, I did not have to include training additional instructors. This made implementation fairly straightforward.

Prior to the start of the fall 2020 semester, my first step was to obtain IRB approval from both Arizona State University and NVC (See Appendix G). The small size of the IRB at the latter sometimes causes delays in obtaining approval, so I initiated the process four weeks prior to the start of classes. Additionally, the pass code for access to the PERTS online growth mindset intervention is reset every academic year, so I reapplied for the new school year. As I began preparing for the new semester, I also started my personal reflection journal, which I maintained throughout the study.

Once classes started in the last week of August 2020, I spent time during the first week to discuss informed consent with my students and obtained consent from those willing to participate. After agreeing to participate, students from both treatment groups completed the MSLQ and SOITIS pre-survey instruments. On the sixth class day in both groups, I administered the first exam. For the GEAR group, I then officially started the intervention by beginning classroom instruction on SRL and growth mindset. This continued weekly throughout the semester. Exams occurred approximately every three weeks for the duration of the semester, totaling five unit exams and a final exam in December.

During the last week of classes, which fell in the first week of December 2020, I administered the post-survey instruments and began recruiting potential students for exit interviews. However, to mitigate potential bias and coercion concerns I waited to conduct student interviews until after I submitted final grades. Once I conducted the interviews I transcribed them for data entry with the help of Zoom's audio transcript feature. I also waited to gather student history data on participants until after I submitted final grades.

Although the very nature of action research requires and even benefits from the dual natures of practitioner researcher, I believe my role as teacher was best served by waiting to enter student data until after I submitted final grades. Once the semester formally concluded I entered quantitative data into SPSS and copied over qualitative data into MAXQDA. Quantitative data originated from student history, pre- and post-surveys, and exam results. Qualitative data came from responses to open ended prompts on the pre- and post-surveys, student learning journal entries, and student interviews. After I finished collecting and entering all data I began analysis.

Data analysis

In this section I discuss the approaches used in analyzing my quantitative and qualitative data. I collected quantitative data to address research question 1, and I needed both quantitative and qualitative data to answer research questions 2 and 3. For these latter questions, I used both quantitative and qualitative data for triangulation, using each type of data simultaneously to corroborate or contradict the other. Thus, I employed a convergent (or concurrent) mixed methods research designs, in which quantitative and qualitative data are collected concurrently, analyzed separately, then brought together again for interpretation and triangulation of results (Creswell & Guetterman, 2019).

Quantitative

For numerical data collected (student histories, pre- and post-survey results, and exam scores) I first cleaned and organized the data in Excel then used SPSS 27 to run descriptive analysis and statistical comparison tests. These procedures allowed me to compare baseline performance between groups and to check for potential differences in post-intervention results in course achievement, SRL ability, and growth mindset. Although I checked my data for outliers, normality, and homogeneity of variances, and present the results here, parametric tests of central tendency are robust enough to withstand violations of their assumptions and therefore can be still be used without comprising the validity of results (Glass et al, 1972; Norman, 2010; Zumbo & Zimmerman, 1993).

To compare academic baseline measures across the two groups, I used independent samples t-tests to their TSI scores and college GPA. I then investigated whether or not the GEAR intervention possibly influenced students' ability to pass the class. I defined "passing" a grade of C or higher in the course. "Not passing" was all other outcomes (withdrawing from the course or earning a grade of D or F). Since this is a dichotomous outcome (each student either passed or did not pass) and I had a sufficient sample size, I then performed a Chi-square (χ^2) test of homogeneity to compare the pass and no pass distributions scores between my RC and GEAR students.

To compare the set of six exam scores and two survey results (pre- and post-intervention) for each of my survey instruments I performed several two-way mixed ANOVA tests with a between group factor (RC or GEAR group membership). To compare exam scores I first converted exams 1 and 3, which were out of 50 points, to a percentage to ensure equivalent measurement across the six exams. For the survey instrument results I summed students' responses to the eight SOTIS and twelve MSLQ items to create growth mindset and self-regulated learning composite scores, respectively.

For all of the above analyses, my intent was to test the null hypothesis (H_0) that there would be no difference between the two groups. Thus, the alternative hypothesis (H_1) is there is a difference between RC and GEAR students. I set my significance level at $\alpha = .05$, which means I am willing to accept a 5% probability that I mistakenly reject H_0 and attribute random variation as a statistically significant difference between the two groups.

Using a parametric test (such as ANOVA) on ordinal data (such as a Likert scale) is a topic of debate in the statistical community. One side argues this should never be done; only nonparametric tests can be used on ordinal data (Jamieson, 2004; Kuzon et al, 1996). However, citing empirical evidence the other side argues that summing ordinal items sufficiently approximates a continuous level of measurement to justify using parametric tests, especially when the sum is comprised of eight or more related items (Carifio & Perla, 2008). Other scholars go even further, again using real and simulated models to demonstrate that parametric tests of central tendency are robust enough to withstand violations of their assumptions and therefore can be used on ordinal data without comprising the validity of results (Glass et al, 1972; Norman, 2010; Zumbo & Zimmerman, 1993). In his empirical defense of using parametric tests on ordinal data, Norman (2010) also recognizes it as a common practice in educational research.

Qualitative

Qualitative data analysis provides a number of meaningful benefits including explanation of possible discrepancies, valuable insight into participants' experience, and triangulation of results (Creswell & Guetterman, 2019; Ivankova, 2015; Mertler, 2017). Given the volume of qualitative data I collected across three different sources (open-ended survey prompt, journal entries, and interviews) I used qualitative content analysis as a systemic, flexible, and iterative approach to reduce and abstract my qualitative data (Schreier, 2014) and relate it to my research questions. The creation of my coding frame was simultaneously influenced by SRL and growth mindset concepts and driven by the data itself.

Following the process for qualitative content analysis laid out by Schreier (2014) I first selected a subset of my sampled qualitative data to create my coding frame. I selected at least one artifact from each group across my three different qualitative data sources (16 open-ended survey responses, 2 journal entries, and 2 interviews), taking care to select artifacts that represented both students who struggled and students who did well.

I began building my coding frame by first using my second and third research questions to generate two main categories, "perceptions" and "learning strategies." I then looked to my data to generate subcategories for each of the main categories, which I did on paper and pencil. This was an iterative process that involved visiting the data, generating categories, defining categories, then revisiting the data, revising categories, and adjusting definitions. About halfway through this process, I added eight additional open-ended responses (four RC/four GEAR), one GEAR interview, and one GEAR journal entries in order to expand and revise my coding frame. A third main category, "self-awareness", emerged from the data during this cycle, which I repeated roughly six times per main category until revisions to my coding frame for each main category were minimal.

At this point my coding frame consisted of thirty-six separate categories and subcategories across three main categories. Since this would have been an overwhelming number of categories to keep track of simultaneously, I applied all subcategories within one main category at a time before moving onto the next main category. Continuing to work with paper and pencil, I then moved onto segmentation and the first round of trial coding. Throughout both my frame building and trial coding, I started a running list of observations to consider as memo topics during my main analysis.

The mutual exclusivity requirement of content analysis means that each segment of data can be assigned only one subcategory code per main category (Schreier, 2014). Although Schreier (2014) recommends segmenting your data before beginning the first round of trial coding, I chose to segment and trial code simultaneously. I did so for several reasons. First, I found selecting segments and choosing the appropriate code to be intertwined. In many instances, figuring out how to segment the data was more or less equivalent to assigning its code. Because of this, the consistency of my segmentation provided another measure of my coding frame's consistency—namely, how consistently I apply the coding frame to the data. And finally, it was more expedient to do so.

Since I was the only person coding the data, I waited ten days and then recoded the same material in order to check the internal consistency of my coding frame. This time, I performed all of my coding in MAXQDA. I again coded one main category at a time, compared my second-round codes to those from my first round, noted any discrepancies in both segmentation and coding, and then modified my coding frame as applicable. I kept track of all discrepancies, decisions, and frame modifications because I knew maintaining an audit trail would aid me in my final interpretations (Schreier, 2014) and increase the validity of my claims (Birks, 2017; Creswell & Miller, 2000; Freeman et al., 2007).

The "learning strategies" main category produced the most consistent results as my segments and codes agreed across both trial rounds of codes approximately 85% and 80% of the time. I made modifications to the frame similar to the edits I made to the other two categories: adding additional examples, segmentation guidelines, and a new decision rule. However, as I compared the two rounds of coding I realized that one of my subcategories, "vague", needed to be its own category with two subcategories of its own, "ambiguous" and "imprecise". I added these categories and then applied them to my data.

My segments and codes for the "perceptions" main category agreed across the two trial rounds of coding by roughly 83% and 65%, respectively. I did not need to add any new categories but instead provided further clarification regarding when to apply which code. So, I modified the frame by adding additional examples from the data and expanding guidelines regarding segmentation. I also clarified the decision rule between "incremental" and "positive / self-reaction" and generalized the decision rule for "motivation / goal-orientation", as this latter category resulted in many of the inconsistent applications of the frame. Using this newly modified frame I then re-coded a third of my data subset, including the interview and journal entries that produced the most inconsistencies originally. This time my "perceptions" segments and codes matched by about 90% and 80%, respectively.

My segments and codes for the "self-aware" main category agreed across the two trial rounds of coding by roughly 90% and 65%, respectively. Over one third of the mismatches resulted from a code I did not catch during my first round of coding but did catch in the second round, which I attributed both to being more familiar both my data and better applying my coding frame. I did not need to add any new categories but modified the frame by adding additional examples and indicators from the data and expanding guidelines regarding segmentation. Using this newly modified frame I then re-coded a third of my data subset, including the interview and journal entries that produced the most inconsistencies originally. This time my "self-aware" segments and codes matched by about 90% and 80%, respectively.

The final coding frame for my study includes the following categories and subcategories. My research questions, theoretical framework, and participants' data simultaneously drove the creation of these categories and codes. I then used this frame to generate my qualitative observations and results. For my full coding frame, including definitions, indicators, examples, and decision rules, see Appendix H.

Perceptions (Main category)

- Incremental
    - Conditions
- Fixed
    - Circumstances
- Negative
    - Self-doubt
    - Math
- Apprehension
- Positive
    - Self-reaction
    - Math
- Motivation
    - Goal-orientation
    - Outcome expectations
    - + (increasing)
    - – (decreasing)

Learning Strategies (Main category)

- Content (Planning / Used)
    - Help
    - Collaboration
    - Passive
    - Active
    - Metacognitive
- Control (Planning / Used)
    - Focus
    - Time management
    - Organization
    - Self-care
    - Motivation
- Vague
    - Ambiguous
    - Imprecise
- Handicapping

Self-awareness (Main category)

- Lack of
- Adjustment
    - No/vague reason

    - Personal reason
    - Learning connection
- Connection
- Acknowledgement

With my coding frame complete, I moved on to my main analysis and coded the remainder of my qualitative data (all open-ended responses from the pre- and post-intervention surveys, six total interviews, and journal entries from eight students). To address my second research question, which compares results from the RC and GEAR groups, I coded only the five common journal entries with all three of my three main categories. However, to address my third research question regarding perceptions of the GEAR participants, I also coded all journal entries by my GEAR participants with my "perceptions" main category. After my initial round of coding, I then revisited and recoded any segments about which I felt hesitant. This constituted roughly a third of the material, which is a reasonable rule of thumb to use for recoding (Schreier, 2014).

Although memo writing is not an official step in content analysis, I kept notes of my observations while building the coding frame and coding during my main analysis. Once I finished coding, I then revisited these notes and began to write memos based on these observations. This was a process that involved searching for relationships between my observations and my research questions as well as between the observations themselves. I also began to pull quotes from the data itself so as to analyze and share results in my students' own words as much as possible.

To address my second research question concerning the impact of the GEAR intervention on students' SRL ability and growth mindset beliefs, I then used MAXQDA to isolate comments made by both groups which made it easier to compare the two groups code by code. As I combed through the data, I compared frequencies and took note of any qualitative similarities and differences between the two groups.

To address my third research question regarding GEAR students' perceptions of themselves as mathematical learners I adapted a version of Saldaña's (2016) longitudinal data matrix. Each row represented a participant and three columns stood for their perceptions pre-, during, and post-intervention. Breaking down their feelings, responses, and reactions in this way allowed to me observe any changes in perceptions that occurred over the course of the semester.

Additional Considerations

Conducting a mixed methods study requires attention to the potential validity, reliability, and ethical issues that arise in both quantitative and qualitative methods (Creswell & Guetterman, 2019), as well as possible limitations of my study. Validity in research refers to the quality of inferences made from quantitative and claims from qualitative data (Fraenkel & Wallen, 2005; Freeman et al., 2007), whereas reliability deals with the consistency of results, whether numerical or qualitative (Fraenkel & Wallen, 2005; Gibbs, 2012). Ethical matters arise from issues surrounding data, power dynamics, and the study design.

Validity

Threats to the validity of inferences drawn from quantitative data can be internal or external. When testing an intervention, internal validity is crucial in order to make substantiated claims regarding the efficacy of the intervention. In education all sorts of confounding variables might explain the variance in numerical data. In particular, the internal validity of my results could be threatened by participant maturation, pretest sensitization, and nonequivalence between groups (Smith & Glass, 1987).

Roughly a quarter of my participants were first time in college (FTIC), so improvement in their SRL ability or growth mindset might have partially been caused by natural maturation during their first semester in college, particularly since FTIC students are required to take a student development course during their first semester. Pretesting is a threat because participants may be alerted to the “desired” outcomes of the study, thus causing posttest scores to increase for a reason other than the intervention alone (Smith & Glass, 1987). These threats can be at least partially mitigated by having an alternate treatment group, which I did. However, since my study population was selected out of convenience and assigned as intact groups (rather than random selection), nonequivalence between groups might be an issue. One way to mitigate this potential threat was to hold class for the groups at the same time of day so that I am comparing a 9am class on Mondays and Wednesdays to a 9am class on Tuesdays and Thursdays as opposed to comparing a morning versus afternoon or evening class. Furthermore, collecting student history data as well as pretest surveys allowed me to compare pre-intervention baselines in academic performance, SRL ability, and mindset beliefs and control for any significant differences.

External validity in quantitative research typically refers to the generalizability of results. Would the same experiment performed in a new context with different participants net similar results? While the external validity of my study is hurt by the lack of random selection, generalizability to other settings is not the purpose of action research—instead, action research seeks credibility and transferability (Mertler, 2017).

By including rich description and detailed data I can address the complexities of the study in addition to my specific context. This delivers transferability by providing a clear picture of my research setting and thus offers others insight used to determine the applicability of my research to their own context (Mertler, 2017). My priority then concerns detailing my local context and developing an intervention that other coreq College Algebra instructors at my institution can use successfully.

Guidelines for establishing validity of qualitative research are not the same as those for quantitative inquiry (Birks, 2017; Freeman et al., 2007; Gibbs, 2012). However, mixed methods researchers are still interested in making meaningful claims from their qualitative data, and there are a wide variety of tools available to enhance the validity of your qualitative conclusions, many of which are also central tenants of producing quality action research. Triangulation of multiple data sources is a common method used to increase validity of results (Creswell & Miller, 2000; Freeman et al., 2007; Gibbs, 2012; Mertler, 2017), and I collected and analyzed several sources of data to answer my research questions. I maintained an audit trail of the reasoning behind my research decisions by keeping track of every draft of my coding frame as well as written justification behind each edit and transparently included this reasoning in the study's report, which enables others to more fully understand the research context (Birks, 2017; Creswell & Miller, 2000; Freeman et al., 2007). Related to audit trails is researcher reflexivity, or the "recognition that the product of research inevitably reflects some of the background, milieu, and predilections of the researcher" (Gibbs, 2012, p. 91), which I addressed by keeping a researcher reflection journal. These practices serve to further ground my study in description and data, increasing the credibility and transferability of my research as well as the validity of my qualitative results (Creswell & Miller, 2000).

Other key components of action research which serve to increase qualitative research validity are ensuring that your study makes a contribution to research (Birks, 2017), grounding your study in theory (Freeman et al., 2007), and addressing the relationship between researcher and participants, including the potential ethical issues that might arise out of the resulting power dynamic (Birks, 2017; Freeman et al., 2007).

Reliability

Reliable research results are a necessary condition to produce valid research conclusions (Fraenkel & Wallen, 2005; Mertler, 2017). One way to measure the reliability of quantitative results is to examine the internal consistency of your survey instruments, checking to ensure that they are consistent in measuring their intended constructs (Field, 2016; Fraenkel & Wallen, 2005). The instruments on which I based my SRL and growth mindset surveys have been shown to have alpha values of .79 (Pintrich et al., 1991) and .90 (De Castella & Byrne, 2015), respectively, internally consistent results duplicated by the alpha values of my own data set (.75 for the MSLQ instrument and .93 for the SOITIS instrument). Qualitatively, I incorporated memo writing and explicit code definitions into my content analysis, which researchers can use to increase the reliability of their codes (Birks, 2017; Gibbs, 2012). And the content analysis practice of trial coding and a subsequent recoding 10 to 14 days later further improves the internal consistency of the coding frame (Schreier, 2014).

Ethical Matters

Another condition necessary to produce valid research is running an ethical study (Gibbs, 2012). Kitchener and Kitchener (2009) propose that in social science research the fundamental ethical questions deal with how data is handled and the relationship between researcher and participants. To these issues, Mark and Gamble (2009) add the study design, particularly as it relates to having a control group.

Data collection, analysis, and storage must be done in ways that respect the participants, starting with informed consent. While older than 18, young adults in college may not fully comprehend what it means to participate in research, so I took additional care to explain elements of the study that might influence their willingness to participate (Gibbs, 2012; Kitchener & Kitchener, 2009). Once I collected data, I stored it in a manner that maintains confidentiality and privacy by assigning participants a random identification number and keeping all materials on password protected computer to which only I have access. A possible threat to anonymity is the thick, rich descriptions expected of valid qualitative results. While I maintain anonymity in the transcriptions of students' journals and interview data, I let students know that complete anonymity in my final report may be impossible.

In addition to the handling of data, there is an important power dynamic to consider. I was the participants' instructor, the person responsible for assigning their course grades. I did not want students to ever feel as though their cooperation would in any way influence their outcome in the class. To address such power imbalances, the researcher needs to build trust and rapport with their participants (Gibbs, 2012), which is something I always attempt to do as an instructor, independent of research reasons. I encourage and honestly answer questions, explain my reasoning behind decisions, and apologize if I do make a poor decision. In both research and in life, it is important to follow Immanuel Kant's moral imperative to "treat … others … always as an end and never merely as a means" (as cited by Kitchener & Kitchener, 2009, p. 18). One way of incorporating this philosophy into social science research is to adopt the feminist ethics of care, under which the researcher is obligated to care for participants (Kitchener & Kitchener, 2009; Mauthner et al., 2012). Furthermore, in feminist theories researchers should avoid situations in which they ask participants to share a lot of information about themselves while sharing little to nothing about themselves (Tisdell, 2008). Since I asked students to share many of their personal thoughts and experiences in their journal posts, I shared many of my own thoughts and feelings regarding the journal prompts.

There was also the question of running an alternate treatment group if I believed that the GEAR intervention would be useful to students. To justify a social science research design that includes a control group, one must consider the value of the knowledge produced and if benefits of the research outweigh the potential harm (Kitchener & Kitchener, 2009; Mark & Gamble, 2009). My department must find solutions to help our incoming corequisite College Algebra students succeed, as there is much at stake if they fail. And although my theory-driven research hypothesis was that the GEAR intervention would be beneficial, I ran this study because I wanted to establish this empirically. From the outset, it was entirely possible that spending the additional class time every week on math content remediation would be more helpful to underprepared students. If that was the case, pushing out an ineffective GEAR intervention would be, at best, a waste of resources, and at worst, harmful to our students.

On the other hand, even if the GEAR intervention proved effective, I knew convincing other teachers to adopt a change in instructional practices could prove difficult. I was thus hopeful that research results suggesting that this new method was potentially effective would be helpful in re-training others. Furthermore, if the GEAR intervention proved to be so effective that a significant difference between the two treatment groups became obvious during the course of the semester, I was ready and willing to effectively terminate the study as described here and begin sharing a version of the intervention with my RC group.

As it played out over the course of the semester, this was not necessary. According to the criteria laid out by Mark and Gamble (2009), because my research addressed an important problem, there was uncertainty about efficacy of the intervention, the results would be used to inform instructional-based decisions, and I respected participants' rights—the use of an alternate treatment group in my study was ethically justified.

Chapter 4

Chapter 3 laid out the methods and methodological foundations of this study. In Chapter 4 I present my findings, organized by research questions. For research question one (RQ1), which is addressed solely by quantitative data, I discuss baseline comparisons then final course outcome results. To address research question two (RQ2), I first lay out quantitative results from the pre- and post-survey instruments then present my coding frame and subsequent qualitative results. For research question 3 (RQ3), since quantitative results are addressed by the previous research question I begin directly with the themes that arose from GEAR students' qualitative data. For each research question I end with a reflection on how I might improve the GEAR intervention. I end the chapter with interesting correlative results between the three research question results to consider the possible relationship between relevant constructs, discussing the discrepancies between quantitative and qualitative results, and synthesizing all results in conclusion.

RQ1: Compared to a group receiving additional mathematics remediation, what impact does GEAR have on students' academic achievement in corequisite non-STEM College Algebra?

I collected and analyzed quantitative data to address RQ1. To compare baseline difference between the groups I gathered TSI scores and college GPA, when applicable. I also administered six exams covering various College Algebra content, one prior to the GEAR intervention, four concurrent to the intervention, and one at its conclusion, and I kept track of which participants completed and then passed the course.

Baseline Comparisons

Since my participants were not randomly assigned individually to the RC or GEAR condition, I started by testing for possible academic differences between the populations. I wanted to understand the academic baselines of my two groups to determine if one group was perhaps better prepared for College Algebra than the other. NVC uses the Texas Success Initiative (TSI) Assessment to determine whether or not students are college-ready. The exam scores range from 310 to 390, and 350 is considered the college-ready cut-off score. Theoretically, the higher a student's TSI math scores, the better prepared they are for college-level mathematics. Since students' previous academic outcomes have been found to be reliable predictors of future academic performance (DiFrancesca et al., 2016), I also gathered participants' college GPA and previous college math experience when available. I gathered this data only from participants who consented to access of their academic histories.

TSI scores were available for 32 RC participants and 33 GEAR participants. I ran an independent-samples t-test to determine if there was a difference in the TSI scores between RC and GEAR participants. There were no outliers in the data, as measured by the SPSS boxplot output. TSI scores were not normally distributed, as indicated by Kolmogorov-Smirnov's test ($p < .001$). There was homogeneity of variances, as evidenced by Levene's test for equality of variances ($p = .514$). The mean TSI score of the GEAR group was higher ($M = 337.67$, $SD = 11.14$) than that of the RC group ($M = 333.09$, $SD = 12.66$), but the difference between the two groups was not statistically significant, $M = -4.58$, 95% CI [-10.48, 1.33], $t(63) = -1.548$, $p = .127$. Thus, the GEAR group averaged about four and half points higher on the TSI exam than the RC group, but we cannot reject the null hypothesis that the two groups were equivalent on this measure.

College GPA was available for 31 RC participants and 25 GEAR participants. I ran an independent-samples t-test to determine if there was a difference in college GPA between RC and GEAR participants. There were no outliers in the data, as measured by the SPSS boxplot output. College GPAs did not deviate significantly from normal, as indicated by Kolmogorov-Smirnov's test ($p > .05$), and there was homogeneity of variances, as evidenced by Levene's test for equality of variances ($p = .213$). The mean GPA of the RC group was higher ($M = 3.07$, $SD = .61$) than that of the GEAR group ($M = 3.02$, $SD = .76$), but the difference between the two groups was not statistically significant, $M = .05$, 95% CI [-.31, .43], $t(54) = .341$, $p = .735$. Thus, average GPA of students in the RC group was about three points higher than those in the GEAR group, but we cannot reject the null hypothesis that the two groups were equivalent on this measure.

At the start of the semester, 5 (13.9%) of the students in the RC group were FTIC and 31 (86.1%) were continuing college students, compared to 16 (38.1%) FTIC and 26 (61.9%) continuing college students in the GEAR group. This was a statistically significant difference in proportions, p = .016. Of the 31 continuing college students in the RC group 13 (41.9%) had taken and passed a math class in college within the past year and 18 (58.1%) had not. Of the 26 continuing college students in the GEAR group 11 (42.3%) had taken and passed a math class in college within the past year and 15 (57.7%) had not. There were no significant differences in the proportions of continuing college students who had taken and passed a math class in college within the past year between the two groups, $p = .977$.

Since the t-test results were not statistically significant ($p > .05$) we cannot accept the alternative hypothesis that the two groups differed by TSI scores or college GPA. Thus, based on these two measures sufficient evidence does not exist to suggest that the two groups differed significantly in their academic preparedness for a college-level math course. There was a statistically significant difference between the FTIC proportions of the two groups ($p < .05$), so we can conclude that the RC and GEAR groups differed on this measure, with the GEAR group containing a higher proportion of FTIC students. Of the continuing college students among both groups, the proportions of students who had taken and passed a math class in college within the last year were not statistically different ($p > .05$), so we cannot accept the alternative hypothesis that the two groups differed by this measure. These results imply that of the pre-course measurements I was able to collect, the two groups differed on proportion of FTIC students.

Both groups took Exam 1 on the fifth day of class, prior to the official start of the GEAR intervention. I ran an independent-samples t-test to determine the statistical differences between the Exam 1 scores of students in the GEAR and RC conditions. There were no outliers in the data, as measured by the SPSS boxplot output. Exam 1 scores were normally distributed, as indicated by Kolmogorov-Smirnov's test ($p = .076$), and there was homogeneity of variances, as evidenced by Levene's test for equality of variances ($p = .617$). Students in the GEAR group scored higher ($M = 75.98$, $SD = 19.22$) than students in the RC group ($M = 67.56$, $SD = 18.02$), a statistically significant difference, $M = 8.42$, 95% CI [0.15, 16.67], $t(79) = 2.028$, $p = .046$, $d = .44$.

Given how course placement works, it would be a reasonable expectation that FTIC students might be slightly more prepared for a college-level math course, as they are testing directly into the coreq College Algebra course rather than its prerequisite. The mean TSI of GEAR group was about 4.5 points higher than the RC group, but this difference was not statistically different. Additionally, Exam 1 covered only proportions and conversions, two non-algebraic topics included in the course at the request of NVC's Science department, but neither of which is substantially related to the remainder of the College Algebra curriculum. Therefore, while Exam 1 results indicate that students in the GEAR group outperformed the RC group on these two topics, I do not believe this to be sufficient evidence to conclude that GEAR participants as a whole were better prepared for College Algebra than RC participants. However, the higher proportion of FTIC students in the GEAR group combined with a higher average on Exam 1 should be taken into account when interpreting the academic outcomes of the two groups.

Academic Outcomes

Dichotomous Dependent Variables. In order to determine whether the GEAR intervention had any impact on participants' ability to pass the course, I ran a Chi-square test of homogeneity. I defined passing the course as earning a final course average of 69.5% or higher, thus resulting in a final course grade of C or better, since a lower grade results in needing to retake the course. Students who did not pass the class either earned lower than 69.5% (resulting in a grade of D or F) or dropped the course (resulting in a W, for withdrawn). At the end of the semester, 20 (51.3%) of the students in the RC group passed the class and 19 (48.7%) did not, compared to 21 (48.8%) of the students in the FTIC group who passed the class and 22 (51.2%) who did not. Although the RC group had a slightly higher proportion of students who passed the class, this difference was not significant, p = .825.

Since the intervention did not appear to affect what is typically referred to in academia as student success (passing the course), I wondered if perhaps it might have impacted student retention (staying in the course until completion, regardless of the final grade earned). Technically on transcripts, remaining in the course until after the last day to drop counts as completing the course. However, I chose to define completion as staying in the course and taking the final exam, since skipping the final exam is a way (albeit informal) of giving up on the course.

At the end of the semester, 28 (71.8%) of the students in the RC group completed the class and 11 (28.2%) did not, compared to 33 (76.7%) of the students in the FTIC group who completed and 10 (23.3%) who did not. Although the GEAR group had a slightly higher proportion of students who completed the class, this difference was not significant, p = .608.

Although neither distribution difference tested at the significance level, it may be of interest toward practical significance that the GEAR group had a slightly lower proportion of passing students but a slightly higher proportion of students who chose to complete the course, indicating that in the GEAR group more failing students chose to complete the course than in the RC group.

Upon examining this further, 8 (42.1%) of the failing students in the RC group chose to complete the class and 11 (57.9%) did not, compared to 12 (54.5%) of the failing students in the FTIC group who chose to completed the class and 10 (45.5%) who did not, so the GEAR group did have a higher proportion of failing students who chose to complete the class. Although this difference was not statistically significant ($p = .427$) the fact that a higher proportion of GEAR students were willing to complete the course despite not passing is interesting from a practical perspective and could indicate a variety of things, including an overall average that is closer to the passing cut off (69.5%) or a higher growth mindset, which was the focus of the intervention.

Continuous dependent variables. Descriptive statistics for the five exams taken during the intervention are presented in Table 3 on the next page. For each of the five exams, frequencies, means, standard deviations, and medians are provided for each of the two treatment conditions.

To compare the differences in individual exam results based on everyone who took each exam separately I ran independent samples t-tests for Exams 2 through 6. Across all five exams there were three outliers, one student in the RC group whose Exam 4 and 5 scores both fell below 1.5 times the interquartile range and one student in the GEAR group whose Exam 4 score fell below 1.5 times the interquartile range. Data for Exams 1, 2, 3, 4, and 6 did not deviate significantly from normal, as indicated by Kolmogorov-Smirnov's test ($p > .05$) though Exam 5 scores were not normally distributed ($p = .016$). There was homogeneity of variances for Exams 3 through 6, as evidenced by Levene's test for equality of variances, but not for Exam 2 ($p = .004$). Results for Exams 2 through 6 are presented in Table 4. For each of the five exams, mean difference, 95% confidence interval (CI), and effect size are provided. None of the results were found to be statistically significant ($p > .05$).

I conducted a two-way mixed ANOVA with a within-subjects factor of time and a between-subjects factor of group membership to determine if there was an interaction

Table 3

Descriptive statistics for the number of responses, exam means, standard deviations, and medians by group condition

	Exam 2		Exam 3		Exam 4		Exam 5		Exam 6	
Condition	GEAR	RC	GEAR	RC	GEAR	RC	GEAR	RC	GEAR	RC
# of responses	$n = 42$	$n = 37$	$n = 40$	$n = 33$	$n = 37$	$n = 33$	$n = 34$	$n = 31$	$n = 33$	$n = 28$
Mean	68.75	63.73	56.63	49.18	54.95	51.12	69.34	66.37	63.49	58.75
SD	15.53	22.53	21.17	23.84	19.62	18.04	22.10	22.34	20.77	19.90
Median	69.00	66.50	56.00	45.00	54.00	52.00	74.75	73.50	66.00	61.75

Table 4

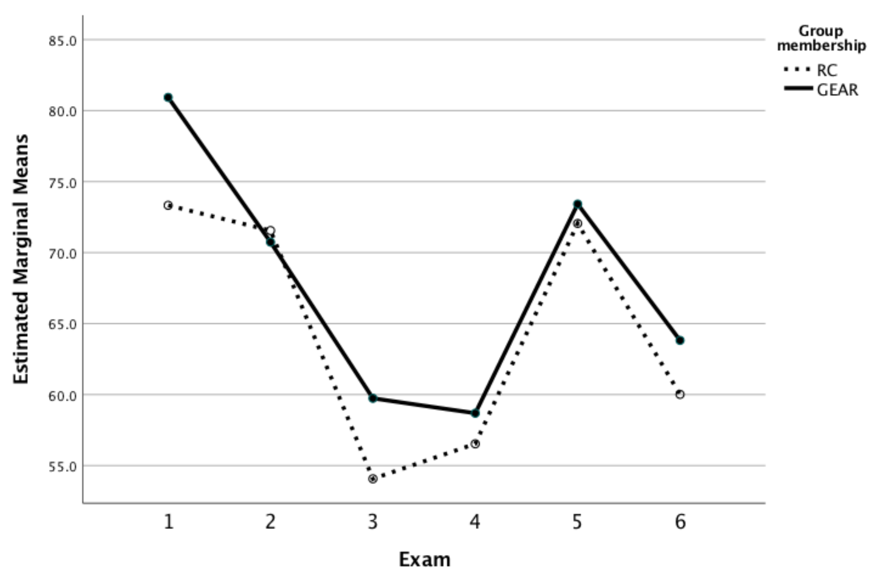
Independent t-test results for Exams 2 through 6

	Exam 2	Exam3	Exam 4	Exam 5	Exam 6
Mean Diff	5.02	7.44	3.82	2.97	4.74
95% CI	[-3.80, 13.84]	[-3.06, 17.95]	[-5.21, 12.85]	[-8.05, 14.00]	[-5.74, 15.21]
Effect size	.26	.33	.20	.13	.23

effect of group membership on exam scores over time. This test excluded all participants with any missing data points. In the RC group 27 students had scores for all six exams; inthe GEAR group 31 students had scores for all six exams. Across all exams there was one outlier, a student in the GEAR group whose Exam 1 score had a studentized residual value of -3.02. Data for Exams 1, 2, 3, 5, and 6 did not deviate significantly from normal, as indicated by Kolmogorov-Smirnov's test ($p > .05$) though Exam 4 scores were not normally distributed ($p = .012$). There was homogeneity of variances, as determined by Levene's test of homogeneity of variances ($p > .05$). There was homogeneity of covariances, as assessed by Box's test of equality of covariances ($p = .155$). Mauchly's test indicated that the assumption of sphericity was not met for the two-way interaction, $\chi^2(14) = 28.90$, $p = .011$. Therefore, a Greenhouse-Geiser correction was applied ($\varepsilon = .838$). Results for the sample are presented in Figure 3.

Figure 3

Two-way Mixed ANOVA Results Across Time



The interaction between time and group membership was not statistically significant, $F(4.191, 234.710) = .953$, $p = .437$, partial $\eta^2 = .017$. The main effect of time did show a statistically significant difference between exams scores over the course of the semester, $F(4.191, 234.710) = 30.017$, $p < .001$, partial $\eta^2 = .349$. However, the main effect of group did not show a statistically significant difference between collapsed exams, $F(1, 56) = .770$, $p = .384$, partial $\eta^2 = .01$. Thus, it does not appear as though membership in the GEAR as opposed to the RC intervention group had a statistically significant effect on students' exam grades.

I expected the main effect across time. The exams are not true repeated measures in that they do not test the exact same construct repeatedly. Instead, the exams cover different material and students usually do worse on quadratic functions (Exams 3 and 4) and the cumulative final exam (Exam 6) than on they do on linear relationships (Exams 1 and 2) and exponential and logarithmic functions (Exam 5). However I did not expect the post-intervention exam results between the two groups to so closely track one another, a visual confirmation that interaction between time and group membership was not strong which indicates that exam context more significantly influenced students' exam scores than did their group membership in the GEAR or RC interventions. However, although the two groups score very similarly on Exam 2 (the first exam post-intervention by two weeks), the drop off from Exam 2 to Exam 3 was less steep for the GEAR group. And even though the RC group experienced a small rebounded from Exam 3 to Exam 4, the GEAR average remained higher throughout the remainder of the semester, though this difference was small.

Statistical versus Practical Significance

The power of a test is the probability that it will detect a difference in the population when one actually exists. Power depends on sample size, effect size, and the strictness at which statistical significance is set (Field, 2016). The more overlap between confidence intervals the lower the *p* value, but sample size affects the width of confidence intervals because lower sample size means higher variability and thus wider confidence intervals. Thus, a smaller sample size lowers the power of a test. So smaller effect sizes require higher sample populations to detect statistical significance. A sample the size of my study (fewer than 100 participants) would need a sizable effect to detect statistical significance, but my effects ranged from .13 to .33. The ability to detect such effect sizes would require much larger sample populations (Wuensch, 2015). For example, the Cook et al. (2013) study that found their SRL intervention had a statistically significant positive effect on course grades had nearly 700 participants.

The GEAR group did start with a higher FTIC proportion and Exam 1 average, both of which tested at significance. However, it is not clear how much these variables account for the subsequent variability in exam scores between the groups. It is interesting to note from Table 4 that all five post-intervention exams show a positive effect (none of the means are negative). While a larger sample size would have been necessary to detect a statistically significant difference between the groups' exam scores the consistency of these small, positive effects indicates practically significant implications.

Additionally, while the course completion rate and exam averages of the GEAR group were slightly higher than the RC group the pass rate was slightly lower. But the pass rate does not distinguish between the grade of D and the grade of F, even though the former represents a better learning outcome. If GEAR intervention helped just a few students earn D's who would have been otherwise earned F's, this likely would not have been caught by the above data and results. Taking my smaller sample size into consideration when interpreting the positive effects realized, it is probable that the GEAR intervention had a practically, though not statistically, significant effect on the academic outcomes of students.

Room for Improvement

The SRL presentation employed in the Cook et al. (2013) study mentioned above was a substantial component of the explicit SRL instruction in my GEAR intervention. However, the presentation was designed for college-ready chemistry students at a moderately selective state university. The corequisite students at my own open-door policy school comprise a considerably different population, and thus the presentation could use some adjustments. In the future, I plan to supplement the broad strokes painted by the presentation with additional days spent modeling and practicing the metacognitive strategies discussed. Put another way, for some of the least prepared students in my coreq College Algebra classes suggesting a strategy such as, "Practice giving mini lectures" may be too general to be helpful. Instead, I could plan instruction time around demonstrating how to develop and practice mini lectures and then give students class time to try it out with one another.

RQ2: What impact does GEAR have on students' SRL ability and growth mindset regarding math?

I collected and analyzed both quantitative and qualitative data to address RQ2. Quantitative data consisted of responses to a twelve item, seven point Likert scale questionnaire (MSLQ) regarding metacognitive learning strategies to examine students' SRL ability and an eight item, seven point Likert scale questionnaire on incremental and entity beliefs to assess students' growth mindset (SOITIS). Qualitative data included one open-ended response on each of the survey instruments, as well as reflective interviews—two with RC students and four with GEAR students. Qualitative data also included the five journal entries common to both groups from which I purposively sampled four students from each condition to represent students who performed at high, medium, and low levels in the course. I present the quantitative results first, discussing SRL and growth mindset findings concurrently. I then discuss the qualitative results, starting with the patterns that appeared to address students' SRL ability and then those that address growth mindset.

Quantitative Results

After reverse scoring items 1 through 4 on the SOITIS responses and items 1 and 8 on the MSLQ responses, I summed the eight SOITIS responses (min = 8, max = 56) and twelve MSLQ responses (min = 12, max = 84) to create a growth mindset (GM) and metacognitive strategies for learning (MSL) composite for each student. Descriptive statistics are given in Table 5. Frequencies, means, standard deviations, and medians are presented for both pre- and post-intervention surveys for each condition group.

The first thing I noticed was that for both groups, the GM composite was lower at the end of the semester than the start. While disappointing, it is perhaps not surprising given the enthusiasm and optimism with which students usually start the semester. I also noticed higher variability for the growth mindset scores among students in the GEAR group, possibly due to an extreme low outlier on both the pre- and post-intervention

SOITIS surveys. On the other hand, the MSL composite was higher at the end of the semester than the start for both groups.

Table 5

Descriptive statistics for the number of responses, means, standard deviations, and medians by group condition and pre- or post-intervention

	RC - GM		GEAR - GM		RC - MSL		GEAR - MSL	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
# of responses	*n* = 36	*n* = 28	*n* = 41	*n* = 30	*n* = 36	*n* = 28	*n* = 40	*n* = 30
Mean	45.81	43.36	48.10	43.57	58.61	61.14	58.15	60.93
SD	8.76	8.30	9.22	11.80	8.19	8.23	9.83	8.18
Median	48.00	45.00	47.00	45.50	58.00	59.50	60.00	61.5

I conducted a two-way mixed ANOVA with a within-subjects factor of time and a between-subjects factor of group membership to determine if there was an interaction effect of group membership on GM composite scores over time. This test excluded all participants with any missing data points. In the RC group 28 students had scores both pre- and post- SOITIS surveys; in the GEAR group 30 students had scores for both. Across all SOITIS surveys there were four outliers, one a student in RC group on the pre-survey and three students in the GEAR group on the post-survey. All outliers fell below 1.5 times the interquartile range. GM composites on both the pre- and post- surveys were not normally distributed ($p = .019$ and $p = .009$, respectively). There was homogeneity of variances, as determined by Levene's test ($p > .05$). There was not homogeneity of covariances, as assessed by Box's test of equality of covariances ($p = .048$). Since the within-subjects factor has only two categories (pre and post), the condition of sphericity is not applicable. GM composite scores of student in the RC group decreased pre- to post-intervention (*M* = -2.25, *SD* = 6.76) while GEAR students' GM scores fell slightly less over the same time period (*M* = -1.00, *SD* = 14.18).

The interaction between time and group membership was not statistically significant, $F(1, 56) = .022$, $p = .884$, partial $\eta^2 < .001$. The main effect of time did show a statistically significant difference between the pre- and post-intervention GM composite scores, $F(1, 56) = 4.154$, $p = .046$, partial $\eta^2 = .069$. However, the main effect of group did not show a show a statistically significant difference between collapsed pre- and post GM composite scores $F(1, 56) = .033$, $p = .857$, partial $\eta^2 = .001$. Thus, it does not appear as though membership in the GEAR as opposed to the RC intervention group had a statistically significant effect on students' GM composite scores.

In the RC group, 28 students had scores for both pre- and post- MSLQ surveys; in the GEAR group 29 students had scores for both. Across all MSLQ surveys there was one outlier, a student in RC group on the pre-survey who fell above 1.5 times the interquartile range. MSL composites on both the pre- and post-surveys were normally distributed as assessed by Kolmogorov-Smirnov's test ($p = .591$ and $p = .785$, respectively). There was homogeneity of variances, as determined by Levene's test ($p > .05$). There was also homogeneity of covariances, as assessed by Box's test of equality of covariances ($p = .162$). Since the within-subjects factor has only two categories (pre and post), the condition of sphericity is not applicable. RC students' MSL composite scores increased pre- to post-intervention (*M* = 2.28, *SD* = 7.95) while GEAR students' MSL scores rose slightly more over the same time period (*M* = 2.75, *SD* = 12.19).

The interaction between time and group membership was not statistically significant, $F(1, 55) = .030$, $p = .863$, partial $\eta^2 = .001$. The main effect of time did not show a statistically significant difference between the pre- and post-intervention GM composite scores, $F(1, 55) = 3.399$, $p = .071$, partial $\eta^2 = .058$. The main effect of group also did not show a show a statistically significant difference between collapsed pre- and post MSL composite scores $F(1, 55) = .018$, $p = .895$, partial $\eta^2 < .001$. Thus, it does not appear as though membership in the GEAR as opposed to the RC intervention group had a statistically significant effect on students' MSL composite scores.

Thus, the two quantitative snapshots (pre- and post-intervention) of students' self-regulation strategy usage and growth mindset did not return any statistically significant difference between the two groups, seeming to suggest that the GEAR intervention did not have a meaningful impact on either measure. This would uphold similar quantitative findings indicating that it can be difficult for interventions to substantially change SRL ability (Dignath and Büettner, 2008; Dignath-van Ewijk & ven der Werf, 2012) or mindset (Li and Bates, 2019; Orosz et al., 2017; Schmidt et al 2017) while contradicting others (e.g., Aronson et al., 2002; Blackwell et at., 2007; Brown & Harris, 2014; De Corte et al., 2011; Fuchs et al., 2003b; Hussein, 2018; Pintrich, 2002; Zimmerman, 2001). I further explore the commonalities and differences between my own study and results and the current literature in Chapter 5.

Qualitative Results

Similarities in SRL Between the Groups. Students in the RC and GEAR groups expressed self-handicapping feelings and behaviors with roughly the same frequency and subject matter. Difficulty managing time or fighting procrastination was the most frequent, popping up among multiple students within each group, which is not surprising given that this is something with which students consistently recognize they struggle. The most common refrain sounded like the GEAR student who admitted they would, “procrastinate on the studying I need to do.” Though simply harboring negative feelings such as this RC student, “I have little desire to become better at it…I personally just hate math” also showed up in both groups, as did “second guessing myself” and forgetting about the math labs.

Given that procrastination was on multiple students’ minds, it makes sense that the most commonly mentioned control strategy discussed by both groups was time management. However, the specific ways RC and GEAR students planned to manage their time differed slightly. Students in the RC group tended to focus more on "studying right after class" or "[starting] right away on my homework” whereas it was more common for GEAR participants to discuss the importance of “studying a bit of math everyday." One GEAR student actually developed his own "Have you worked on math today?" habit to remind himself to work on math consistently. This was promising because one of the strategies discussed in the GEAR intervention was studying more frequently for shorter periods of time.

Another similarity between the groups was the relative absence of the other control strategies. Although students will often admit staying motivated is a challenge (“I still have the mindset of leaving college more on the backburner of my priorities”) the only RC student who touched on this alluded to motivating themselves by “…[approaching college] to be hard then having to skip class and treat it like being high school again.” Three GEAR students dug a little deeper in their goals and attitudinal efforts to succeed. One talked about purposefully embracing a positive attitude and "[catching] myself and not let myself feel pity or let my bad attitude bring me down," and two others discussed setting smaller or realistic goals for themselves to "to work my way up." When unprompted, students hardly mentioned focus, organizational, or self-care strategies at all, indicating that they are not likely to tie such strategies to outcomes they care about (such as exam grades).

Differences in Self-awareness Between the Groups. Overall, GEAR students had higher frequency and quality of self-aware acknowledgements and connections regarding themselves as learners. GEAR students were more likely to consciously acknowledge successes in areas where they felt that their math ability or motivation had improved, oftentimes even in the face of an undesirable outcome, such as the student who noted in their post-MSLQ response, "...this semester although my grade isn't an A I learned so much better" or the student who mentioned in their final reflective journal entry that, "Even though I did not do so good this semester, that is not going to stop me from only growing and trying to do better for next semester." The GEAR intervention encouraged a self-reflective nature through both regular class conversations and the weekly journal entries, which may have supported development of students' self-awareness. In the RC group there were fewer self-aware acknowledgements, and of the few statements made, they tended to be more recognitions of apprehension (such as lacking confidence, "getting anxious over the exams", or "[finding] one on one tutoring overwhelming") than of improvement or motivation.

GEAR students made more cause and effect connections in the data collected pre-intervention than RC students. However, in the data collected during and post-intervention, RC students actually made *fewer* learning connections than before (~3% decrease per participant entry) whereas GEAR students made even *more* connections (about an 80% increase per participant entry). So the GEAR group saw a marked increase in the number of cause and effect learning connections made—thus demonstrating an awareness or appreciation of how their own behaviors and strategies affected their course outcomes and learning. The most common connection made by both groups was the belief that time and effort resulted in improvement or desired results, though this connection was made three times as frequently by GEAR students than by those in the RC group, such as the GEAR student who noted in the post-survey that, “after taking this class I learned that I have the ability to strengthen my math skills as long as I apply myself.” Furthermore, these positive connections often appeared in the exam reflections of GEAR students but not those in the RC group, indicating that GEAR students were perhaps more likely to make internal attributions to disappointing feedback, thus believing that they could control their future ability to improve.

During her reflective interview, one GEAR student made a particularly astute chain of connections regarding her procrastination:

> I think my classes were pretty manageable, like the amount of work. So I think I started slacking, so I was like, 'Oh, this isn't that bad. This is so easy. I don't have to study.' So then I wouldn't. And then [my work] would all pile on, and then I wouldn't have time to effectively do my work and it would just be rushed.

Although most students admit to procrastination and will even acknowledge it is a problem for them, this student was the only one across either group who made connections regarding both why they procrastinated (overconfidence) and why it became an issue (limiting the effectiveness of their learning).

Thus, students who participated in the GEAR intervention made more self-aware acknowledgements and connections of both greater variety and higher quality than students who did not. This suggests that the GEAR intervention did improve students' overall reflective abilities about their habits and thinking, a critical element in self-evaluating, making internal causal attributions, and reacting with adaptive inferences.

Differences in Content Strategies. Across both groups, help strategies were the most commonly mentioned learning strategy, although RC students were slightly more likely to mention such strategies than GEAR students (27 to 21 mentions, respectively). Specifically, attending one of NVC's math labs for tutoring was the most commonly specified learning strategy among both groups, at roughly the same frequency. Students in the RC group were more likely to turn to videos (such as class recordings or examples posted on YouTube or Khan Academy). While several GEAR students also mentioned online videos, they were more likely to specifically mention, "asking for help in other places, with you and other students" or "asking questions during class". Additionally, though discussed significantly less than solo help strategies, several GEAR participants talked about going to lab with a friend or study group ("I would recommend visiting lab with your math group! I find that working on problems with my group in lab has made the experience more beneficial."), and one even mentioned that he has been tutoring his younger brothers. In comparison, only one RC student mentions any sort of collaborative effort, a brief and somewhat vague, "Also discussing with a classmate." Although the GEAR intervention does not focus on socially regulated learning, it does address collaboration, and it appears as though at least some GEAR participants used this strategy. See Table 6 for a summarized breakdown of the content learning strategies mentioned by RC compared to GEAR participants, broken down by subcategory.

Active strategies were the second most commonly mentioned content strategies for the RC group, and the RC group talked about more active strategies as a whole than the GEAR group (14 active strategies mentioned by RC participants compared with 5 by GEAR participants). The most discussed active strategy was some form of, "I just tried to practice what we learned and do all the assignments." Working problems came up over and over again in the RC group, second in overall learning strategies only to attending math lab. This was the only active strategy also mentioned by several GEAR students, though at a much lower rate.

GEAR students were much more likely to discuss the use of metacognitive learning strategies. Only one RC participant, a student who earned an A in the course, mentioned a metacognitive learning strategy, "…compare and contrast [other people's methods] and to see what I like or what I like more." By contrast, a dozen different GEAR students discussed using metacognitive strategies ranging from (in order of decreasing frequency): teaching the material, retrieval practice, self-assessment, strategy adjustment, checking that your answer or solutions make sense, setting a goal for your study session, and comparing/contrasting different methods. Behind help strategies, metacognitive strategies were the second most commonly mentioned learning strategies by GEAR participants. The GEAR intervention explicitly addressed all of the metacognitive strategies mentioned by GEAR participants, indicating that students used the information we discussed during class meetings.

Table 6

Content strategies listed by RC and GEAR participants, organized by frequency of mentions (highest to lowest) within each subcategory

	RC	GEAR
Help	Math lab, tutoring, online videos, class videos, extra help (general), help (instructor), instructor feedback	Math lab, tutoring, online videos, asking questions, class videos, extra help (general), help (instructor), instructor feedback
Collaboration	Discuss with a classmate	Study group, tutoring others
Passive	Rewriting notes, reading over notes, highlighting, taking notes	None
Active	Practice (homework or additional problems), create an overview of material, answering questions, relating math notes, correcting mistakes based on feedback	Practice (homework or additional problems)
Metacognitive	Compare and contrast methods of solving	Teach the material, retrieval practice, self-assessment, strategy adjustments, make sense of answer/solution, set a goal for a study session, compare and contrast methods of solving

Passive learning strategies were the third most commonly listed content strategies for the RC group (6 mentions), centering on class notes - either taking, reading over, rewriting, or highlighting. Interestingly, none of the GEAR students mentioned a passive strategy in their open-ended MSLQ response, and the only passive strategy discussed by a GEAR participant occurred during one student's interview when he mentioned that he liked the exam study guides I provided but wished I had also given them step-by-step solutions for when he got stuck on a problem, a passive approach to getting himself unstuck. However, he then goes on to say:

> …but of course, I would go look at other problems, [and] then that's why there's a math lab, so that kind of helps out too… I'm pretty sure that's why [you didn't provide full solutions], which worked cause I would go there.

So, although this was a wish for passivity, in actuality the student ended up using more active strategies (which he also realized was likely my intention). This indicates that students in the GEAR group were less likely to turn to passive learning strategies post-intervention.

Regarding vague wording around strategy mentions, I noticed that many strategies I coded as "ambiguous" were likely actually passive strategies, but the wording used by the student left it too vague to tell. "Study over my notes" was just specific enough (using notes) to avoid the "imprecise" code, but "study" could mean just look over (passive), re-attempt class examples (active), or even attempt to self-assess (metacognitive). RC participants had a slightly higher tendency to mention an ambiguous strategy (12 for RC group compared to 8 from GEAR students). On that note, by far the most vaguely imprecise strategy mentioned was some sort of version of "study" or "study more". Both groups used it roughly equally, but GEAR students were more likely to add a qualifying detail, such as "study for an hour and set a goal for myself of what I'm trying to achieve and learn" or "I had studied already...[by working practice problems]". Across both groups, the students who were the most imprecise in describing their learning strategies also did not pass the class.

It is unsurprising that most common learning strategies mentioned by either group were help strategies, first math lab tutoring then watching videos, because the corequisite College Algebra class at NVC has a required math lab component for the course. And the nature of the remote classroom environment means students are more habituated to receiving content information via the internet, so they turn to online videos, including recordings of our class, frequently as well.

However, beyond the planning and use of help strategies, qualitative differences between the two groups emerged. Students in the RC group were more likely to mention passive (or ambiguously passive) strategies, and the primary active strategy they talked about was working on our homework problems, which is a beneficial part of the learning process but not particularly self-regulating. On the other hand, numerous GEAR participants mentioned a wide variety of more self-regulatory, metacognitive learning strategies such as self-instruction and retrieval practice, two strategies we explicitly discussed. So, although not employed by every member of the GEAR group, the intervention provided many students a larger toolbox of self-regulating learning strategies from which to draw.

In addition to RC participants mentioning more content-based learning strategies than GEAR students, when parsing mentions between “planning” versus actual “use”, RC participants also had a higher use to planning ratio (49 used to 11 planning for the RC group, 33 to 16 for the GEAR group). That is to say, more of their content strategy mentions were in the past tense, "I did use this strategy..." rather than simply "I plan to use this strategy..." This suggests that RC participants were perhaps better at following through on plans to actually implement their content learning strategies but could also have been related to the weekly journal entries I asked GEAR students to submit, in which they were continually self-assessing and adjusting strategy plans.

Self-aware Strategy Adjustments. Although a few students adjusted their strategies dealing with focus, time management, or motivation, on the whole, students across both groups tended to focus on content over control strategies. Students in the GEAR group made more learning strategy adjustments across every subcategory (listed with no reason, a personal reason, or a learning connection) than students in the RC group, over 50% more adjustments (33 to 50) in total. Additionally, both the adjustments and underlying reasons given by students in the GEAR group tended to be more varied and more metacognitive in nature.

Nearly half of the adjustments mentioned by students in the RC group came with no explanation for why they used that strategy, compared with less than 40% of the adjustments mentioned by students in the GEAR group. For RC participants, the most common adjustment given with no reason by far was some form of a help strategy such as simply stating, "One on one tutoring, math lab" or "Look up other people who have done it on YouTube." GEAR students also mentioned help strategy adjustments without including a self-aware reason for those adjustments, but they also listed metacognitive strategies such as, "try to critically think, rather than fall back on my notes immediately," and "I tried to teach it to the wall a few times."

The most common personal reason (with similar frequency) across both groups for a strategy adjustment was because they found it helpful, in the manner of the GEAR student who stated, "I plan on sticking to [going to the lab and asking questions] because they really seem to be helping and I can tell a difference when I am doing my homework and on the exam as well." Beyond this, the reasons varied quite a bit both across and within the groups. Two students mentioned time management related reasons, such as the RC student who noted, "I would also complete assignments much sooner way before the deadline, so there's more pride in doing the work correctly and on time," and the GEAR student who decided to, "…[look] at my time everyday and [see] if there's a pattern of when I have free time and if I see a pattern I can turn that free time into math time!".

The additional personal reasons for strategy adjustments provided by RC students included: a classmate's recommendation, "to complete the full [lab minutes] requirement", and "[one-on-one tutoring is] more engaging and convenient". Whereas the additional personal reasons provided by GEAR students seemed to dig a little deeper into the actual learning process: "because I didn't want to just pass, I wanted to learn this stuff", getting themselves unstuck on a problem, "[pretend teaching a class is]…actually a really fun process and it makes doing my homework more enjoyable", fixing a mistake they kept making, and motivating themselves. Additionally, nearly half (four out of nine) of the personal reasons listed by the RC group came from a single set of journal entries by a student who did fairly well in the class, while the GEAR reasons were more spread out across a wider variety of students.

Perhaps one of the greatest indications of self-regulated learning is making an adjustment to one's learning strategies for an overt, learning connected reason. Students in GEAR groups discussed more than double (15 in the GEAR group as compared to 7 in the RC group) the number of strategy adjustments while also making an explicit underlying connection to how that strategy would benefit their learning. The most common connection made across both groups was that the adjustment mentioned helped them to more fully or better understand the course material, such as the GEAR participant who noted in her post-intervention MSLQ survey, "I also go [to the math lab] with a friend and sometimes we teach each other when we don't understand something and it makes have to understand the concept fully." Several GEAR students also discussed how the use of the math labs or watching videos would help them "…make sure things are fresh in my head."

Multiple metacognitive strategies and reasoning showed up in GEAR students' adjustment data as well, from retrieval practice ("Oh! Also, try to keep working on my homework first without using my notes so I can get myself ready for the next exam where there won't be any notes to look at if I get stuck") to self-awareness of the strategy adjustment process itself ("I need to look at my habits and see which ones have and haven't been working for me. ...it seems I need to revisit my drawing board and come up with a better plan to make sure I study and prepare.") One GEAR student revealed a great example of self-regulated learning by noting in their post-MSLQ survey:

> A strategy that I have been using now that finals week is around the corner is taking the amount of sections we learned through this whole semester, and spreading them out through seven days. Each day I go through around two to three sections and picking problems out of each to test my skill.

Not only did this student make valuable use of a time-management strategy, but they also demonstrated clear awareness that they were self-evaluating themselves ("to test my skill") in the days leading up to our final exam.

From the number, variety, and quality of self-aware strategy adjustments discussed by students in the GEAR group compared to students in the RC group, it seems as though GEAR students were better than RC students at strategic planning and self-experimentation over the course of the semester. Students in the GEAR intervention more frequently reached for strategy adjustments and were also more likely to be cognizant of the reason(s) they were making the adjustment.

Intervention Weakness. Qualitatively, it seemed as though the participants who were most similar regarding learning strategy usage between the two groups were the students who started the class the least prepared for College Algebra material. There were similarities between these students across regarding imprecise strategy planning or usage and a lack of self-awareness, especially poor strategic planning. Ben (pseudonyms used throughout), one of the GEAR students I interviewed after the semester concluded, as well as Megan and Nora, two RC students whose journal entries I analyzed, had three of the lowest scores on the initial Exam 1 and spoke in very similar ways about learning math and their experience in the class.

Across both groups, the students who were the most imprecise in describing the learning strategies they planned for or used were the students who struggled to pass the class, such as Megan who planned to "study…for a longer period of time" or "manage my stress better." However, this was particularly noticeable in my interview with Ben who referred to "trying to get better" or "[trying to] remember what strategies to use, how to do this problem, how to do that problem. That's about it. That's about everything I do." When pressed to give some specific examples of what he meant by "strategies", he responded:

> Basically, to just be in my room, everything away, my phone, everything. Start thinking how to break down the steps in this problem, how to…I don't know. I just like…in a quiet place…where I can concentrate.

While he mentioned some good focus strategies here, such as studying in a quiet place and putting away distractions, it was concerning that a student who clearly wrestled with the content of the course could not describe any specific content learning strategies.

This demonstration of poor strategic planning was the most common trait of lack of self-awareness displayed among both groups. One RC student wrote in their open-ended pre-ITIS response that "...no matter how much tutoring I get nothing really helps," but then the only learning strategy they listed in their post-MSLQ response was, "Going to tutoring." Most (just over half) of the "lack of" codes in the GEAR group came from Ben, suggesting to me that despite turning in weekly journal entries in which I asked students to practice reflection, he remained oblivious regarding self-regulation. In addition to poor strategic planning, he also contradicted himself frequently ("I learned a lot. It was, I don't know, it was kind of hard for me.") and waited until the morning of a test to study because of a self-handicapping belief that, "…if I study the day before, I don't remember anything". The two biggest contributors to the RC group's "lack of" frequency (though not half) were Megan and Nora, who made statements such as, "I always try my best and sometimes I do well" and "Hopefully if I keep [studying a little every day] I'll do good on the last test and the final." All three gave the impression that their outcomes in math class are inexplicable, rather than something under their conscious control.

In the reflexivity journal I kept, I wondered throughout the semester whether the GEAR intervention might be helping students who were already better prepared for the course and if it was less able to reach students with weaker math and student skills, the very students who need the most help. Having analyzed the results, I suspect this to be the case. For students who already had either a bit of history of success in math or started with some study skills, the GEAR intervention seems to have helped to improve their self-regulation abilities. But for students who entered the class without such histories, I observed little if any improvement. This suggests that the intervention may be helpful for students who meet a certain baseline of content or study skills, improving them further. However, perhaps more consideration is needed toward different interventive designs or measures to support those arrive with fewer of these skills.

Pre-intervention Mindset Beliefs. In pre-intervention qualitative data, students in the GEAR group made more explicit statements of both growth and fixed beliefs than students in the RC group, sometimes the same student expressing both simultaneously such as, "Math has always been a difficult subject for me to excel in, I know I can learn math but I have to learn it at my own pace and need someone who is patient when working with me," which alternatingly implies a belief in fixed innate ability, then an incremental feeling they can improve but under an externally controlled circumstances (class pace and the teacher).

Of the incremental beliefs expressed by students in the RC group, the two most commonly expressed (with roughly the same frequency) were generic statements about mathematical ability ("I believe that everyone, no matter their skill level, can always improve their intelligence") and the belief they could improve with hard work and practice ("I feel like I am capable of self growth with math as long as I put effort and time into all my work like I know I will and can.") These were also the most common beliefs expressed by GEAR students, but GEAR students were more likely to specify they could improve through effort than to make a generic incremental statement. Multiple GEAR students also expressed belief in the importance of determination, ("I do believe that if I set my mind to become better at math I will"), willingness to ask for help, and motivation ("It is just like any other where as long as you ...care even a little about you will eventual excel").

The most common fixed belief expressed across both groups was the necessary condition that one's ability to improve in math depends on the teacher. As one RC student put it, "...but overtime [sic] I've noticed that with certain teachers it has improved when they understand the material enough to explain it clearly." Similarly, a GEAR student stated, "I believe that if a person improves at math or grows to love math, it's because they had a great teacher." Both groups also had multiple students who attributed ability in math to luck or innate ability, and both groups had couple of students who made more generic fixed statements along the lines of, ‘It doesn't matter what I do, I'm still bad at math.' Thus, although I observed slightly more variation among GEAR participants’ initial incremental statements, overall the two groups seemed to start in a similar place regarding mindset beliefs.

Regarding pre-intervention expressions of negative or positive self-reactions or previous math experiences, participants’ responses across both groups told very similar stories. Roughly 40% of respondents in both groups explicitly expressed some version of “I’m not good at math,” and a few others described previous negative experiences or struggles with math or a lack of confidence with the subject matter. Very few participants in either group voiced positive self-reactions prior to the intervention. A couple students in both groups discussed a turnaround in a previous math class leading to more positive feelings or confidence, such as the GEAR student who admitted, “I always thought that I was just stupid when it came to math. … [but] I took a math course last semester and I realized that I'm not stupid.” One student from each group described a time when they suddenly but inexplicably understood the subject, which is a positive reaction but demonstrates a fixed mindset. And one GEAR student outright says, "I love math", which was the only such expression of affinity across the entire population.

Post-intervention Apprehension and Motivation. During the semester and at its conclusion, both groups expressed apprehension at roughly the same rate, though for varying reasons. RC students expressed concern over the time it had been since taking their last math class, the pace of the class, the remote learning environment, test anxiety, finding "one-on-one tutoring overwhelming", and just “dreading” math in general. Just over half of the apprehensive mentions in the RC group were from two students who both barely passed the course. GEAR students also expressed concern over time since their last math class and the online environment as well as uncertainty about their grades (“I've always had to worry about my math grades”), nervousness over asking questions, and a diagnosed anxiety disorder. On a positive note, one GEAR participant told me that while, “…the word ‘quiz’, that would have made me panic a little bit more” because “it feels like it's more, ‘you gotta do really good on this’,” the term we used (learning check) made him feel more comfortable and he “learned a lot.”

The attention paid to grades as opposed to learning was a common theme. Both groups appeared to be most strongly motivated by grades. Such motivation ranged from, “Ideally, I would like to get an A” to “I've struggled with a few of my quizzes and one major test that left me on a ledge for my grade,” and everything in between. The second most common motivation mentioned by both groups was learning- or improvement-oriented, such as the GEAR student who noted in their post-MSLQ response, “this semester although my grade isn't an A, I learned so much better.” Overall, mentions of grade-related motivations outnumbered learning orientations by nearly a two-to-one margin in both groups. But half of the GEAR participants mixed the two. One great example of this was demonstrated during an interview with a GEAR student who stated early in the interview that, “although I didn't get the grade that I was hoping for, I passed. And I didn't barely pass, I think I passed pretty, pretty good,” but later when discussing her motivation for studying for an exam explained, “…because I didn't want to just pass. I wanted to learn this stuff.”

Post-intervention Fixed and Negative Self-beliefs. Post-intervention, across both groups, multiple students still expressed a general belief that math was either something you could or could not do (“Math is sometimes an impossible subject for some individuals, as for some it is easy”), though fewer students in the GEAR group exhibited this belief than in the RC group (five and eight, respectively). Several students in the RC group also talked about environmental circumstances (such as 2020 events or remote learning) as influential factors in our class. Overall, the number of students in the RC expressing general or specific fixed circumstances as necessary for learning math successfully rose from five pre-intervention to nine post-intervention, whereas in the

GEAR group this number dropped across the semester from eleven to seven. So, even though post-intervention SOITIS composite scores fell across both groups, the GEAR intervention appeared to mitigate an increase in fixed beliefs specific to external locus of control. Interestingly, the number of students attributing success (or failure) to the class or teacher dropped in both groups, with two RC students and only one GEAR student mentioning this as a factor in their course outcomes, and this drop was not due to attrition. All of the students who mentioned class or teacher circumstances as prerequisites for success completed the course.

Negative self-doubt statements (along the lines of "I'm just not very good at math") went down across both groups from pre- to post-intervention at about the same rate (RC group 13 to 9; GEAR group 13 to 10), again the drop not due to attrition as all students making the initial self-doubt comments remained in the course. But the GEAR students tended to mix their negative self-beliefs with positive ones, often in the same sentence or statement. Such as the following, from a GEAR student, “I have seen improvement when I put in time and effort, but I still can't master the subject.” Or the following from another GEAR student, who expressed self-doubt, yet paired this with motivation to strategize around study habits:

> But even though I am applying myself as hard as I think I am, apparently I am not judging from this past exam. I need to look at my habits and see which ones have and haven't been working for me. Math in general has always been a struggle for me so it seems I need to revisit my drawing board and come up with a better plan to make sure I study and prepare myself to pass my next exam.

Post-intervention Incremental and Positive Self-beliefs. Across both groups, the number of students who discussed general or specific incremental beliefs fell from pre- to post-intervention. The most common incremental belief expressed across both groups was still the belief that with effort and practice they could improve, though GEAR students expressed this sentiment more frequently, just as they did in the pre-intervention data. Multiple GEAR students again indicated that sheer determination plays a role ("Anyone and everyone can learn anything as long as they have the dedication and mindset to learn it"), whereas this was a factor for only one RC student. A few students across both groups made general statements such as the GEAR student who exclaimed, "Anyone had the ability to change anything!" and the RC student who said, "I can always improve on the way I learn about a specific subject." And two students in both groups mentioned needing to find your best way or method to study, like the GEAR student who stated in their post-SOTIS response, "Everyone learns different methods and once they find their method most efficient, its possible to improve" and the RC student who said, "I feel there's always a way to learn or relearn something and it may be a better and/or easier than you first learned."

GEAR students were more likely to mention multiple internally controlled conditions that would aid improvement of their mathematical ability, so their reasons were more varied and far reaching than those of the students in the RC group. Additional incremental beliefs discussed by GEAR students included having the right mindset or attitude, finding your motivation, heeding self-care, taking effective notes, and paying attention. It was particularly rewarding to read statements from GEAR students who referenced our class specifically as a turning point, "I have never been very good at math but after taking this class I learned that I have the ability to strengthen my math skills as long as I apply myself," or a learning moment, "...being in this class has taught me about my strengths and weaknesses when it comes to learning math and understanding it."

In fact, such positive self-reaction statements were possibly the biggest observable difference between the two groups regarding growth mindset. Students in the GEAR group exhibited over twice the number of positive self-reactions than students in the RC group (36 to 16). While several students in both groups responded positively to a specific learning strategy they were using and expressed more general sentiments of improving in the course, being proud of themselves, or having more confidence in math, nearly twice the number of GEAR students expressed such feelings than RC students.

Perhaps the most striking difference between the groups had to do with response to a perceived setback. I observed this in a couple of students in the RC group such as the student who decided, "Though I do receive grades that are not exactly what I wanted I don't let that set me back, but rather I let it push me to do better and study harder." However, I saw this expressed over and over again among GEAR participants. Students consistently took both less than ideal exam and semester results and responded in positive ways indicative of growth mindset. Responses such as, "Honestly I am disappointed with myself but I won't let it stop me from applying myself more on the next exam," popped up after disappointing exam results and positive takeaways from the semester were mentioned by multiple students who passed ("I feel proud in how well I've done throughout the semester. I may or may not end up with an A in this class after the final, but ultimately I know I did the best I could when I could") and students who did not ("Even though I did not do so good this semester, that is not going to stop me from only growing and trying to do better for next semester"). This agrees with existing research suggesting that the condition of experiencing setback might be necessary to see the full impact of a mindset intervention (Aditomo, 2015; Burnette et al., 2018; Corradi et al., 2019).

Overall, several similarities related to mindsets existed between students in the two groups. They expressed apprehension and grade-based goal orientations at comparable rates, and both self-doubt and general incremental belief statements fell from pre- to post-intervention. But the two groups differed in a few important ways. While the number of fixed statements made by RC students doubled (11 to 22) from pre- to post-intervention, the same types of comments in the GEAR group fell slightly (16 to 10, pre- to post). The growth mindset declarations offered by GEAR students demonstrated a wider variety of underlying incremental beliefs, and GEAR students tended to exhibit positive self-reactions to disappointing outcomes at a much higher rate than students in the RC group.

Room for Improvement

Once face-to-face classes are no longer restricted by the pandemic, I plan to incorporate structured corrections assignments similar the one used by Zimmerman et al. (2011). I used a modified version of their quiz corrections form during my earlier action research cycles, but when we moved to an online/remote environment, turning in paper and pencil assignments became much more complicated. Thus, I removed the quiz corrections form from the GEAR intervention because I worried about overwhelming students. However, asking students to correct and reflect based on formative feedback gives them additional opportunities to demonstrate mastery learning and also aids in students' self-judgment capabilities (Montague et al., 2014; Zimmerman et al., 2011).

Additionally, I plan to include additional conversations regarding control strategies, especially those centered on focus and time management. Students regularly admit to distraction and procrastination but much less regularly discuss any specific strategies to improve in these areas; I can also adjust my class discussion and student journal prompts to encourage students to consider such control strategies as they make their course adjustments. Another improvement I may make to the GEAR prompts involves more focus on learning outcomes and less of grades. As a simple example, I can change the very first question I ask on the Exam 1 reflection from, "Did you meet your grade goal?" to "Did you meet your learning goal?" Since establishing process rather than outcome goals is a key component of successful SRL (Cleary et al., 2008; Cleary et al., 2017; Locke et al., 1981; Schunk, 1985), I hope to model the type of goal setting that will help students become better self-regulators.

RQ3: How do students' perceptions of themselves as mathematical learners change during implementation of GEAR?

I collected and analyzed both quantitative and qualitative data to address RQ3. Quantitative data consisted of the responses to the same questionnaire on incremental and entity beliefs discussed for RQ2. Qualitative data included the open-ended responses on both of the survey instruments and four reflective interviews with GEAR students. Qualitative data also included the full slate of journal entries of the four GEAR students I sampled for RQ2. I first present basic quantitative results regarding the overall arc of students' self-perception and then delve comprehensively into the qualitative results.

Population and organization of results

Between the two sections that received the GEAR intervention, I had 30 students with pre- and post-intervention responses to the SOITIS survey and one other with no post-intervention response but who I interviewed after our class was completed. I also interviewed three other GEAR students (who had both pre- and post-intervention SOITIS responses) as well as coded the full journal entries from four others. I put all data pertaining to students' perceptions of themselves as mathematical learners into a spreadsheet and based off of their pre- and post-SOITIS growth mindset composites scores, pre- and post-SOTIS open-ended responses, interviews, and journal entries, determined which students' self-perceptions improved over the semester, worsened, or stayed fairly consistent. Ten students displayed a positive shift in their self-perception regarding learning math, four students became more negative over the course of the semester, and fourteen stayed more or less consistent in their sensitivities.

Increased Positive Self-perceptions. Of the ten students who came to view themselves as more capable mathematical learners, six students earned an A or B in the course while four earned a C or D, which was slightly but pleasantly surprising as this indicates that positive progress in their self-beliefs was not predicated solely on course grades. However, the one student who moved from an outright negative perception of themselves ("Math has never been my strong subject even from a young age. I've always struggled") to a more positive view did state that they based their "reasoning …off my experiences with math [this] semester and how well I did in comparison to semesters before." In contrast, another student whose growth mindset composite actually fell from the maximum of 56 pre-intervention to a 43 post-intervention stated in their post-intervention survey that “The last time I took a math course it ended in a bomb fire, this semester although my grade isn't an A I learned so much better,” indicating not only a focus shift from grades to learning but that they believe themselves to be a better learner now, even though they scored themselves lower on the SOITIS scale. However, these two students were outliers to some degree among the students who expressed an increased positive self-perception. Most moved from a mixed to positive view of themselves and the two common themes that came up were shifting from an external to internal locus of control and an increase in confidence.

Multiple students demonstrated a shift over the course of semester from viewing learning math as a byproduct of something out of their control to something that was under their influence. One student initially felt the subject matter itself determined their success noting in their pre-SOITIS comments, “I have been both great and weak at math based on the formulas or problems.” But at the end of the semester credited improvement to, “practice and studying…and [finding your] method.” Another initially said, “I believe some people have better qualities for math but with training everyone can get better,” which turned into, “Practice makes perfect,” landing on an incremental condition (practice) rather than innate ability and teaching. This shift from teacher-centered views to greater personal ability was also evident in two of the journal entries I coded.

Maria, an FTIC student who earned an A in the class, partly credited learning successes in prior experiences to a teacher-driven approach admitting, “I felt more prepared when my teachers provided me with a study guide.” However, early in the GEAR intervention she started to shift more responsibility of learning to herself when she commented on an article that we had read, “the most important insight I gained would have to be the recognition that learning and the ability to retain information is much more dependent on the student themselves" and went on to realize that the previous all-nighters she pulled might not have been the best way to learn, "it makes me wonder how much better I would have performed if I gave myself more time to learn material beforehand." For the rest of the semester, Maria demonstrated a very high locus of internal control, trying new metacognitive learning strategies such as retrieval practice and tying it to her class successes. She even recommended to others that if they were struggling with something to pause and "[reflect] on what it is you don't understand and [take] the time to see what you could do differently. As long as you continue to put in effort, you will eventually get your desired outcome."

In another set of journal entries Jenna, also an FTIC student but who earned a D in the class, started the course by mixing incremental beliefs ("One can always expand knowledge and can learn more about the subject") with past negativity towards math and her high school experience. When she wrote, "…none of my teachers would be interactive so every time I would sit in class, I felt as I wasn't learning anything" she revealed a perception that learning is something that happens *to* her rather than *by* her. Her perception of a student's responsibility towards learning starts to shift in her learning article post and continues throughout the semester. She continually demonstrated willingness to adjust her learning strategies and consistently recognized that "in order to [improve my exam scores], I need to put in the extra work."

A second common refrain that showed up was an increase in confidence as mathematical learners. Several students who started the class optimistic but uncertain ended the semester more self-assured, such as the student who said in their post-SOITIS survey, “I have never been very good at math but after taking this class I learned that I have the ability to strengthen my math skills as long as I apply myself.” One of the students who scored herself the maximum points possible on the growth mindset composite at the start of the class revealed in her reflective interview that in her previous math class, “I just really did not care. I did not put in the effort. So yeah, I really didn't learn anything in the past.” So even though she believed in theory that she could be successful if she exerted herself, this belief was tentative and she was not sure of herself, “I never put in the effort before. So, in my head it was still kind of, can I do it? Can I not do it?” Additionally, she was “extremely nervous” about our class, her most recent math experience being years ago (a class she failed at NVC) on top of being in a remote learning environment. But after she employed new learning strategies and saw results, ultimately earning an A in the course, her self-doubt and nervousness were gone. She felt “really good” about her relationship with math, mentioning, “the concepts we learned they stuck. … I just found myself absorbing the material a lot easier”, and she was more personally convinced that if “you put in the effort you will get it.”

This move from tentative optimism to a fuller confidence was also reflected in Maria’s journal entries. Pre-intervention, she expressed some mixed beliefs stating, “I believe I have the capability to learn more and increase my intelligence on the subject,” but also conceding she did not feel knowledgeable on the subject. She also revealed a past tendency towards a fixed mindset. In her admission, “I felt [math] was difficult for me to retain the material being taught and if I didn’t understand it I felt hopeless. In my experience, I have noticed I like math when I feel that I can do it.” She essentially noted that she liked math when it came easily to her but gave up when it did not. So, she lacked confidence whenever she hit struggle. After exam 2 she was still expressing a lack of full confidence when she admitted in her exam reflection post, “I knew I wanted to do my best, but I kept my expectations low” and acknowledged that it can be “nerve racking [sic]” to ask questions. In the following exam reflection she divulged that initially she was apprehensive about returning to a math class after taking a long break from school.

However, a breakthrough occurred when I asked GEAR students to monitor and adjust their self-talk. She recognized the negative emotions she sometimes harbored towards math confessing, “I rarely form negative thoughts on myself…usually, if I say negative things it’s about the subject itself.” But then she took a reflective moment and realized, “Once I understand that my poor feelings for a subject are rooted in misunderstanding of it, I may be able to form a better relationship with the material.” From this point on, the confidence increase in her reflections became obvious. In the last exam reflection post she stated, “I can say that from the beginning of the class to now, I feel more confident in my math skills.” And although she maintained a relatively positive attitude throughout the class, by her final journal entry she held a confidence that she lacked at the beginning of the semester declaring, “I feel proud in how well I’ve done throughout the semester. I may or may not end up with an A in this class after the final, but ultimately I know I did the best I could when I could,” and she concluded by exclaiming, “This semester has been quite an experience, but it’s been good!” expressing appreciation for the challenge she rose to meet.

Decreased Positive Self-perceptions. Unfortunately, there were also four students whose self-perceptions as mathematical learners suffered over the course of the semester. Disappointingly but perhaps not surprisingly, three of the four did not pass the class and the fourth earned a solid C. Two of these students mixed in self-doubt tied to a perception of innate inability, stating early on that “I have always struggled with math ever since I was in Elementary school” and another, “I’m really not good at math.” However, all four initially expressed, to varying degrees, a belief that improving at math is possible. For example, the student who bemoaned their struggle since primary school ended their statement with, “But I know when I push myself I can be better and do so much better.” Unfortunately, the GEAR intervention did not inoculate these students to a negative self-reaction once they started earning less than desired grades.

Two of the four students did not answer the open-ended prompt at the end of the semester, so it is difficult to provide much of an analysis across the four students. The student whose pre- to post-growth mindset dropped the most, from the maximum score to nearly the minimum, missed a lot of class (and thus much of the intervention) due to personal health issues. Another student who started off the course with the very positive statement, “I believe not matter what as long as you put in effort you will like the outcome” ended the course on the much more despondent note, “I struggle a lot with math. Ever since middle school I always had to take extra help classes and I feel like I've received so much help that its hopeless for me to great at math.” However, she also demonstrated willingness to adjust her study habits, “The lab is really useful to me and I always go in before I have an exam …. I also go with a friend and sometimes we teach each other when we don't understand something,” which suggests that part of her believes she is able to improve.

One of the students who suffered a decrease in positive self-perception was Ben, the GEAR student I interviewed who found himself struggling with our course material and self-regulation. He expressed a general fixed mindset pre-intervention that was buffered by an optimism that he might improve, “I’m really not good at math, but I try to do new things to make myself better at it.” But by the end of the semester any trace of optimism was gone and he instead felt, “I’m not that good at math and it’s hard for me to understand the topics we talk about.” When I asked how he felt about himself and math now that our class was over, he started his answer by saying he felt as though “learned a lot.” However, from there his answer quickly turned into a jumbled display of self-doubt:

> It was, I don’t know, it was kind of hard for me. It was just a little hard just to try to work everything out, ‘cause [pause] I don't know how to like, what it's called, but how we did a test, the exams and everything where you have to it down and everything. Yeah, those are the real, real hard things for me to do. I was never good at those, but I mean it's [pause] it’s about the same now.

Additionally, he also felt as though his school schedule this semester contributed to his lack of focus. And he liked being in a group with students who had similar career interests, but felt “kind of unlucky about it because everyone in my group they didn’t want to really talk. And then I would ask something and try to learn it and they wouldn’t know it neither, so it was kind of hard to … try to learn it.” Statements like this indicate an external locus of control. Events both outside and inside the classroom felt beyond his power. Unfortunately, the GEAR intervention did not seem to help Ben with academic achievement or development of a growth mindset. This concurs with the prior supposition that students most helped by the intervention were those who started with some measure of content or study skills.

Consistently Positive Self-perceptions. Nine students maintained a consistently positive self-perception of their ability to learn mathematics throughout the semester. Though many (4 of 9) of these students ended up earning an A or a B in the course, three earned a C, and two did not pass. One of the students who did not pass had to deal with some personal issues towards the last third of the semester, but her pre- and post- SOITIS answers did not change, leaving her with the same growth mindset with which she started the class. The other student who did not pass but remained positive focused on improvement in both of their pre- and post-survey open-ended responses, declaring at the end of the semester, "I always believe that if you work hard on improvement, eventually you will see that improvement." Four others did not leave any open-ended responses on the post-survey, but of those who did leave both pre- and post- open-ended responses, one student's answers focused on learning ("Everyone can learn something knew as long as that said person is dedicated to learn") and another's on change ("Anyone had the ability to change anything!").

Additionally, I interviewed Sam, a second semester college student who had not yet taken a math class in college and earned a B in our class. I also coded the journal entries of Miguel, another second semester college student who earned an A in the developmental prerequisite course the summer before starting College Algebra, and earned a C in our class. While both men started the class with a positive outlook and maintained their positivity throughout our class, each of them also demonstrated a type of gain displayed by the students who improved their self-perceptions.

At the start of the semester Sam "felt pretty confident" due to recent experience and practice tutoring his younger brothers in their math classes. He thought he approached our class similarly to past math classes but noted he "[felt] it was a little bit different" because instead of focusing solely on a score or grade he used the feedback I offered on assignments and he "learned a lot… And [the feedback and subsequent learning] is what I really liked." Reflecting on his post-intervention feelings about math he stated that he, "…learned a lot of lessons throughout it, that I know that I could have done better. But still, I feel better than before."

Miguel began the semester with strong assertions about his ability to learn math although attributes some of his most recent success to the teacher he had:

> …now that I am older I want to study and learn more, I know I can become smarter than I am right now. The math teacher I had last semester was amazing. Thanks to him I learned a lot of new things.

He goes on in his autobiography post to credit this teacher with his understanding of a concept that he initially did not understand, "...but thankfully the teacher went out his way and showed me different examples and broke them down."

Miguel's subsequent shift to a stronger internal locus of control evidenced itself in two ways. First, he began noting across multiple journal entries the importance of challenging yourself and "learning more than what the teacher is demanding" because, as he later stated, "…our brain is a marvelous a thing when it comes to learning it expands, it retains knowledge, and it hurts when its been pushed to it limits and that's a good thing cause when things get tougher [your brain] is exercised well enough to over come any challenge." He picked up on this thread again when reviewing his learning strategies, reminding himself that challenge is good thing because "it makes my brain work different and better." Second was a demonstrable self-assurance in his strategy choice and usage.

He thought of and used interesting strategies that we did not expressly discuss in class (he called it the, “Have you worked on math today?” strategy), but he also in chose a strategy (ask ‘why, how, and what if’ questions) that most students did not try because it requires a certain of level of confidence with the material to use. In his final exam reflection post he discussed a couple of his specific strategies and how he they made him, “[feel] as if my brain understands it better and more thoroughly and it's helped me out so much!” So, while Miguel started the class with an optimistic view regarding learning mathematics, our class provided him an opportunity to use even more learning strategies and to gain confidence with those strategies.

Consistently Negative Self-perceptions. Two students started and ended the class with pessimistic feelings surrounding learning math. The first failed our class after earning low exam scores and skipping the final exam. He stated in his post-survey response, “Math has just always been hard for me. I could never pass or even just slide by even with tutoring I can't do it.” The second student’s data and perceptions were a bit confounding. His self-doubt was present from the start, “Personally math itself does not stick with me in the slightest and I severely struggle with maintaining a level head when either studying or directly learning math.” He went on to earn reasonably good grades and ended up with a B. However, his self-assessment at the end of the semester was just as grim, “As my past experiences in math have shown me. I can only go so far in math until I breakdown and forget everything.” While it is clear that the GEAR intervention did not facilitate either of these students improvement in their self-image regarding math, for the latter student even getting reasonably good grades did not help this.

Mixed Self-perceptions. The six students in this grouping tell a varied but interesting story. Rarely are people's views solely positive or solely negative but rather a blend of the two. These students tended to have lower grades than those who were consistently positive but higher than the students who felt very negatively about themselves—suggesting that a pattern persisted of associating grades with self-perceptions in math. Similar to students with more generally positive self-perceptions, a few shifted to having more an internal locus of control, but a few did not. They all had a mixed set of views regarding their ability to learn math.

Students with consistently mixed views tended to make statements that combined self-doubt and optimism, such as the student who started the semester at, "I have always struggled in math, but believe that I can improve with the correct training and teaching over time," and sixteen weeks later ended with, "I have always struggled in math. I have seen improvement when I put time and effort but I still can't master the subject." One student's pre-survey open-ended response indicated a strong belief in fixed ability, "I feel like Math is a subject that is either looked up on or down on. Depending on the person and their abilities determining their skills of math." However, unlike students who made similar pre-survey remarks but ended up believing personal effort made the difference, this student remained stuck on innate aptitude post-intervention, "Math is sometimes an impossible subject for some individuals, as for some it is easy." Another student did shift from teaching being the primary requisite for improvement, "I believe that if a person improves at math or grows to love math, it's because they had a great teacher" to self-responsibility for learning. But they hid it in a somewhat antagonistic post-survey statement, "I really try to understand it but if I don't, I give up. I have other things to do in my day rather then spend 4-5 hours trying to understand something…" While this is certainly a negative view, it does indicate that the student believes learning math is something that in theory they could do.

Jennifer was a student with nearly 60 hours of college credit who had taken and failed a developmental math class nearly 7 years ago before leaving college for awhile and returning during the summer of 2020, when she earned an A in the prerequisite class to College Algebra. She ended with a B in College Algebra. In her pre-intervention journal entries, she discussed her past self-doubt and admitted she "…did not put any effort into actually trying to learn what was being taught because I was so used to automatically assuming that I wasn't going to understand it." However, she juxtaposed this history with a newly found optimism discovered in the math class she just finished that "really opened my eyes to slowly finally understanding the complex language of math. I had never felt that way before!" Her journal entries from the first half of semester remained mostly positive, bolstering herself through optimism, effort, and control strategies. However, when she wrote a post giving advice to a hypothetical struggling student, some self-doubt and mixed messaging crept in as she said, "…some subjects are more comfortable than others… I know you may think you will never learn math but don't underestimate your mind and how it works!"

Her Exam 2 reflection is, in her words, where the "rollercoaster [of these past 11 weeks]" really became apparent in a single post. She was feeling positive about the class, "…being in this class has taught me about my strengths and weaknesses when it comes to learning math and understanding it," but also feeling badly about her most recent exam result, "But even though I am applying myself as hard as I think I am, apparently I am not judging from this past exam." Then, in a single sentence she made a both a defensive and an adaptive inference, one right after the other, "Math in general has always been a struggle for me so it seems I need to revisit my drawing board and come up with a better plan". Overall, she felt disappointed but rather than questioning her ability she instead primarily reacted to adapt, not avoid.

In her penultimate post for the semester, she recognized a loss of some her earlier positivity:

> One main thing that's happened to me lately is my positive attitude towards math. I suppose you could say I became a little discouraged when I didn't do so well on my second exam which kind of brought my demeanor and attitude down quite a bit…Rereading these journal entries has given me hope again that I was almost losing. I know things aren't going to be easy but that doesn't mean just because certain situations or things get hard I should give up because I know I can be successful and pass this class with a B.

So, by the end of the entry, she reconnected with her positivity and determination to put in the work "to finish the last few weeks strong and confident." Ultimately, she felt "successful for the most part in this class" even though "math isn't [my] greatest subject", but she ended by reinforcing her belief in keeping a positive attitude and making an effort to learn.

My interview with Claudia provides perhaps the best example that the growth versus fixed mindset dichotomy is actually not a simple dichotomy at all. Claudia was a second semester college student who had not taken any math classes since high school. She earned a C in our class. She expressed both positive and negative views of herself as a learner throughout the interview, epitomized by the discussion of her reaction to some low exam grades around mid-semester:

> I do think that in the beginning, I was very determined and motivated. And then there was I think, like a month where I think I took two tests and I failed them both. And so that really brought my motivation down, and I didn't really want to study and I would just like, 'Oh, I'm not good at it anyway, so I'm just going to fail.' But then, I think it was for exam three I got that motivation up again, and [laughingly] part of it was because if I didn't pass that I would fail the class. And I didn't want to do that, but then, working up to exam three I was really diligent with my homework. And then [pause] I was actually learning the material and asking for help in other places, with you and other students, because I didn't want to just pass, I wanted to learn this stuff. So there definitely was a little slump where I felt unmotivated, but I got myself together.

In this chain of events, she demonstrated a textbook defensive, handicapping reaction to failing an exam by blaming innate inability and then adopting an avoidance reaction. However, she was then also able to reconnect with her motivations to continue putting effort into the class, ultimately succeeding in passing. But her path was twisted, and she took multiple turns regarding her self-perception.

Prior to the intervention, she expressed a belief that she could improve, but the improvement was dependent on, "the correct training and teaching". Post-intervention she credited her improvement to "time and effort" and expressed that she was "proud of myself." Even though her pre- and post-intervention views were mixed, post-intervention she expressed a stronger internal locus of control, similar to other GEAR students who perhaps took a straighter road towards positivity. The story arcs of Jennifer and Claudia are very similar. They had initial feelings of determination and optimism, were tested by less-than-desired outcomes on exams, but ultimately arrived back at positivity and belief in hard work and effort.

Over the course of the GEAR intervention, a few students' perceptions of themselves as capable learners of math either declined or stayed negative throughout the semester, usually tied to grades they found disappointing. However, many students across varying course outcomes improved their self-perceptions as mathematical learners. Two important aspects of this improvement, which showed up consistently regardless of where the student started or ended their journey, were a shift from an external to more internal locus of control and an increased sense of self-confidence. And although Molden and Dweck (2006) claimed that people mostly hold either incremental or entity views within a domain, a third common theme was the blending of positive and negative self-views, indicating that the idea of having a growth versus fixed mindset towards math is perhaps not so clear cut.

Room for Improvement

This is a case when the timing of a particular piece of the intervention might make a difference. I had students complete the PERTS growth mindset modules very early in the intervention, during the second week before we had Exam 2. However, studies indicate that growth mindset interventions might make a stronger impact if students have experienced a setback (Aditomo, 2015; Burnette et al., 2018; Corradi et al., 2019). Therefore, I am going to move the PERTS growth mindset modules to the week after Exam 3, the first quadratics exam on which most students saw a sharp drop in their exam grade. This is when I noticed many previously positive students start to doubt themselves and exhibit potentially handicapping reactions, so it will be a better time to incorporate reminders of and instruction on growth mindset principles.

I would also like to add a class conversation and journal post on causal attributions. This is a topic I included during one of my earlier action research cycles but then cut for the final intervention. I think the topic would make a great companion to monitoring and adjusting one's self-talk, as I could start to train students to recognize defensive, external blame and substitute with controllable, internal attributions. Closely related to students' causal attributions is their goal orientation. Given the relationship I observed between students' self-perceptions and their exam grades, I think it might additionally help to shift my SRL instruction and journal prompts from including outcome-oriented, grades-centered language to more a process-orientated, learning-centered focus.

Correlations Across Academic and Survey Data

The qualitative data, which I collected multiple times throughout the semester, provided a more detailed picture of the ups and downs students experienced over the course of our class, as well as some of the nuance in their experiences related to the intervention and aspects of SRL that are more difficult to measure quantitatively. One such detail was the observation that often students' perceptions of themselves as learners seemed to be tied to their exam scores. Although my initial study design did not include the exploration of correlative relationships, it seemed appropriate to consider the relationship of relevant constructs and run a bivariate correlation between each of the pre- and post-intervention survey results as well as students' final exam scores. This gave me the opportunity to examine how students' pre-intervention composite scores were related to their post-intervention composite scores or their Exam 6 score and if such relationships differed at all between the two groups.

I had data on all five exams for 26 and 28 members of the RC and GEAR groups, respectively. I established linearity by a visual inspection of scatterplots. There were a few outliers among the relationships, such as the GEAR student who scored the maximum on the pre-intervention GM composite but nearly the minimum on the post-intervention and the RC student who scored very high on the pre-intervention MSL composite but had the lowest Exam 6 score. All MSL composite score variables and Exam 6 data were normally distributed, as determined by Shapiro-Wilk's test ($p > .05$), which is recommended for sample sizes smaller than 30. However, the pre-intervention GM composite of the RC group and the post-intervention GM composite of the GEAR group were not normally distributed ($p = .014$ and $p = .007$, respectively). Results for each group are presented below in Tables 7 and 8.

Table 7

GM, SRL, and Final Exam Score Correlations for the RC group (n = 26)

Variable	1	2	3	4
1. Pre-GM	-			
2. Pre-MSL	.320	-		
3. Post-GM	.680**	.170	-	
4. Post-MSL	.418*	.525**	.477**	-
5. Exam 6	.071	.129	.355	.069

Note: * indicates $p < .05$. ** indicates $p < .01$.

For participants in the RC group, both of their pre-intervention composite scores had statistically significant correlations to their corresponding post-intervention counterparts. This correlation was strong between GM counterparts ($r(24) = .680$, $p < .001$) and moderate between pre- and post-MSL scores ($r(24) = .525$, $p = .004$). RC students' post-MSL composite scores also had positive, moderate correlations to both pre- and post-GM composite scores, indicating a relationship between students' growth mindset and their self-reported metacognitive strategy usage at the end of the course.

Table 8

GM, SRL, and Final Exam Score Correlations for the GEAR group (n = 28)

Variable	1	2	3	4
1. Pre-GM	-			
2. Pre-MSL	.225	-		
3. Post-GM	.455*	.244	-	
4. Post-MSL	.230	.202	.618**	-
5. Exam 6	-.098	-.111	.298	.347

*Note: * indicates p < .05. ** indicates p < .01.*

For participants in the GEAR group their pre-intervention GM composite scores had a statistically significant, positive, moderate correlation to their corresponding post-intervention GM scores, ($r(26) = .455$, $p = .012$). However, unlike the RC group their pre- and post-MSL composite scores were not as clearly related. The only other relationship testing at significance was between their post-GM and post-MSL composite scores, a strong, positive correlation ($r(26) = .618$, $p < .001$).

There are several potentially interesting takeaways from the differences in these relationships between the two groups. First, in both groups their post-GM scores were significantly related to their pre-GM scores, possibly demonstrating the stability of growth mindset found by various researchers such as Li and Bates (2019), Orosz et al. (2017), and Schmidt et al (2017). However, while pre-GM composite scores accounted for nearly half (46%) of the variability in the post-GM scores of the RC group, they accounted for just over a fifth (21%) of the variability in the post-GM scores of the GEAR group. Additionally, while the pre- and post-MSL composite scores were moderately correlated in the RC group, the GEAR group lacked no such a significant relationship between the pre- and post-MSL scores. Taken together, these results suggest a possible uncoupling of post-mindset and metacognitive strategy usage from pre-results within the GEAR group, which did not occur in the RC group.

Second, in both groups post-GM scores were significantly related to their post-MSL scores, indicating a positive relationship between growth mindset and SRL task usage. This corroborates a substantial amount of research establishing a link between incremental views of intelligence and the use of positive academic strategies (Blackwell et al., 2007; Burnette et al., 2018; Corradi et al., 2019; Doron et al., 2009; Hong et al., 1999; Shively & Carey, 2013). However, this observed relationship was stronger within GEAR students, suggesting that students who expressed more incremental views of mathematical intelligence were more likely to use metacognitive learning strategies if they were in the GEAR intervention group.

Third, in neither group were pre-GM or pre-MSL composite scores significantly related to Exam 6 scores. However, in the RC group the moderate positive relationship between post-GM scores and Exam 6 approached significance, whereas in the GEAR group their post-MSL scores were most closely related to Exam 6 scores. This is an interesting result because it points to the possibility that students in the GEAR group were less likely to connect incremental views to their grades but more likely to connect the use of metacognitive strategies—suggesting that they were better able to see cause and effect in attributing their study behaviors to outcomes.

Discrepancy Between Results

Overall, the quantitative results initially showed very little, while the qualitative results suggested an alternative story. There are several potential reasons including elements of the study design and survey instruments.

My relatively small sample size affected the power of the statistical tests I ran, making it less likely that the quantitative results would test at statistical significance. But this does not mean the GEAR intervention did not have practical significance. The effect sizes found for academic achievement difference were small but all positive, indicating the GEAR intervention might have contributed to slightly higher exam scores. Practical significance also depends on context for interpretation, and qualitative data helps contribute to context. In addition to my small sample size, the quasi-experimental design I used out of necessity meant that participants were assigned as a pre-existing group to either the RC or GEAR treatments, rather than being assigned randomly as individuals. So, there could have been confounding factors inherent in the two sample populations.

A couple of data collection characteristics might have also contributed to the quantitative-qualitative discrepancies. First, due to natural student attrition I have less data on the students who dropped the class. Since these students are likely to be underprepared for the course they were possibly more or less likely to be impacted by the GEAR intervention, but I do not have post-intervention data for them. Second, I collected quantitative data on SRL and growth mindset only twice during the semester, but I collected qualitative data much more frequently. Thus, the quantitative data is not as sensitive as my qualitative data to the ups and downs of the semester or as finely tuned to students' experiences in between the before-and-after snapshots they provided.

Finally, survey instruments have limitations, both general and also specific to this study. Dignath et al. (2008) found SRL self-reported questionnaire responses to be unreliable. Along with a host of other researchers who found discrepancies between quantitative and qualitative results (e.g., Cleary et al., 2017; DiFrancesca et al., 2016; Zimmerman et al., 2011) they recommended collecting more data than self-reports alone, such as observations, interviews, or student journals, for exactly this reason.

Using empirical evidence, Porter (2011) questions the very validity of college student survey results. Students are likely to misunderstand vague language or interpret it differently from one another. When self-reporting routine behavior, students are also likely to misremember and instead choose their answers based off context clues and the social desirability of their responses. Porter (2011) also discusses research that suggests response accuracy is related to student ability, so that as student ability decreases so does response accuracy. Any of these factors would limit the validity of survey instruments, thus creating a potential incongruity between closed- and open-ended responses.

More specifically, it is possible that the survey instruments I chose for this study were inadequate at providing answers for my specific research questions. I used only one subconstruct of Pintrich's (1991) MSLQ, an instrument that contains over 80 items.

Furthermore, this subconstruct section asks about very specific metacognitive self-regulation tasks but at twelve items long is certainly not an exhaustive list. So, a student's SRL ability, even metacognitive task usage, might have improved in subtle but meaningful ways that could escape the notice of the MSLQ instrument I used.

Where the MSLQ survey might have been too specific, it is possible that the SOITS instrument was too broad. After noticing students with rosy growth mindset composite scores exhibit a much more mixed view of themselves in their qualitative responses, I realized that for some students an item such as, "With enough time and effort I think I could significantly improve my math intelligence level," could be measuring optimism instead of growth mindset. It is worth considering how certain survey questions could alternately measure more than one construct, perhaps picking up on something other than the intended construct.

Summary of Results

There were no statistically significant differences in the academic course performance of students between the RC and GEAR groups. However, with the exception of course pass rates all other academic achievement indicators (course completion and exam grades) were slightly higher for the GEAR group, and the lack of statistical significance could be due to a small sample size, a small effect size, confounding pre-existing differences between the group populations, or some combination of all three.

The quantitative survey data also detected no statistical significance between the two groups on measurement of SRL ability or growth mindset while the qualitative data suggested something different. Students in the GEAR group talked about a much wider variety of learning strategies in general, including more self-regulatory and metacognitive strategies, and they were also more likely to discuss a self-aware reason for use of those strategies. And although both groups comparably expressed apprehension and grade-based motivation at comparable rates, fixed mindset statements fell from pre- to post-intervention in the GEAR group while rising slightly among RC students. Furthermore, growth mindset beliefs expressed by GEAR students were more diverse and included more positive self-reactions than students in the RC group.

Perceptions among students in the GEAR group widely differed, but while a few students' either stayed or became more negative about themselves as mathematical learners, many of the GEAR participants improved their self-perceptions. These improvements were observed in primarily positively oriented students but also students who held more mixed views of themselves and seemed largely driven by a combination of shifting to greater control over their own learning and gaining more confidence in themselves as learners of mathematics.

Although the quantitative results did not appear to be statistically significant, I am encouraged that that qualitative results indicated that GEAR students ended up with a greater exposure to SRL learning strategies, an higher awareness of self-regulation overall, and more positive views of themselves as mathematical learners. In the final chapter, I will discuss the results of this study in context of the existing literature on SRL and GM interventions. In doing so, I am led to explore the implications for further development of the GEAR intervention, future research topics, and improvements to my own practice.

Chapter 5

In Chapter 5, I synthesize the findings of this study and discuss the implications of results presented in the previous chapter. The structure of developmental education is changing, with more students who are underprepared being placed in college-level math courses. As a result, it is important for educators to develop new and innovative means to support these students. In this study, I examine the efficacy of the GEAR intervention, which I designed to improve students' self-regulated learning skills and encourage a growth mindset. My aim is to answer the following research questions:

RQ1) Compared to a group receiving additional mathematics remediation, what impact does GEAR have on students' academic achievement in corequisite non-STEM College Algebra?

RQ2) What impact does GEAR have on students'

a) SRL ability?
b) Growth mindset regarding math?

RQ3) How do students' perceptions of themselves as mathematical learners change during implementation of GEAR?

As follows, I begin by placing my research results in context of the current literature on SRL and mindset interventions. I then address the limitations of my study, discussing possible improvements for my future practice, and suggesting areas for future research. I finish with an overall summary of the importance of researching how to support coreq College Algebra students and the potential promise held by SRL and mindset theories as employed by the GEAR intervention.

Discussion of findings

By considering how my research substantiates some findings and contradicts others, the results of this study contribute to the growing collection of findings on SRL and mindset interventions. Additionally, situated in my specific context, a consideration of these results can offer valuable insight into the type of support that may be helpful to coreq College Algebra students in regards to academic achievement, self-regulated learning, and growth mindset.

Academic Achievement

Studies of SRL or mindset interventions finding positive academic achievement results have centered around younger students at the primary and secondary levels (Blackwell et al., 2007; Cleary et al., 2017; Donker et al, 2014; Good et al., 2003; Montague et al., 2014; Paunesku et al., 2015; Yeager et al., 2016), and several have spanned one-to-two full school years (Cleary et al., 2017; Montague et al., 2014; Semana & Santos, 2018). Notably, the two-year investigation of Cleary et al. (2017) into an SRL-targeted intervention with junior high math students did not fully see academic gains until the start of the second year of the study. This confirms the Dignath & Büettner (2008) meta-analysis of 84 SRL interventions which found higher effect sizes were positively correlated to interventions with longer durations.

There are studies of shorter-term interventions taking place with college-aged students. Cook et al. (2013) found that a one-time SRL presentation on metacognitive learning strategies with college biology students had a significant effect on students' final course averages. In fact, I modeled one of the primary components of the GEAR intervention off of this presentation. However, the participants of this study were college-ready freshman at a moderately selective state university, which is still a substantially different population than the developmental students my institution, which has an open-door policy. Furthermore, Cook et al. (2013) found that their intervention accounted for approximately 10% of the difference in exam points between the two treatment groups, while the first exam (which took place before the intervention) accounted for nearly 40% of the difference between the groups.

The study that mirrors my own context perhaps most closely in both population and duration is that of Zimmerman et al. (2011), in which both developmental and college-level math students spent a semester participating in an SRL intervention that focused on self-reflection and self-assessment. By the end of the semester the treatment group was earning statistically significant higher exam scores with the intervention again accounting for roughly 10% of the difference between the intervention and control groups. It is possible that this difference in results is partially due to the explicit scaffolding provided by the structured correction and reflection forms used, although the developmental-level students in this study were enrolled in a developmental-level math course rather than a college-level one, so the course content was likely to be more accessible.

Taking all of the above into account, it is possible that SRL and mindset interventions developed thus far are more likely to effectively target younger or college-ready students. This does not mean that such interventions cannot support the academic achievement of older college students or students who are underprepared—but the unique situation of these students might necessitate a reimagining of what this support looks like, how it is provided, and what quantifiable results we might realistically expect.

Regarding the current study, subtracting the weeks in which the GEAR and RC students received the same instruction and assignment, the GEAR intervention lasted eleven weeks with most weekly sessions ranging from ten to twenty-five minutes. However, since GEAR tackled both SRL and mindset topics, the actual time spent on either construct was much less. Given the duration of other interventions and the time frame during which academic gains were realized, it is possible that simply spending more time on SRL or mindset support is necessary for coreq students to realize statistically significant academic gains.

There are many possible reasons for this delay in gains, but I suspect that it is related to the novelty usage of new learning strategies. For many of these coreq students, the GEAR intervention was their first introduction to the idea and use of metacognition as a learning tool. Whenever we learn something new, it often the case that becoming fluent in the ideas or good at the skills can take time. Dignath & Büettner (2008) suggested that as students become more experienced in deliberate strategy usage, they will get better at both planning for and using new learning strategies. A fifteen-week semester may not be quite long enough for many students to reach this point, but the GEAR intervention provided an opportunity for these students to begin improvement of their learning strategies—an idea I explored in more nuanced ways in the qualitative findings of this study.

Self-regulated Learning

Many researchers have reported on the unreliable nature of students self-reporting about their use of self-regulatory measures, and have suggested triangulating with qualitative data (e.g., Cleary et al., 2017; DiFrancesca et al., 2016; Dignath et al., 2008;

Zimmerman et al., 2011). The MSLQ survey results did not indicate a significant difference in the use of metacognitive learning strategies between RC and GEAR students. However, qualitative data collected from the open-ended survey question, student interviews, and student journal entries indicated that GEAR students *were* more likely to try metacognitive strategies, attribute course results to effort, and make self-aware acknowledgements of and connections to their learning.

By the end of the semester, students in the GEAR group demonstrated more varied knowledge and use of cognitive and metacognitive strategies, a result observed by other SRL intervention researchers as well (Butler et al., 2005; Cleary et al., 2008; Cleary et al., 2017). In one within-group study of a 5 ½ week summer SRL intervention for college math students, similar in design to a corequisite course, over 50% of participants claimed they would continue using the strategies they learned in their future college courses (Vásquez Mireles et al., 2011). So even if GEAR students were not proficient users of these strategies by the end of course, at least they discovered about new learning techniques and began using them, suggesting at least the potential for future use. Furthermore, we might consider the possibility that were they to continue to encounter these strategies regularly in future coursework, the likelihood of their employing these techniques may potentially increase.

Additionally, I observed a trend within the GEAR intervention of students shifting from an external to a more internal locus of control. Many students initially credited previous failures or successes to external forces, such as a teacher, but by the end of the semester they were making more effort or ability attributions. Orientation of causal attributions is an important element of SRL because students who credit results to internal characteristics are more likely to engage with the SRL cycle, and thus attribution theory can play an important role in SRL interventions (Cleary et al., 2017; Wilson & Linville, 1983).

Given that successful SRL requires a degree of self-awareness, I was encouraged to see GEAR students make more increasingly self-aware statements regarding themselves as learners as well as their learning strategy adjustments. Such increases have also been achieved by other SRL interventions that include a reflective component, such as students who improved the accuracy of their self-assessments and made more goal-directed adjustments (Zimmerman et al., 2011; Semana & Santos, 2018). However, Semana and Santos (2018) acknowledged "the development of self-regulation capacity was not consistent in all students" (p. 754). This was an observation I also made, as the GEAR intervention appeared to help certain students more than others, tending to leave behind those who were the least prepared for a college-level math course and thus perhaps less adept at incorporating SRL strategies into their learning routines.

Mindset and Self-perceptions

Considering only the quantitative pre- and post-intervention survey responses, students across both the RC and GEAR groups saw a decline in mathematical growth mindset, as measured by the SOITIS instrument. The main effect of time did result in a statistically significant difference between pre- and post-scores, but group membership did not. This indicates that the commonalities of the semester between the two groups (such as performing poorly on an exam) influenced students' mindset more than any component of the GEAR intervention. In less than fifteen weeks, the GEAR intervention attempts to undo twelve or more years of schooling during which grades and standardized test scores were the primary measures of success. This, combined with the traditionally graded summative assessments of NVC's College Algebra course, may contribute to the difficulty of overcoming students' preconceived notions of themselves and what constitutes successful learning in a math class.

My results support evidence found by others that mindset interventions produce null or even negative results (e.g., Li & Bates, 2019; Schmidt et al., 2017; Sisk et al., 2018). However, it contradicts GM mindset gains found by others (e.g., Aronson, et al., 2002; Burnette et al., 2018; Hussein, 2018; Yeager et al., 2016; Yeager et al., 2019). The Yeager study results are of particular interest here since I used the PERTS modules developed by Yeager et al. (2016) as one of the primary mindset elements of the GEAR intervention. Yeager et al., (2016, 2019) found a reduction of fixed mindset beliefs in the intervention group when as measured just prior to and immediately after completion of the PERTS modules.

Regarding my own students, I found the journal entry that students wrote in direct response to the PERTS modules ("Advice to a struggling student") to be full of growth mindset beliefs and very low in fixed beliefs. However, over the course of the semester some of this positivity faded, replaced with more self-doubt. This, along with results suggesting GM gains may be temporary (Orosz et al., 2017), leads me to wonder about the lasting effect of GM interventions as well as other possible factors that might be impeding positive results. It also indicates that to be effective mindset interventions cannot be a one-off experience for students. Instead, it is important to build GM principles into the entirety of the course structure, discussions, and assignments. I attempted to do this, but perhaps I did not explain the GM elements of the course explicitly enough to students.

Although the quantitative data indicated a null or even negative shift in mathematical GM beliefs from the beginning to the end of the semester, qualitative results indicated a few promising developments, including fewer fixed mindset statements and more positive self-reactions. One trend I found particularly encouraging was GEAR students' increasing tendency to display positive reactions in the face of academic setbacks, a result also observed through the use of the correction and reflection forms employed by Zimmerman et al. (2011). This is a potentially valuable lifelong learning skill that may be applicable in other contexts and courses.

While the SOITIS instrument has been shown to be a reliable measure of universal incremental versus entity beliefs, it may not be as good at detecting more nuanced elements of mindset, and to other researchers interested in measuring growth mindset I would recommend that they collect qualitative in addition to quantitative data for deeper and more nuanced results.

Limitations

Characteristics of the study design and data collection caused some limitations to this research and its results. Additionally, there are a few potential issues with reliability and trustworthiness, some related to my dual role as instructor and researcher. And finally, the intervention itself could potentially have been inadequate due to the required shift to a remote learning environment.

There are a few limitations built into the study design that I could not control but a few that I could have potentially avoided. As is the case in much of educational research, running a true experiment with randomized assignment was not an option—nor was the sample size, as the school sets the class size. However, both characteristics affect the error in measurements across the two groups. One possibility would have been to recruit additional instructors to partake in the study, thus increasing the sample size, although doing so would have introduced additional potential limitations such as fidelity of the intervention and differences across instructors.

Regarding the survey instruments used, I limited myself in the results I could pull from students' responses since I asked them to complete the survey only twice, once pre-intervention and once at the end of the semester. Collecting survey responses at least one additional time during the semester might have improved the information provided by quantitative data. The weekly journal entries caught the fluctuating thoughts and feelings of students in a way that collecting only pre- and post-survey responses could not. Furthermore, as discussed in Chapter 4, it possible that the survey instruments I used were at once too narrow to measure SRL improvements but too broad to grab nuanced changes in mindset.

Another limitation beyond my control was the under collection of data from students who withdrew from the course. The attrition rates of the RC and GEAR groups were comparable, so a between-group difference is not of primary concern. However, the type of student making up the lost population is not random. Instead, the students withdrawing from the course are likely to be some of the most vulnerable and thus in need of additional support and potential intervention. However, once a student drops a class it can be very difficult to re-establish contact with them. I did attempt to secure a post-semester interview with two of the students who withdrew but neither replied to my follow-up emails.

To improve reliability of the academic measurements I initially planned to ask a fellow faculty member to serve as a second rater for the course exams. However, the shift to a remote environment greatly complicated the logistics of doing so, and I decided against it. I did take extra care to create detailed grading rubrics to ensure that I consistently scored students' work, but some discrepancies might still have occurred. Concerning the trustworthiness of qualitative results, ideally I would have performed member checking with the students who I interviewed and from whom I sampled journal entries. However, similar to contacting students who have dropped the course, once the semester has ended, getting in touch with students becomes much more difficult.

On the occasions when my dual roles of instructor and researcher came into conflict with one another, I consciously chose to focus on my instructor role, as that was my primary ethical responsibility as instructor of record. While I am comfortable with my decision to prioritize student learning over minimization of validity threats, it does mean that the validity of my research results could have been comprised in a few ways. I risked a possible loss of fidelity by asking students in the RC group to respond to five of the journal prompts, especially the exam reflections. Just these few responses alone may have influenced outcomes in the RC group, particularly in the realm of SRL strategies, which they might not have considered or adjusted without the exam reflection prompts.

Furthermore, there were slight differences in the actual class lectures and activities between the two groups. During the semester I collected data, NVC's College Algebra course underwent a slight curriculum shift, which meant adjusting my lesson plans. As a result, for most of the semester the GEAR classes received my initial "trial run" of these adjustments, and the RC group received my third and fourth times through the same lesson plan, which meant they received a more polished version. Very early in the semester I noted this discrepancy in my reflexivity journal and made the conscious decision to "go with good teaching, which is an integral part of the personal nature of action research" over keeping the groups as similar as possible. Towards the end of the semester, I did record in my journal a concern that my 9am GEAR class might have been at a mild disadvantage because they were the first to receive a slightly re-tooled lecture, and I sometimes realized how I wanted to present a certain idea or activity to later classes because I first made mistakes with them.

Finally, I developed the GEAR intervention during previous cycles of research that took place in face-to-face classes. As a result, it is possible that GEAR was not able to effectively target some of students' more pressing remote concerns, such as time management and motivation.

Implications for future practice

Through this experience, I learned many productive lessons about how I can improve both the GEAR intervention as well as my own teaching and research practices. I can subtly shift focus within the GEAR intervention from grades to learning, incorporate more explicit instruction and modeling of SRL strategies, and add more scaffolding for less prepared students. Personally, I will continue to deepen my knowledge of SRL and GM research, improve my formative feedback, and continue a reflective practice.

When analyzing qualitative results, I realized that some of my SRL instruction and several of the journal prompts were centered on grades rather than learning. If I would like to help students shift from outcome-emphasize to more process-oriented learning goals, I need to lessen the emphasis on course grades and instead focus more on learning, especially in the SRL presentation I adapted from McGuire (2015) and the exam reflection prompts. Furthermore, I might also consider lessening the role played by summative assessment and grading as suggested by Boaler (2016), although challenges to doing so exist within the confines of my department's traditional expectations about the course.

Additionally, I want to be more explicit about incorporating all three phases of SRL, as recommended by Dignath et al. (2008). In particular, I will incorporate more straightforward instruction and modeling of metacognitive knowledge (Dignath et al., 2008; Donker et al., 2014; Tanner, 2012; Schraw, 1998), especially on the cognitive strategy of elaboration, which has been found by multiple meta-analyses to make a positive different in SRL instruction (Dignath et al., 2008; Donker et al., 2014). The current version of the GEAR intervention lists such strategies, and sometimes briefly describes them. However, I believe that less prepared students are in greater need of more structure, such as explicit modeling of cognitive strategies, assignment improvements, and reflections. Once the immediate pandemic-influenced changes are over, and students have resumed face-to-face learning, I plan to incorporate the correction and self-efficacy reflection form developed by Zimmerman et al. (2011), which provides very specific scaffolding for students.

There are benefits to performing research as a practioner-scholar, such as developing a closer and more responsive relationship with student participants and thus trying to become more attuned to their needs. That being said, other scholars have found that running the intervention as an instructor rather than a researcher can make SRL interventions less effective (Dignath & Büettner, 2008). As a maturing practitioner-scholar, I may not yet have the same experience as the researchers running the interventions included in Dignath and Büettner's (2008) meta-analysis. Therefore, to improve the GEAR intervention my goal is to use repeated cycles of action research to continually expand both my theoretical and practical knowledge of SRL and GM interventions.

On a similar note, the importance of formative assessments and constructive feedback is highlighted by the research (Clark, 2012; Dignath et al., 2008). But just as students may not yet be fluent in using metacognitive strategies that are new to them, I, as a practitioner-scholar and teacher, am also new to adjusting how I give feedback, and I may benefit from exploring the tone and content that could be most helpful or encouraging to students. In post-reflective interviews two different students mentioned they found the feedback I offered on formative assignments beneficial, so I should continue to improve the effectiveness of my feedback in order to reach more students—and heed the constructive feedback that I hear or receive from students along the way.

Finally, there is the overarching importance of instructor reflexivity as it pertains to my own personal growth mindset while combating a deficit mindset. Multiple times in my reflection journal, I began an entry feeling upset at something that did not go the way I would have liked. Without journaling, my thoughts and feelings would have just ended there–complaining how students were not using their breakout groups effectively or did not work on an assigned set of practice problems for the exam review. However, because I *was* journaling, each of these reflections that started out negative all eventually turned inward as I wondered what I could have done differently to make it a more productive and engaging learning opportunity for students. Maintaining this reflective nature, and explicit writing down of my thoughts and experiences, is imperative to my own continual improvement as a teacher. Thus, I would also suggest the value in these reflective practices to other teachers employing these ideas in their teaching methods.

Implications for future research

The areas of SRL and GM interventions are ripe for further study. In addition to modifications to the study design I used, I believe additional research into the efficacy of such interventions is warranted. A mediation effect between SRL ability, GM, and academic achievement may also exist. And teachers' own approaches and mindset may very well be a factor when considering these interventions.

One straightforward way to expand upon the current study would be to recreate it on a larger scale, with both more students and instructors. Another expansion to consider is a longitudinal study, following students who receive some version of the GEAR intervention across subsequent semesters to see if any results persist and if students become better practiced at strategies they learned about during GEAR. Perhaps even better, but more complicated to feasibly manage, would be to run the GEAR intervention with students across multiple semesters and classes, providing both more time and contextual support for the intervention. To that end, I am also interested in running a smaller, more targeted case study on novice users of SRL strategies in order to better understand how they employ such strategies and how the GEAR intervention might be adjusted to better suit their needs.

While there are many ways to continue exploring the effectiveness of SRL and GM interventions, there are two types of efficacy studies in which I am particularly interested. First, several large scale meta-analyses of such interventions have been published (eg. Burnette et al., 2018; Dignath & Büettner, 2008; Schneider & Preckel, 2017; Sisk et al., 2018), but many of these studies occurred at the primary or secondary school levels. Given the known difficulty of changing people's behaviors and beliefs, I would like to see a meta-analysis of SRL or GM interventions (or both) at the college level. Second, in addition to college-level results, the longevity of growth mindset beliefs resulting from the PERTS modules (Yeager et al., 2016; Yeager et al., 2019) should be investigated. Currently they have published results from students entering secondary school and any mindset changes are recorded immediately following completion of the modules. Do these shifts in mindset "stick" after academic setbacks? If so, what are the contextual conditions under which the effects seem to last?

In a correlational study Burnette et al. (2007) found positive motivational beliefs such as belief in effort and strategy usage, learning goals, and low external attributions, mediated a positive relationship between incremental beliefs of intelligence and academic achievement. In this vein, the relationships between SRL constructs, mindset, and academic performance should be further explored to determine whether and how much a construct such as metacognitive strategy usage or growth mindset mediate academic improvement. I would also be interested to see if mindset predicts whether or not a student is likely to attempt using new learning strategies.

Embedded in all of the above is the teacher's own mindset and attitude towards student potential and ability. Others have demonstrated a relationship between classroom practices and tone, instructional content, teacher beliefs, and students' own self-perceptions and mindset (Burnette et al., 2018; Canning et al., 2019; Sun, 2018; Yeager et al., 2019). Additional studies should be run measuring the self-beliefs of students with teachers who have gone through GM training versus those who have not. Expanding this idea further, of those teachers who go through training, it would be interesting to see if there are any differences between those who complete a short, one-time training compared to instructors who continue to meet, discuss, and reflect on GM ideals on a regular basis.

Conclusion

As the state of Texas pushes more and more students into a corequisite model of remediation, the stakes for these students remain high. Due to the structuring of these courses at NVC, students who do not pass suffer greater academic and financial consequences. While the coreq model holds promise for accelerating students through remediation and completion of college-level credit, most of the current literature focuses on borderline students in non-algebraic pathways, and there is a lack of research addressing the students (often at least 50%) who fail their coreq course. These students need additional learning support beyond content specific development, and it is critical to explore ways to give these students the best opportunity to pass their college-level math course on their first attempt, as well as provide them with tools to be successful in their future college classes. Furthermore, it is possible that any such support might also be helpful on a larger scale to students who struggle with the content or confidence to be successful in their college-level math courses.

Although the GEAR intervention appeared to make little to no initial difference in course grades, it did not hurt these outcomes, and just as importantly for students' long-term learning, GEAR participants left the class with more learning strategies at their disposal. As Pintrich (2002) noted, "If students don't know about a strategy they won't be able to use it" (p. 222), so even if students do not master cognitive and metacognitive learning strategies within the span of a single semester, there is value in the fact that the GEAR intervention has introduced them to more effective, self-regulating methods of learning. Additionally, even if entity beliefs are difficult to alter by this point in college students' mathematical education, I am guaranteed to get nowhere if I do not at least try to plant seeds of growth mindset and attempt to structure my course to support such beliefs. Overall, the GEAR intervention showed promise regarding students' positive reactions to setbacks, shift to internal attributions, and willingness to try new learning strategies. And by exploring further refinement and improvements to GEAR in future cycles of action research, I plan to practice the very same SRL and growth mindset that I now preach to my students.

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APPENDIX A

RECRUITMENT AND CONSENT LETTER

Dear Student:

You are invited, with no obligation, to participate in a research study whose main purpose is to improve students' experience and success in Northwest Vista College's corequisite College Algebra course. I am working under the direction of Dr. Danah Henriksen, a faculty member at Arizona State University (ASU), where I am a doctoral student. I am conducting a research study to develop a curriculum and assignments aimed at improving student success and learning in corequisite College Algebra.

If you choose to participate in this research study, I would like to use the results to help improve NVC students' experience in corequisite College Algebra. For purposes of the study, all identifiers (i.e. names and Banner ID) will be removed from your data. All information from this study will be kept confidential and, if reported, will be done so anonymously. At no point will your identify be revealed. All data will be stored either in a locked file cabinet or a password protected desktop computer, accessible only by myself. You must be 18 years of age or older to participate in the study.

Your decision about whether or not to participate will in no way interfere with your course grade or relationship with me or your instructor. You may choose to withdraw from the study at any time without penalty. (Please note that regardless of your participation or non-participation, you are still responsible for all course assignments. Non-participation simply means your data will not be collected for research purposes.)

There are not foreseeable risks or discomforts to your participation. Results of this study may be used in reports, presentations, or publications, but your name will not be used.

Do you have any questions? (Please circle one) NO
YES

If you circled yes, please contact me, Amy Collins Montalbano, at acollins51@alamo.edu or 210-486-4318, before signing and returning this form.

YOU ARE MAKING A DECISION WHETHER OR NOT TO ALLOW AVAILABILITY OF YOUR CLASS DATA FOR RESEARCH AND PRESENTATION PURPOSES ONLY. YOUR SIGNATURE BELOW ALSO INDICATES THAT YOU ARE OVER THE AGE OF 18.

I agree to participate in the research study..

Participant's Name (please print): ___________________________________ Date: __________

Participant's Signature:____

Thank you,

Amy Collins Montalbano, Doctoral Student
Dr. Danah Henriksen, Assistant Professor
If you have any questions about your rights as a participant in this research, or if you feel you have been placed at risk, you can contact Dr. Danah Henriksen at (602) 543-1017 or the Chair of Human Subjects Institutional Review Board through the ASU Office of Research Integrity and Assurance at (480) 965-6788.

APPENDIX B

STUDENT LEARNING JOURNAL PROMPTS

Letter by your future self

Imagine that it's Thursday evening of December 10. The presidential election is over, we have a COVID vaccine (maybe!), and 2021 is knocking on the door - ready to kick out 2020 and usher in an era during which we can be regular humans again.

It also means that you've finished your 1314 final exam and have earned an "A" in the class. Congratulations!

But it took a lot of time and effort between now and then to do so.

Put yourself in that place, fifteen weeks from now, and write a letter describing what you did to earn your A.

Your response should be honest, open, and demonstrate thoughtfulness. As with most things in life, you'll get out of it what you put into it.

I am not looking for a formal paper, but please do your best to use correct spelling and grammar.

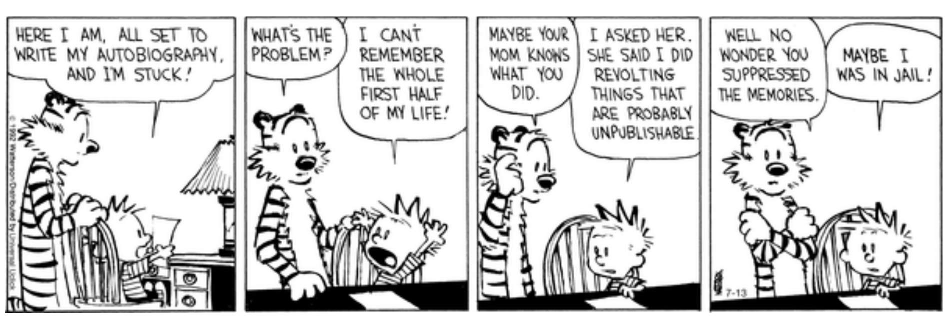
You will write up your response on your Edublogs and copy and paste the permalink to submit.

Math Autobiography

Ours is not your first math class! Your past experiences have helped shape who you are as a student. Think about your math history and post a short reflection on the account you have created at Edublogs. Please address the following in two separate paragraphs:

First Paragraph: Reflect on the answers you provided on the surveys we filled out. Why might you feel and act/study the way that you do? Briefly discuss a pivotal experience or two, prior to our class, which has influenced your attitude and actions towards math (whether positive or negative).

Second Paragraph: State one or two of your goals for this course and briefly explain *why* these are your goals. (Or put another way, what motivates you to achieve these goals?)



Learning (Your First Job)

Read the article on learning in college linked to on our Learning Journal page (you can also find it under our class announcements).
As you read, keep in mind the following questions:

1. What was the most important insight you gained from the reading?
2. Did you disagree with anything? If so, why?
   (If you did not disagree with anything, then what idea or statement did you find yourself most
   in agreement with? Why?)
3. What surprised you most in the reading?
4. What did you already know?
5. Can you think of any other good learning practices that the reading didn't mention?

After you have finished reading the article and considering your answers to the above questions, post a brief reflection on the account you created with Edublogs.

You can either simply type up your answer(s) to each question (#1-5), write up your response in paragraph form, or even simply use a bulleted list to keep track of your responses.

New Strategies to Use!

First paragraph (longer term goal):

What strategies from our class presentation will you commit to using for the next three weeks?
Briefly explain why you've chosen these strategies.

Second paragraph (shorter term goal):

Set a goal for yourself for this class for the next week.
(Next week you'll evaluate how you did and set a new goal).

Advice to a struggling student (adapted from the PERTS growth mindset prompt)

Part 1 is simply the final writing prompt in the NVC-Stanford College Improvement study you completed at the end of class on Tuesday.

All you have to do for this week's journal entry is copy and paste the answer you typed up there into your Edublogs.

Think about new students starting college next year. Imagine a student who is struggling in their classes and is feeling discouraged. Maybe the work feels too hard for them, or maybe they are having trouble staying motivated.

What is the most important thing (or things) you learned from the online modules you went through that could help them?

Please write 5-10 sentences.

Part 2 Weekly Goal

Step 1) Review the goal you set for yourself last week and evaluate how you did. Did you meet your goal or not?
If you did, elaborate in a sentence or two. If you did not, why not?

Step 2) Consider your answer(s) in Step 1 and adjust/set a new goal for yourself for the next 7 days.

Setting SMART goals

If you'd like, you can review the short video here on how to set SMART goals: https://www.youtube.com/watch?v=1-SvuFIQjK8 (~ 4min)

Re-visit the weekly learning goal(s) you set for yourself last week.

Now adjust your goal(s) so that they better meet SMART guidelines. Be sure to explicitly point out how your new goal(s) satisfies the SMART guidelines. I recommend using a format similar to what we did in class:

"State Old goal"
S – edit/addition make it *Specific*
M - edit/addition to make it *Measurable*
A - edit/addition to make it *Attainable* (or Actionable)
R – edit/addition to make it *Relevant*
T – edit/addition to make it *Time-bound*
"Restate new weekly learning goal"

Exam 1 Reflection (Discussion board in Canvas)

You should probably revisit our discussion on effective learning strategies and incorporate some of these strategies (*linked here in Canvas to a list*) into your newly revised goals. Think about how you prepared for Exam 1, if you're happy with your result, and (if not) how you could better prepare for Exam 2.

Answer the following questions:
1) Did you meet your grade goal? (Do **not** post your score.)
2) If you answered YES, list three things you did that contributed to meeting your goal.
If you answered NO, list three things you can do before Exam #2 to meet your goal.
The prompt for the GEAR group contained the additional line:
(Revisit our list of effective metacognitive strategies that will help you learn the material!)

And reply to at least one other classmate in a substantial way. (i.e. Advance the conversation somehow – don't just say "thanks" or "me too". Be thoughtful.

Time Management & Procrastination

In our switch to a remote learning environment, our habits, schedules, and routines are completely thrown off kilter. This can make it harder to manage our time and easier to procrastinate. This journal entry will ask you to think about and explore your own relationship with time management and procrastination, as well as consider new strategies you might employ to help you with both.

Part 1
Choose *one* of the following TED talks on procrastination to watch or listen to:
Watch: Inside the mind of a master procrastinator (~15 min)
Listen: The real reason you procrastinate (~36 min)

Part 2: Write up a brief Edublogs post addressing the following.

Paragraph 1: In a few sentences, expand upon any point made in the above video you watched (or podcast you listened to). eg. Did you relate to anything in particular? Did you find anything helpful? etc.

Paragraph 2: Based off of your thoughts from above and our class discussion over this topic, think about how might you work time management and/or procrastination strategies into your next weekly goal. Remember to practice using SMART guidelines (Specific, Measurable, Attainable, Relevant, Timely).

Monitoring and Adjusting Self-Talk

The things we tell ourselves hold power over us. Do you want that power to be negative or positive?

Step 1)

Sometime in the next week, pick a 24 hour period to pay attention to your self-talk regarding math class. During this observation period, you don't have to try to change anything; just pay attention and maintain awareness.

Keep a running list of the things you tell yourself, especially when you find yourself making a mistake or feeling frustrated. Record these in your Edublogs (enumerated or as a bulleted list is fine).

Step 2)

Once your observation period is over, come back and revisit your list. Are any of your self-talk statements negative or self-destructive? If so, revise them to be more compassionate and encouraging.

Example:
"I don't want to ask that question. I'll look dumb,"
Revised to:
"Questions are natural when something is new. Asking will help me learn! And someone else is probably wondering the same thing."

Example:
"Ugh! How could you have made such a stupid mistake?"
Revised to:
"Wow, I must really be tired. I know when I get tired my brain starts making silly mistakes."

For more information on the negative effects of self-talk and how to begin gently correctly yourself, see this article:
https://www.verywellmind.com/negative-self-talk-and-how-it-affects-us-4161304

Revisiting Metacognitive Learning Strategies

Make sure that you study for the upcoming exam effectively!

Revisit the summary of metacognitive learning strategies we discussed earlier this semester.

Exam 2 Reflection (Discussion board in Canvas)

Choose one and use the SMART guidelines we've covered to discuss how you will use this strategy to study for Exam 2.

Think about how the first eleven weeks of the semester have gone, and in a generous paragraph (or bulleted list) make a plan to finish the last five weeks strong!

Consider the following:
- What habits have benefitted you? What habits have hurt you?
- How have you adjusted how you study for/learn math since our class started? What's worked/hasn't worked?
- What do you plan on continue doing? What do you plan on trying new?

The prompt for the GEAR group contained the additional line:
(Revisit our list of effective metacognitive strategies!)

And reply to at least one other classmate in a substantial way (i.e. Advance the conversation somehow - don't just say "thanks" or "me too". Be thoughtful.)

Self-care Measures

Briefly describe the measures you are (or will start) taking to care for yourself (physically, mentally, emotionally) during this time of relative isolation. Choose one of the resources below to review and incorporate into your answer.

A few resources:
CDC recommendations for managing stress and anxiety
Flexibility in the midst of a crisis
Regulating emotions in a COVID19 world
Virus anxiety resources
17 free ways to practice self-care

Revisiting Past Journal Entries

Go back and re-read your journal entries for the two following topics:

1) Learning (Your First Job)
and
2) Advice to a Struggling Student

Then write a short paragraph addressing the following:

- Anything helpful from these two entries that you've lost touch with the past few weeks
- Has there been anything keeping you from taking advantage/using this helpful information? If so, what? And how to do you plan to overcome it?
- How you plan to reconnect/use this helpful, re-discovered information in the last few weeks of our class

Revisiting – Letter by your future self

Go back and re-read your journal entry "Letter by your future self".

If you believe you are going to earn that A (or whatever your grade goal was) in our class, write a brief paragraph evaluating the wisdom of the strategies you planned and describe if you ended up doing anything differently.

If you realistically expect less than an A (or whatever goal you set for yourself), evaluate yourself on how well you followed your planned strategies and when, how, why you strayed. Or, if you feel like you followed your plan, what improvements might you have made to it?

APPENDIX C

MOTIVATED STRATEGIES FOR LEARNING (ORGINAL)

The following questions ask about your motivation for and attitudes about this class. **Remember there are no right or wrong answers, just answer as accurately as possible.** Use the scale below to answer the questions. If you think the statement is very true of you, circle 7; if a statement is not at all true of you, circle 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you.

1	2	3	4	5	6	7
not at all true of me						very true of me

1. During class I often miss important points because I'm thinking of other things.	1	2	3	4	5	6	7
2. When reading for this course, I make up questions to help focus my reading.	1	2	3	4	5	6	7
3. When I become confused about something I'm reading for this class, I go back and try to figure it out.	1	2	3	4	5	6	7
4. If course materials are difficult to understand, I change the way I read the material.	1	2	3	4	5	6	7
5. Before I study new course material thoroughly, I often skim it to see how it is organized.	1	2	3	4	5	6	7
6. I ask myself questions to make sure I understand the material I have been studying in this class.	1	2	3	4	5	6	7
7. I try to change the way I study in order to fit the course requirements and instructor's teaching style.	1	2	3	4	5	6	7
8. I often find that I have been reading for class but don't know what it was all about.	1	2	3	4	5	6	7
9. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.	1	2	3	4	5	6	7
10. When studying for this course I try to determine which concepts I don't understand well.	1	2	3	4	5	6	7
11. When I study for this class, I set goals for myself in order to direct my activities in each study period.	1	2	3	4	5	6	7
12. If I get confused taking notes in class, I make sure I sort it out afterwards.	1	2	3	4	5	6	7

APPENDIX D

MOTIVATED STRATEGIES FOR LEARNING (ADAPTED)

The following questions ask about your motivation for and attitudes about this class. Remember there are no right or wrong answers, just answer as accurately as possible. Using the scale below, please indicate by circling the extent to which you agree or disagree with the following statements.

1	2	3	4	5	6	7
Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Neither or Disagree**	**Agree**	**Somewhat Agree**	**Strongly Agree**

1. During class I often miss important points because I'm thinking of other things.	1	2	3	4	5	6	7
2. When studying for this course, I make up questions to help focus my studying.	1	2	3	4	5	6	7
3. When I become confused about something for this class, I go back and try to figure it out.	1	2	3	4	5	6	7
4. If course materials are difficult to understand, I change the way I read the material.	1	2	3	4	5	6	7
5. Before I study new course material thoroughly, I often skim it to see how it is organized.	1	2	3	4	5	6	7
6. I ask myself questions to make sure I understand the material I have been studying in this class.	1	2	3	4	5	6	7
7. I try to change the way I study in order to fit the course requirements and instructor's teaching style.	1	2	3	4	5	6	7
8. I often find that I have been studying for class but don't know what it was all about.	1	2	3	4	5	6	7
9. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.	1	2	3	4	5	6	7
10. When studying for this course I try to determine which concepts I don't understand well.	1	2	3	4	5	6	7
11. When I study for this class, I set goals for myself in order to direct my activities in each study period.	1	2	3	4	5	6	7
12. If I get confused taking notes in class, I make sure I sort it out afterwards.	1	2	3	4	5	6	7

APPENDIX E

SELF-ORIENTED IMPLICIT THEORIES OF INTELLIGENCE SURVEY

The following questions are exploring students' beliefs about their ability to change their mathematical intelligence level. There are no right or wrong answers. We are just interested in your views. Using the scale below, please indicate by circling the extent to which you agree or disagree with the following statements.

1	2	3	4	5	6	7
Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Neither or Disagree**	**Agree**	**Somewhat Agree**	**Strongly Agree**

1. I don't think I can personally do much to increase my math intelligence.	1	2	3	4	5	6	7
2. My math intelligence is something about me that I personally can't change very much.	1	2	3	4	5	6	7
3. To be honest, I don't think I can really change how intelligent I am in math.	1	2	3	4	5	6	7
4. I can learn new things, but I don't have the ability to change my basic math intelligence.	1	2	3	4	5	6	7

5. With enough time and effort I think I could significantly improve my math intelligence level.	1	2	3	4	5	6	7
6. I believe I can always substantially improve on my math intelligence.	1	2	3	4	5	6	7
7. Regardless of my current math intelligence level, I think I have the capability to change it quite a bit.	1	2	3	4	5	6	7
8. I believe I have the ability to change my basic math intelligence level considerably over time.	1	2	3	4	5	6	7

APPENDIX F

SEMI-STRUCTURED INTERVIEW PROMPTS

1. How did you feel about yourself and math before we started the class?
2. How do you feel about yourself and math now, after our class is over?
3. How did you study for math *prior* to our class?
4. How did you study for *our* math class?
5. In your <title> journal entry, you wrote <quote>. Would you mind expanding on that thought a little further?
6. Is there something you might not have thought about before that occurred to you during this interview?
7. Is there something else you think I should know to better understand your experience in our math class?
8. Do you have any questions for me?

Thank you very much for agreeing to be interviewed. I appreciate your time and participation.

APPENDIX G

IRB APPROVAL DOCUMENTATION

EXEMPTION GRANTED

Danah Henriksen
Division of Educational Leadership and Innovation - West Campus
-
Danah.Henriksen@asu.edu

Dear Danah Henriksen:

On 8/11/2020 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Examining the Effects of Self-Regulated Learning and Growth Mindset Instruction for Underprepared Students in Corequisite College Algebra
Investigator:	Danah Henriksen
IRB ID:	STUDY00012268
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Consent Form - Control.pdf, Category: Consent Form; • Consent Form - Intervention.pdf, Category: Consent Form; • Initial recruitment - Verbal script.pdf, Category: Recruitment Materials; • Interview - Verbal consent script.pdf, Category: Consent Form; • Interview Recruitment - Verbal and email scripts.pdf, Category: Recruitment Materials; • IRB Protocol.pdf, Category: IRB Protocol; • ITIS Survey Instrument - Pre and Post.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • MSLQ Survery Instrument - Post.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • MSLQ Survery Instrument - Pre.pdf, Category:

	Measures (Survey questions/Interview questions /interview guides/focus group questions); • Semi-structured interview prompts.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (1) Educational settings, (2) Tests, surveys, interviews, or observation on 8/11/2020.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

Sincerely,

IRB Administrator

cc: Amy Collins
Amy Collins

ALAMO COLLEGES DISTRICT
Northwest Vista College

Human Subjects Protection Program	Institutional Review Board

APPROVAL DATE:	08/14/2020
TO:	Amy Collins Montalbano
CC:	Eliza A. Hernandez, PhD
FROM:	Prakash Nair, PhD
SUBJECT:	Initial Approval

Protocol Number: #018-2020

Title: Examining the Effects of Self-Regulated Learning and Growth Mindset Instruction for Underprepared Studen Corequisite College Algebra

Review Category: Qualifies for Exemption

Approval determination was based on the following Code of Federal Regulations:

Eligible for Exemption (45 CFR 46.101)

Criteria for exemption has been met (45 CFR 46.101) - The criteria for exemption listed in 45 CFR 46.101 have been met (or if previously met, have not changed).

(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

(5) Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) Public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

Provisions:	
Comments:	• The Northwest Vista College Human Subjects Protections Program has implemented a post-approval monitoring program. All protocols are subject to selection for post-approval monitoring.

This research project has been granted the above exemption. As principal investigator, you assume the following responsibilities:

1. Informed Consent: Information must be presented to enable persons to voluntarily decide whether or not to participate in the research project unless otherwise waived.
2. Amendments: Changes to the protocol must be requested by submitting an Amendment Application to the Institutional Research Office for review. The Amendment must be approved before being implemented.
3. Completion Report: Upon completion of the research project (including data analysis and final written papers), a Completion Report must be submitted to the Institutional Research Office.
4. Records Retention: All research related records must be retained for three years beyond the completion date of the study in a secure location. At a minimum these documents include: the research protocol, all questionnaires, survey instruments, interview questions and/or data collection instruments associated with this research protocol, recruiting or advertising materials, any consent forms or information sheets given to participants, all correspondence to or from the IRB or Office of Institutional Research, and any other pertinent documents.
5. Adverse Events: Adverse events must be reported to the Institutional Research Office immediately.
6. Post-approval monitoring: Requested materials for post-approval monitoring must be provided by dates requested.

APPENDIX H

FULL CODING FRAME

PERCEPTIONS

Affective. Encompasses students' beliefs, impressions, feelings, emotions, and attitudes. Motivations for and emotional responses to actions or environment.

- Incremental

Definition - This category applies when a student expresses belief improving their mathematical ability is under their control. The exact outcome may vary – from achieving a certain course grade to a more general statement about learning – but it must be tied to mathematically related in some way.

Indicators – improve, do/be better, I/you can

Examples - "You can always know more and improve what you already know" (Pre-ITIS 504); "…because now I just want to do better" (Journal 7953); "When you feel stressed out about school because you cannot seem to understand what you are learning, it is not because you are not smart." (Journal 8933). "…and [I] want to improve even more this semester" (Pre-ITIS 581)

- Incremental: Conditions

Definition - This category applies when a student specifies a necessary condition (or conditions) to improve their mathematical ability. The condition must under their control. The verb tense is not relevant; it can be a condition the student believes has already helped in the past or could help them in the future.

Indicators - practice/studying, determination, hard work/effort, paying attention, right learning strategy, faith in yourself, time/consistency, self-reflection

Examples – "I know with the right amount of time and more effort, my ability will improve." (Post-ITIS 581); "…when you take notes, you always want to write down anything that you think might be important and go over your notes as frequently as possible. When you do this the information will start sticking to your brain…even though it might take a lot of time" (Journal 7953); "I know [homework] will be beneficial for me."(Journal 7953); "…it makes me wonder how much better I would have performed if I gave myself more time to learn material beforehand." (Journal 8933); "I want to push myself because I know I am capable of doing the work and putting time into learning how to do it. (Journal 7953)

Decision rules – [Incremental] can apply without the use of [Conditions], but for [Conditions] to apply, the student must express a corresponding incremental view.

For example – "You can always know more and improve what you already know" (Pre-ITIS 504) is [Incremental]. But "I can learn and get better in math and all things with time." (Pre-ITIS 602) is [Incremental: Conditions] because of the inclusion of the necessary condition "with time."

- Fixed

Definition – This category applies when a student expresses belief that improving their mathematical ability is NOT under their control. This category applies to perceptions that (any kind of) effort on the student's part does not make a difference. It is responsive, an explicit reaction to a result.

Indicators – nothing helps, doesn't matter

Examples – "…no matter how much tutoring I get nothing really helps" (Pre-ITIS 504); "…even with tutoring I can't do it" (Post-ITIS 4851); "What hasn't worked for me has been the fact that I find it hard to remember each step in the math process. Even with a lot of studying instill struggle with this aspect." (Journal 214); "…and if I didn't understand it, I felt hopeless." (Journal 8933)

- Fixed: Circumstances

Definition - This category applies when a student specifies a necessary factor (or factor) to improve their mathematical ability, but the factor is NOT under their control. Rather, the factor is an external circumstance, a (perceived) innate characteristic of the student, or inexplicable and therefore cannot be changed or influenced by the student. The verb tense is not relevant; it can be a condition the student believes has already affected them in the past or could affect them in the future. Their orientation (incremental or fixed) is also not relevant. In other words, the outcome can be something that sounds incremental (improving mathematical ability), but if the condition is outside of the student's perceived control, this category applies. Furthermore, [Circumstances] can be implied. For example, if a student is discussing a math class and explaining their experience in terms of factors that were out of their control, then this category is applicable.

Indicators – support, teaching/teacher, the material/subject, class pacing, online environment, time away from math, hope/unexplainable results

Examples – "With…proper teaching I feel more…successful when completing assignments" (Pre-ITIS 320); "I have both been great and weak at math based on the formulas or problems. Depending on the problems" (Pre-ITIS 1599); "I recently discovered that I may have Dyscalculia, which explains a lot of my math career" (Post-ITIS 214); "…hopefully I am able to remember each step…and hopefully this will benefit me." (Journal 214); "I'm way better in person in a class setting." (Interview 854)

Decision rule – [Incremental: Conditions] vs [Fixed: Circumstances]. If the factor is vague, then first look the verb(s) used in an attempt to determine what is the responsible actor.

Example – "I believe that I can go as far as my mind lets me" (Post-ITIS 320). Even though their mind is something internal, the verb "lets" is passive on the part of the student, so it indicates a belief in innate characteristics here. [Fixed: Circumstances]

If verbiage doesn't help, look to surrounding context.

Examples – "I believe everyone….can always improve their intelligence with the right tools and support" (Pre-ITIS 209) is coded [Fixed: Circumstances] because it paired with "support" which is an external factor.

"I think if I had more time I would be able to significantly be better in math" (Post-ITIS 504) is coded [Incremental: Conditions] because it is sandwiched between other incremental statements, in their Pre-ITIS response and the second half of this statement.

If context does not help, then do not code to avoid misrepresenting the student's belief.

- Negative: Self-doubt

Definition - This category applies when a student communicates a negative perception specific to their self. Time frame is not relevant; it can be a negative self-perception developed at any point or expressed at any time during data collection.

Indicators – bad at math, struggle with math, don't understand, worst subject, "hopeless", not capable, brain not made for it, low expectations, others are good [implying not me]

Examples – "I know I am not that good at math" (Pre-ITIS 470); "…friends who are really good in math" (Post-MSLQ 221); "Why am I not understanding this?" (Journal 7953); "…but I kept my expectations low" (Journal 8933)

Decision rule – [Fixed] vs [Negative: Self-doubt]. [Fixed] applies when a student perceives that some kind of effort has been attempted but cannot help. It will often follow up a [Negative: Self-doubt] statement, and the two are very closely related. But [Fixed] applies to an explicit reaction to an outcome, as opposed to a more general "I can't do it" feeling that should be coded [Self-doubt].

Examples – "Math has never been my best subject" (Post-ITIS 221) is coded [Negative: Self-doubt]. The follow-up "…even when I do take the time to study and practice I get confused with numbers and end up second guessing myself" is [Fixed].

Context matters! "I was like, 'Oh, I'm bad at math. I can't do it.' " (Interview 7857) is an explicit reaction to studying for but failing an exam, so it is coded [Fixed].

- Negative: Math

Definition - This category applies when a student shares a negative perception of or experience with the subject of mathematics. Duration is irrelevant; it can be a one-time or enduring perception or experience.

Indicators – math is [negative description], negative past or current experience with math

Examples – "In high school, math was not my favorite subject" (Journal 7953); "I have always had really bad experiences with math since fourth grade." (Interview 7857); "I originally signed up for a summer course and then that course was really just kind of…it was brand new to the online learning, and, it was really difficult. …It got shut down and just, it was all over the place. … It just didn't make me feel confident" (Interview 854)

Decision rule – Whether or not a statement falls under [Negative: Math] or [Negative:Self-doubt] depends on the student's orientation. Do they place the "fault" with their self [Negative: Self-doubt] or the subject matter [Math]?

Examples – "This is too hard" (Journal 7953) [Negative: Math] versus "Math has just always been hard for me" (Post-ITIS 4851) is [Self-doubt] because of the addition of "for me". Or 'I get confused' [Self-doubt] versus 'Math is confusing' [Negative: Math].

- Apprehension

Definition – This category is specific to expression of worry or fear a student has about their self, the subject, or the class. This includes implied fears, such as not asking questions (stated) for fear of looking foolish (not stated).

Indicators – class pace, fear of failure (general), time off of math, test anxiety, dread, worry

Example – "I haven't taken a math class in over 13 years…I do not know how fast I will pick up on the new material." (Pre-ITIS 264); "…because I never put in the effort before. So in my head it was still kind of, can I do it? Can I not do it?" (Interview 9973); "This is the first time I've actually taken a class online." (Interview 854); "I believe this will help me feel less stressed and less guilty about having unfinished work." (Journal 8933); "I need to be asking more questions but I feel dumb asking them." (Journal 7953)

Decision rule - [Fixed: Circumstances] vs [Apprehension]. Some segments (eg. class pacing, time away from math) might be interpreted as both. [Apprehension] should be the default. But use of [Circumstances] applies when student explicitly attributes it to an outcome.

For example – "I know I can learn math but I have to learn it at my own pace…" (Pre-ITIS 3097) is [Circumstances]. The pace of the course is not under the student's control and they are directly attributing it to their ability to learn math.

- Positive: Self-reaction

Definition - This category applies when a student conveys a positive perception specific to their self. Neither time frame nor duration is relevant; it can be a positive self-perception developed at any point (including theoretically in the future), expressed at any time during data collection, and lasting any length of time (short or long-term).

Indicators – pride, confidence, enjoyment, exceed expectations, challenge self, adaptive inferences

Examples – "I'm proud of myself" (Interview 7857); "…from the beginning of the class to now, I feel more confident in my math skills" (Journal 8933); "[I learned] so much better" (Post-ITIS 2950); "I will take this class as a learning moment" (Journal 7953); "…so I try and be optimistic about my learning for math" (Pre-ITIS 6677); "I like [the new way I study] because I succeed" (Journal 9973); "I was able to work out the problems again and understand the math better." (Journal 214) "…just because you might have low grades, that doesn't reflect you as a person" (Journal 7953)

Decision rule – [Incremental] vs [Positive: Self-reaction]. As its name indicates, [Positive: Self-reaction] is reactive – it applies to an explicit reaction to an action or outcome, as opposed to a more general "I can do it" feeling that should be coded with [Incremental]. Rule of thumb, look to verb tense. A belief that something under student's control will help is [Incremental] or [Conditions] versus a perception that it did [Self-reaction]. Furthermore, if a student is expressing a positive feeling but it does not quite seem to be under their control (egs. "I will try" or "I am optimistic"), then [Self-reaction] over [Incremental].

- Positive: Math

Definition - This category applies when a student shares a positive perception of or experience with the subject of mathematics. Neither time frame not duration are relevant; it can be a one-time or enduring perception or experience.

Indicators – math is [positive description], positive past or current experience with math, appreciating challenge of course

Examples – "…I took my remedial math class…I didn't feel dumb in a math class" (Journal 214); "This semester has been quite an experience, but it's been good!" (Journal 8933)

- Motivation: Goal-orientation

Definition – This category applies when student mentions a short-term, class-related motivation. May be explicitly stated as a goal for the course, but doesn't have to be. Continuing the use of a learning strategy due to some explicit acknowledgement of a positive outcome falls into this category.

Indicators - grades, fear of failure (as a justification), learning, proving something to yourself

Examples – "…although my grade isn't an A I learned…" (Post-ITIS 2950); "My reasoning is based off of…how well I did" (Post-ITIS 6955); "I want to be great at math, just like I want to be great at everything in life" (Pre-ITIS 2950); "And although I didn't get the grade that I was hoping for, I passed. And I didn't barely pass like I think I passed pretty, pretty good." (Interview 7857); "[I want to]… actually know how to do the work I am given." (Interview 7857); I would say I did meet my goal and this is a technique I will continue to use. (Journal 7953)

Decision rules – Many student perceptions overlap with [Goal-orientation]. Default to the belief (incremental/fixed) or reaction (positive/negative), but use [Goal-orientation] when student uses it in a context explicitly referring to why they acted the way they did (i.e. fear of failure motivating them to some action).

For example, fear of failure might be coded as [Apprehension] or [Goal-orientation]. "I am feeling overwhelmed about my next test and if I will pass or not" (Journal 7953) is [Apprehension] but "I got that motivation up again, and part of it was because if I didn't pass [the next exam] that I would fail the class." (Interview 7857)

SEE ALSO: Notes on Segmenting (1).

- Motivation: Outcome expectations

Definition – This category applies with a student mentions longer term goals tied to results of our class.

Indicators – graduating, future career

Examples – "I'm going to keep in mind why I wanted to come to school and what this would mean for me once I've accomplished the goal of graduating college one day." (Journal 8933); "I like it because it gets me to where I need and want to be" (Interview 9973); "[Understanding the material] is super important to do because this won't just happen in school but it will happen all throughout our lives." (Journal 7953)

▪ Motivation: +/-

Definition- This category applies whenever a student expresses high/increase in motivation (+) or low/decline in motivation (-).

Examples – "I've found that over the last few weeks, I have felt that I've lost touch with my motivation throughout the semester" [-] (Journal 8933); "I really don't feel like doing my homework”[-] (Journal 7953); “I do think that in the beginning, I was like, very determined and like motivated” [+] (Interview 7857); “Remembering my goals will help give me the final push for the semester and motivate me to do well in my classes” [+](Journal 8933)

Notes on segmenting:

(1) Resist the urge to over-parse!

Many sentences contain multiple different perceptions. For example, should “I am motivated from having a bad experience throughout high school” be parsed into “I am motivated from…[Motivation: +]…having a bad experience throughout high school” [Negative: Math]? Is “Practice makes progress” coded “Practice makes…[Condition]…progress” [Goal-orientation]?

For simplicity and clarity sake, keep individual words together. (Do not split “progress” from the statement above). Keep entire clauses together if parsing them causes the statement(s) to lose clarity. When a motivation is included in a segment that contains another perception, <u>the other perception supersedes</u>.

Above examples – “I am motivated from having a bad experience throughout high school” (Journal 7953) is coded [Negative: Math]. “Practice makes progress” (Post-ITIS 470) is [Incremental: Conditions]

If a motivational reason is implied in the second half a value statement (whether positive or negative) as the motivation for that feeling AND the statement can be parsed while keeping its clarity, code the feeling and motivation separately.

Example – “[I feel] Really good [about myself and math]…[Positive: Self-reaction]…the concepts we learned they stuck. I just found myself absorbing the material a lot easier.” [Goal-orientation] (Interview 9973).

(2) If splitting a sentence into separate clauses does not sacrifice clarity, then include any conjunction connectors (but, so, however, etc.) in the segmenting so that when pulled

out on its own by MAXQDA, it remains as an indicator that the segment is in contrast/connected to another nearby.

(3) When the condition and outcome match in perception (both incremental or both fixed), then keep entire clause together when segmenting. However, if the condition/outcome are mixed, segment separately.

Example – "… but I feel with the right materials and teaching [Fixed: Circumstances] I can improve my math skills over time [Incremental]." (Post-ITIS 3097)

(4) Since MAXQDA cannot assign non-contiguous words/clauses to the same code, simply code them separately if both clauses contribute unique information (and link in comments). Code the more meaningful of the two if not (i.e. if they are more or less saying the same thing).

(5) Related to (4) - If a student makes near-identical statements in close proximity to each other, then chose only the more informational of the two to code. Do not repeat the code for repeat information.

(6) When deciding what to include in a segment, keep it simple but again, don't over-parse. If a next-door clause isn't technically part of the code but it provides context for that code, include it. For interviews, this may mean including part of my question (for context).

LEARNING STRATEGIES

Behaviors a student exhibits or intends. Actionable items.

- Content: Planning

Definition- This category applies when a student indicates an intention to use any content-related learning strategy. It is not relevant if the student actually ever uses the strategy. The efficacy of the task is irrelevant, but it must be content-specific.

Indicators – goal, future tense: I plan to…, I will…, I would like to…

Examples – "Some goals I have for this course are too [sic]: ask more questions and be interactive with my piers [sic] and my teacher" (Journal 7953); "…I think I might take this approach [one on one tutoring]" (Journal 214)

- Content: Used

Definition- This category applies whenever a student claims to have tried or used a content-related strategy. The efficacy of the task is irrelevant, but it must be content-specific. It is not relevant if the student used the strategy in our class or previous class. Whether it was a one-time trial or long-term use is also not relevant.

Indicators – past tense, present tense descriptions of how they learn

Examples –"I tried to organize the problems from formulas or equations and determine which was easier or harder to understand" (Pre-MSLQ 1599); "My friends and I joined zoom tutoring sessions (Post-MSLQ 1709); "I was watching extra videos and going back and watching our class videos if I did not understand something" (Journal 7953)

Decision rules – [Planning] vs [Used]: If it is clear a student has used or tried the strategy, then [Used] should be used; this includes instances in which the student has used the strategy in the past but has not employed it in current class. However, if it is ambiguous and context does not help, then default to [Planning] (i.e. assume they have not used the strategy yet).

[Content] vs [Control]: To qualify as a [Control] here, the strategy must be specific to learning content, rather than a strategy that deals with a more general area of learning, such as affective or self-control components. In the latter case, the category [Control] should apply.

Subcategories of both [Content: Planning] and [Content: Used]

- Help

Information flow is primarily unidirectional, from expert to student.

egs. watching videos, asking questions, tutoring

- Collaboration

Collaborating with peers. Information flow is more bi- or multi-directional.

- Passive

Learning strategies that require little or low cognitive action by the student.

egs. highlighting/circling, taking pictures, rewriting notes

- Active

Learning strategies that require a higher level of cognitive action on the part of the student.

egs. organize/summarize information, pattern recognition, repetition, additional practice, making notes for comprehension

- Metacognitive

Learning strategies that employ an element of thinking about your thinking.

egs. teach mode, intense study session with goal and/or self-evaluation, self-correction, self-assessment

Decision rules – [Help] vs [Collaboration]: If a student mentions going to lab (or any sort of tutoring) with other people, assume the primary purpose is to ask questions [Help] unless they specifically mention or allude to collaboration among peers [Collaboration].

[Metacognitive]:

"Self-correction": refers to a student attempting to figure out their mistakes on their own

Example: "If I was having trouble understanding, I tried to figure out why." (Pre-MSLQ 209)

"Self-assessment": refers to a student making evaluative judgments regarding what material (general) they understand versus what they are having trouble with.

Example: "I plan on finding the materials I feel I may need to work on the most before the final" (Journal 8933)

If student is referring simply to specific problems they didn't get, coding then depends on what they did to address those problems. Did they – go to the lab [Help]; ask a friend [Collaboration]; practice more of those kinds of problems [Active]; try to figure out where they went wrong [Metacognitive] b/c this is self –correction.

Examples: "When I run into problems and formulas I don't quite get, it really just means that I need to practice those kinds of equations more" (Journal 8933) [Active]; "I will showing [sic] up to lab on Monday night to work on…previous math problems I have struggled with" (Journal 8933) [Help].

[Active] vs [Metacognitive]: All metacognitive strategies are active but not all active strategies are metacognitive. For an active strategy to be metacognitive, some sort of awareness or understanding of one's thought processes must be evident.

- Control: Planning

Definition - This category applies when a student indicates an intention to use any content-independent learning strategy. It is not relevant if the student actually ever uses the strategy. The efficacy of the task is irrelevant, but it must be content-independent.

Indicators – goal, future tense: I plan to…, I will…, I would like to…

Examples – “From now on I will definitely put away distractions” (Journal 7953); “I [will] work at a reasonable pace and will not pile on all my assignments onto myself at the last minute” (Journal 214); “I think that I need to set more realistic goals for myself instead of just wanting to get an A, I need to work my way up.” (Journal 7953)

- Control: Used

Definition- This category applies whenever a student claims to have tried or used a content-independent strategy. The efficacy of the task is irrelevant, but it must be content-independent. It is not relevant if the student used the strategy in our class or previous class. Whether it was a one-time trial or long-term use is also not relevant.

Indicators – past tense, present tense descriptions of how they learn

Examples –“I now study for an hour” (Post-MSLQ 6677); “I…did not leave myself to do my assignments at the last minute” (Journal 214); “I always just look [at our Canvas site]” (Interview 9973); “I feel it is important to tie your learning to a purpose of whatever it is that keeps you going.” (Journal 8933); “Usually, I end up reading, but a lot of the time I really do nothing and that makes me feel at peace.” (Journal 8933)

Decision rules – [Planning] vs [Used]: If it is clear a student has used or tried the strategy, then [Used] should be used; this includes instances in which the student has used the strategy in the past but has not employed it in current class. However, if it is ambiguous and context does not help, then default to [Planning] (i.e. assume they have not used the strategy yet).

[Control] vs [Content]: To qualify as a [Control], the strategy must deals with a more general area of learning, such as affective or self-control components, and NOT be specific to learning content. In the latter case, the category [Content] should apply.

Subcategories of both [Control: Planning] and [Control: Used]

- Focus

Strategies intended to improve one's concentration.

egs. limiting distractions, paying attention, not rushing

- Time management

Any strategy related to the planning and/or devoting of time

egs. make a study schedule, keep up with assignments, a specified amount of time or days for study

Decision rule –[Time management] vs [Content]. [Time management] is not directly connected to how/why it will help them learn. If they do make such a connection, then [Content] should also apply with appropriate subcategory. (And be sure to code with the appropriate [Self-Aware] category!)

- Organization

Strategies related to organization (not temporally related) and thoroughness

egs. primarily refers to course materials, such as supplies or notes (physical organization of notes, not mental – then it would be content)

- Self-care

Taking care of one's self mentally and emotionally. Most commonly shows up in the form of battling something negative.

Indicators - anxiety, stress, guilt

- Motivation

Any strategy that has to do with maintaining or increasing a learner's motivation (which includes self-efficacy, goals, and intrinsic interest/value components)

Decision rule - [Focus] vs [Time-management]. A temporal element isn't always [Time-management]. "Don't rush, even if you are the last person to finish" (Journal 7953) is [Focus] because concentration and battling a distraction is at the core of this statement.

- Vague - Ambiguous

Definition - This category applies when a student expresses an intention or use of a strategy (typically a [Content] strategy but it can be [Control]) that could be interpreted in multiple subcategories (eg. passive or active), but student does not give enough detail to determine exactly how they are using this strategy.

Indicators - review/use/go over/look at course materials, color code/highlight/circle important information

Examples – "I know that when you take notes, you always want to write down anything that you think might be important and go over your notes as frequently as possible." (Journal 7953); "I would go over previous homeworks or the reviews" (Interview 9973); "I am someone who has to look at the problem and solutions multiple times" (Post-ITIS 602); "…[highlighting] important sources of information" (Pre-MSLQ 286); "…use [other people's] methods" (Journal 214)

Decision rule - [Vague: Ambiguous] vs [Control]. Ask, "Is there any way this strategy could be used actively (or metacognitively)?" If the answer is yes, then [Ambiguous] should be used.

- Vague - Imprecise

Definition - This category applies when a student expresses a plan/wish or effort towards a goal that is rooted in [Content] or [Control] outcomes but is NOT an actual actionable strategy. This is important information to code because it demonstrates a student's intention towards a certain outcome but indicates that they are unaware of specific actions they can take to achieve it.

Indicators - "try not be anxious" , "stop procrastinating" , "get my motivation up" , "spend more time", "study"

Examples – "I think that what I could have done better was manage my stress better" (Journal 214); "This time, just whatever like old articles I can find on there to use, I would use that." (Interview 854); "A goal that I am setting for myself is to study more" (Journal 7953); "Looking into the future I will take this class as a learning moment and for next semester to not procrastinate" (Journal 7953)

Decision rules – [Ambiguous] vs [Imprecise]. "Study" is [Imprecise]. "Go over my notes" is [Ambiguous]. Rule of thumb: if it's super generic, then use [Imprecise]. If there is some hint of a strategy which could simply be interpreted in multiple ways, then it is [Ambiguous].

[Vague: Imprecise] vs [Control: Time management]. A reference to spending an indistinct amount of time doing something is [Imprecise]. To quality for [Time management] it must be more definite, specifying at least an amount of time and/or schedule.

For example - "I will give myself more time to learn the material (at least 45 min, twice a week)" (Journal 8933) is coded [Time management] because of the parenthetical addition. Without that addition, it would [Imprecise].

- Handicapping

Definition – This category applies when a student mentions behaviors or actions that handicap

their ability to learn or self-regulate

Indicators – avoidance, procrastination, external attributions, second-guessing yourself, all-nighters

Examples – "I didn't, like, I didn't really want to study and I would just like, 'Oh, I'm not good at it anyway, so I'm just going to fail.'" (Interview 7857); "…my classes were like pretty manageable, like the amount of work. So I think I started like slacking, so I was like, 'Oh, this isn't that bad. This is so easy. I don't have to, like, study.' So then I wouldn't." (Interview 7857); "I just didn't care, so I didn't put in effort" (9973 Interview); "I dreaded all my math classes because I concluded that I simply was not good at it." (Journal 214); "I sometimes get lazy and think well if my teacher didn't say anything about homework then I don't need to bother asking." (Journal 7953); "I have always been taught to take notes but when I did so I would kind of forget about them because I didn't think they were that important" (Journal 7953); "I need to be asking more questions but I feel dumb asking them" (Journal 7953); "Usually, if I say negative things it's about the subject itself"(Journal 8933)

Notes on segmenting:

(1) Resist the urge to over-parse!

Many sentences contain multiple different strategies. Examples:

(a) “I may have used circled and highlights key points and things that may help me with the problem. (Pre-MSLQ 1799)”

(b) “figuring out the pattern … practice step by step.” (Pre-ITIS 1599)

(c) “I also go with a friend and sometime we teach each other when we don't understand something and it makes have to understand the concept fully. (Post-MSLQ 1835)”

For simplicity and clarity sake, keep individual words together (i.e. do not segment out individual words); keep the clause together and decide on which of the above codes is most applicable.

However, split and code separately if context is not lost and multiple, different strategies are presented.

Above examples –

(a) Circling and highlighting are essentially the same [Passive] strategy.

(b) Different [Active] strategies. Segment and code separately.

(c) Coding as “I also go with a friend [Collaboration] and sometime we teach each other when we don't understand something and it makes have to understand the concept fully. [Metacognitive]” doesn’t sacrifice context but provides a fuller picture.

(2) If splitting a sentence into separate clauses does not sacrifice clarity, then include any conjunction connectors (but, so, however, and, etc.) in the segmenting so that when pulled out on its own by MAXQDA, it remains as an indicator that the segment is in contrast/connected to another nearby.

(3) Since MAXQDA cannot assign non-contiguous words/clauses to the same code, simply code them separately if both clauses contribute unique information (and link in comments). Code the more meaningful of the two if not (i.e. if they are more or less saying the same thing).

(4) Related to (3) - If a student makes near-identical statements in close proximity to each other, then chose only the more descriptive of the two to code. Do not repeat the code for repeat information.

(5) When deciding what to include in a segment, keep it simple but again, don't over-parse. If a next-door clause isn't technically part of the code but it provides context for that code, include it. For interviews, this may mean including part of my question (for context).

SELF-AWARENESS

Conscious knowledge regarding one's feelings, motives, desires, or character. Also includes mindful recognition of learning (potential or realized). Realizing the "why" behind the "what". Must be specific to one's self rather than observations/beliefs regarding the more general population.

Note: The definition of self-awareness does not include conscious knowledge about one's behavior but rather one's character (which I expand here to characterization of one's behavior). So "…they didn't have like set due dates so I got like really, really, really, really behind…" (Interview 7857)" is not self-aware because it's simply stating behavior.

But “I sometimes get lazy”, which is a <u>characterization</u> of putting off your work, is self-aware.

Decision Q1) Does the segment demonstrate self-awareness? No > See [Lack of]. Yes > See Q2

- Lack of

Definition – This category applies when a student displays a clear lack of self-awareness, such as making contradictory statements or implications, or demonstrating poor or no strategic planning. May lie across responses collected at two different times or in what is not said. May require context, such as learning success (or not) of student.

Indicators – Contradictory statements (not recognized or addressed); an illogical conclusion about themselves; failure to adjust unhelpful learning strategies or repeated failure to adopt new ones; Segments coded [Perceptions: Fixed] and [Learning Strategies: Vague/Imprecise] might be indicators.

Examples – “…no matter who much tutoring I get nothing really helps” (Pre-ITIS 564) followed up with “going to tutoring” (Post-MSLQ 564); “What hasn’t worked for me has been the fact that I find it hard to remember each step in the math process. Even with a lot of studying I still struggle with this aspect. [next paragraph] I plan on continuing to study with the rewriting and hopefully I am able to remember each step.” (Journal 214); “I'm not the most confident when it comes to math so I try and be optimistic about my learning for math.” (Pre-ITIS 6677)

Decision Q2) Does it involve a self-aware modification of a learning strategy?

Yes > See [Adjustment] and continue onto Q3. No > See Q5

- Adjustment

Definition – This category applies when a student makes a conscious change to a [Content] or [Control] strategy. The quality of strategy is not relevant; an adjustment to a passive learning strategy is still an adjustment. Neither is the existence of evidence that they actually implement the strategy (i.e. could just be an intention), although an explicit recognition that they are going to continue using a new strategy does count.

Decision rule – Context must indicate, either explicitly or implicitly, that this is a modification to learning strategies. If it is unclear whether or not it's a modification, assume that it is not, and it does not receive the code. Context matters, as an unprompted strategy mention is more likely to be self-aware change than one that is explicitly prompted by the assignment. Strategies mentioned in the open-ended response for the Post-MSLQ but not the Pre-MSLQ may be considered adjustments (With [Learning Connection] or [Personal Reason]? Yes. [No/Vague Reason]? No.)

Even though actual follow-through on the adjustment is not necessary, the number of times the same adjustment is mentioned without follow-through does matter. The first mention is an [Adjustment]. The second is not coded. Any subsequent mentions (again, if it's clear they still haven't followed through) actually becomes a [Lack of] self-awareness, as they continue to make the same plans over and over again without different results. GEAR journals (maybe RC journals) are the most likely place for this to show up.

If the [Control] strategy referenced is one regarding [Self-care], then this category applies only if the student relates the strategy in someway to school and/or their learning.

Example – "One thing that has really helped is working out…it is good especially when I become stressed with school" (Journal 7953) does receive the [Adjustment] code.

Decision Q3) Is there a self-aware reason for the strategy adjustment? segment involve the intention or use of a learning strategy? No > See [No/Vague Reason]. Yes > See Q4

- Adjustment: No/Vague Reason

Definition - No or little justification given for the adjustment. Student is self-aware of the strategy adjustment itself (which may be have been explicitly prompted), but little else.

Indicators – Vague reason with no specific mechanism

Example - Consider the following two statements, both from the same journal entry (7953):

"[Flash cards] really help the information stick." versus "With flash cards you can split all the information up into small categories and it is so much easier to grasp all of the information." The former is too vague to indicate that the student is aware how the flash cards really help, whereas the latter contains sufficient detail (breaking the information down into smaller chunks) to suggest self-awareness.

Decision Q4) Does the student exhibit an awareness of how or why the strategy could improve learning?

No > See [Personal Reason]. Yes > See [Learning Connection]

- Adjustment: Personal Reason

Definition - The reasoning for intent/use of a learning strategy shows self-awareness of the personal reason(s) why they chose that strategy, but the reason is not learning related. Student demonstrates self-awareness regarding choice of strategy for personal reasons but does not indicate that they are aware of how/why the strategy could improve their learning.

Note: A segment must include an [Acknowledgement] for this category to apply. But if the acknowledgement is specific to a modification in learning strategies, then this category supersedes.

Example – "This is a method I find will be most useful for me as I have never tried it before. …I find it is also one of easiest to apply." (Journal 8933)

o Adjustment: Learning Connection

Definition – This subcategory applies when a student recognizes specific learning outcomes caused by the new strategy (cause/effect). Neither the usefulness of the strategy nor the depth of the connection is relevant.

Note: A segment must include a [Connection] for this category to apply. But if the connection includes an adjustment to learning strategies as its cause, then this category supersedes.

Examples – "Teach someone else what you learn to really make sure you understand" (Post-MSLQ 6480); "I would always go back to the class videos to refresh my memory" (Post-MSLQ 6955).

Decision rule – [Personal Reason] vs [Learning Connection]: [Personal Reason] applies to strategy justifications that are reasons (or causes) for choosing that strategy rather than a learning effect of that strategy, which is [Learning Connection].

Put another way, "Trying [strategy] because [justification]" > If the justification demonstrates awareness of why they chose that strategy but not awareness regarding how the strategy could help them, then [Personal Reason] applies.

Decision Q5) Does the segment exhibit awareness of a cause and effect?

Yes > See [Connection]. No > See [Acknowledgement].

- Connection

Definition – This category applies when a student recognizes a cause and effect. Either the cause or the effect (or both) can be affective or behavioral. Whether the cause and/or effect have value attached to them or not is not relevant (i.e. can be positive, negative, incremental, fixed, or neutral). Neither is the quality or certainty of the connection; any mindful attempt at making a connection counts as practicing self-awareness.

Indicators – so, because, in order to

Examples – "Usually, if I say negative things it's about the subject itself and mostly because I don't understand it" (Journal 8933); "I've always had trouble with math, not too sure if it's because I over analyze how to work the problems" (Post-ITIS 6677)

Decision rule – [Connection] vs [Adjustment]: If a cause with an undesirable effect is recognized but not addressed in any way, [Connection] applies. How to address the cause/effect by taking a new action would fall under [Adjustment]. So [Connection] category is the realization only, without any corresponding new action(s).

- Acknowledgement

Definition – This category applies to explicit statements of conscious information or realizations the student has about their self as a learner. Whether the statement has value attached to it or not is not relevant (i.e. Can be a positive, negative, or neutral claim). Note: It must be specific to themselves rather than a statement about the general population.

Indicators – realize(d); I want to get better at […]; I learn best when […]; I tend to[…]; I know […]; Segments coded [Perceptions: Positive/Self-reaction] and [Apprehension] can be indicators

Examples – "As an active learner…" (Journal 8933); "I'm better if I ask questions and get answers I need" (Pre-MSLQ 602); "I felt myself improve" (Pre-ITIS 581)

Decision rule - Not a perception regarding their ability ("I'm bad/good at math."), but a declaration that involves the process of learning in some way. Not a [Connection] because it lacks a cause/effect identification. Not an [Adjustment] if there is no corresponding action for improvement indicated.

[Acknowledgement] vs [Connection]: If a statement falls under both (i.e. the connection includes self-aware acknowledgements), then [Connection] supersedes.

[Acknowledgement] vs [Lack of]. The following sentence is [lack of] self-aware initially parading as an [Acknowledgement]:

"Even though I don't feel like doing my homework, I know it will be beneficial for me." (Journal 7953)

Although the student is acknowledging a couple of things here (not wanting to do their homework and noting that homework would be beneficial), they are failing to recognize in a self-aware manner why they are lacking motivation even though they know homework will help them.

Notes on segmenting:

(1) Since MAXQDA cannot assign non-contiguous words/clauses to the same code, simply code them separately if both clauses contribute unique information (and link in

comments). Code the more meaningful of the two if not (i.e. if they are more or less saying the same thing).

(2) Related to (1) - If a student makes near-identical statements in close proximity to each other, then chose only the more informational of the two to code. Do not repeat the code for repeat information.

(3) Related to (2) – The first time a student mentions a strategy adjustment, code it [Adjustment]. If student mentions a second time (still as a plan without actually using and including no new self-aware connections or details), do not code. For every subsequent time its mentioned (again, without actual use or new information), it actually becomes [Lack of] for failing to realize that they continue intending to use a strategy without ever following through. (The definition of insanity – or here, lack of self-awareness – is doing the same thing over and over again but expecting different results.)

(4) When deciding what to include in a segment, keep it simple but again, don't over-parse. If a next-door clause isn't technically part of the code but it provides context for that code, include it. For interviews, this may mean including part of my question (for context).