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# Interventions to Develop a Growth Mindset in a Remedial Math Classroom

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**Abstract**—College students in remedial mathematics programs not only struggle with fundamental concepts but tend to have a low mental outlook about their ability to succeed in a math class. Educators can implement interventions to promote a growth mindset with students, changing their attitude to one that recognizes hard work leads to mastery of any skill or concept. The students develop the confidence and desire to succeed in mastering the course material in their math classes as well as other academic subjects.

**Keywords**—mindset, remedial math, math education

## INTRODUCTION

College students arrive to their institutions with varied educational backgrounds and tools for learning. It is not uncommon for students to grow up thinking that they are “not good at math” or that it is okay to perform poorly in math classes since “math is hard.” This viewpoint can be passed onto the student through seemingly harmless comments from a primary education teacher [1], parent, or mentor and often defines their attitude towards their potential to succeed in not only mathematics but the other STEM (Science, Technology, Engineering, and Mathematics) fields as well.

Dr. Carol Dweck is a psychologist who has conducted extensive research into the idea of mindset. She classifies people as having either a fixed or growth mindset when they approach a challenge, such as in education [2]. People with fixed mindsets impose limitations to their abilities by thinking that “I’m not a math person.” People with a growth mindset, however, view difficult tasks as challenges they can overcome with hard work and practice. The education system in China is built on an intrinsic belief that anything is possible with hard work [3]. This is vastly different from primary education in America with the exception of youth sports. The young athletes develop a growth mindset by tirelessly practice drills and plays to develop fundamental skills and improve their overall performance [3]. You rarely hear a child say “shooting free throws is hard” or that they’re “not a soccer person.” As educators, especially in STEM disciplines, we need to teach our students that they can change the mental model of their performance potential by embracing a growth mindset building a positive mental attitude towards learning.

Every cadet at the United States Military Academy (USMA) is required to take three courses as part of the core mathematics

curriculum, totaling 12 credits hours. MA103: Math Modeling is the first math course every freshmen takes which emphasizes applied mathematics through modeling with discrete functions [4]. MA104: Single Variable Calculus follows where students learn about differentiation, integration, and the application of both concepts to model real world problems. Students apply their understanding of derivatives and integrals to solve applications based problems with the use of computational software. The core mathematics sequence concludes with MA206: Probability and Statistics, which explores probability distributions and data analysis to gain statistical insight on the underlying population.

Cadets who have a weak mathematical foundation in algebra and trigonometry may be selected to take MA100: Pre-Calculus during their first semester at USMA. The focus of MA100 is to prepare students for success in the core math curriculum by developing an understanding of functions, fundamental pre-calculus skills, vectors, and matrices [4]. Upon completion of MA100, cadets proceed through the regular three-course sequence of the core math curriculum, following a semester behind their peers. As the semesters progress, this population grows slightly as students who fail MA103 or MA104 typically retake the course the following semester along with the remedial population.

## MOTIVATION

The remedial math population typically arrives at USMA with a weak opinion of mathematics and low assessment of their abilities to perform math. Survey responses provided by remedial math students in MA104 during the first week of classes in Academic Year (AY) 18-1 indicated that while 62% of students believe they have the knowledge and ability to succeed in the course only 36% have confidence in their mathematical abilities. When experiencing difficulty in math class, half reported they would try hard to figure it out on their own while the others would quickly seek help or give up trying. more about GM

Single variable calculus is a required course for all students, two-thirds of the remedial population reported they would “never” take another math course and would not take MA104 if it was not required. This response to math education for this population is not unexpected since over the past ten years, 82%

of MA100 students pursue non-STEM degrees where multi-variable calculus is not a required course. This is very different from the main cohort of core math students where only half select non-STEM programs. Despite having completed both a pre-calculus and a math modeling course at USMA, over half of the students feel unprepared for the calculus curriculum in MA104. Additionally, 70% start the semester believing they need to have already taken a calculus course prior to USMA in order for them to be successful in MA104. The students' negative mental model regarding their math abilities fixes their mindset about their ability to succeed in calculus, before ever evaluating a derivative.

## GROWTH MINDSET INTERVENTIONS

In an effort to change each student's mental model, several growth mindset interventions were implemented in MA104 during AY 18-1. The course syllabus was written to include growth mindset language and served to set the tone for the semester. The syllabus outlined the course vision and broke down each lesson topic into either an Algebraic, Numerical, or Graphical approach. This exposes students to the course material from different angles in an attempt to make the material more accessible.

The course-wide assessments were "designed to encourage a growth mindset and active participation in the classroom" through feedback and revisions. Students were assigned five Problem Solving Labs (PSL) during the semester which required them to model a real-world scenario, conduct a quantitative analysis, and communicate the results in a report. Instructors would grade student lab reports for a majority of the assignment points, provide feedback, and then the students would have to implement the feedback through a re-submission for the remaining points. The in-class exams assessed a student's understanding of course material in the four ways it's presented in the classroom: Algebraically, Numerically, Graphically, and in application. This provided students with weak foundation skills the opportunity to leverage their numerical and graphical understand instead of struggling to solve purely algebraic problems.

The main and most direct growth mindset intervention used during the semester was a three part learning strategy assignment, worth 6.5% of their course grade. In the third week of the semester, students were asked to review a couple of online videos about growth mindset and reflect on the following questions (Part 1) [5]:

- What are your learning goals (how does MA104 fit in this picture)?
- Do you enjoy learning and how do you think you learn best?
- What is something you are really good at? Why do you think you are good?
- What is the job of an instructor here at USMA?

The following class was dedicated to growth mindset development where students shared their thoughts about the videos and responses to the reflection questions as small groups and as a whole class. Student were then asked to write a learning strategy letter (Part 2) addressing their answers to the four questions above to develop a "plan to attack learning" during the semester, i.e., a learning strategy targeting their mindset and level of effort they seek to achieve. Instructors provided students with feedback on their letters and suggestions to help them achieve their desired goals. The final part of the assignment was a learning reflection essay due during the last week of the semester. Students were asked to "honestly and candidly" address their performance in accomplishing their learning strategy.

## OBSERVATIONS

The initial student response to the growth mindset lesson not very positive. After watching the videos, students viewed "growth mindset" and "mental model" as buzz words without a realistic foundation in academics. During the dedicated class period, students easily made the connection that success in sports comes from hard work and quality practice with a focus on fundamental skills. However, they remained skeptical about applying the same theory to their study of mathematics. The students miss understood the purpose of the initial learning strategy letter, writing positive affirmations about their work ethic and reason for attending USMA instead of developing a learning strategy. As a course, we provided feedback and refined guidance for a re-submission of the assignment. The students improved their initial work and developed actionable learning strategies.

Throughout the semester, the course instructors continued to discuss the importance of quality practice on daily homework and building a growth mindset. These discussions occurred before and after each exam and on an individual level when were seen for additional instruction (AI). Although not all students committed to changing their mental models, many started to attribute improvements on exam performance to individual effort doing homework and focused studying, rather than luck or simply receiving an "easy" exam.

The end of semester learning reflection essay provided students an opportunity to reflect on there progress over the semester. Most students responded honestly and with a surprising level of maturity and perspective.

"Because of this semester in MA104, I have a new set of critical thinking skills that I have applied to other classes and problems in my life. I feel more confident in my abilities to learn and understand math... My grit is stronger than before and I don't beat myself up as much as I did when math made me feel incompetent. Other cadets actually come to me for help now!" -Student 1

“Since I have been at West Point, I have realized that I am better at math and I am smarter than I have been brought up to feel and think I was. My confidence started to become drained when I was in Junior High and a teacher would refuse to help me when I needed it. This caused me to always question whether I was doing things right or not. Being in [remedial] math and realizing my abilities has made me more willing to learn and improved my confidence level in ways that I never imagined.” -Student 2

“There were nights where I breezed through my homework just to get it done, and honestly it reflected on the following quiz with a poor grade. On the nights where I really sat down and worked at the problems, I learned the math better and scored higher on the quizzes...Not only did the repetition help me on quizzes, but when problem solving labs and test came around, I also did better on those.” -Student 3

The student comments indicate they are updating their mental models regarding the way they study math and in their own math abilities. They identified entering the remedial math program with a fixed mindset about their ability to learn math that was established many years before arriving at West Point. The students discuss the importance of repetition in their practice and the valuable understanding gained by struggling with material. A secondary impact was an improved self-confidence which went beyond the classroom. As an institution committed to developing future leaders, inspiring students to change their mindset in the classroom will improve their confidence to lead Soldiers in an uncertain world. While the total impact of our intervention is not easily measurable, the qualitative responses indicate students are aware of their own mindset and that their mental models can be changed to achieve success in their academic pursuits, especially mathematics.

## RECOMMENDATIONS FOR FUTURE WORK

The student learning reflection responses were encouraging and communicated their understanding of approaching academics with a growth mindset. I don't think any course can expect students to change their mental model regarding the learning of math that's been developed over twelve years in one semester but small interventions enable them to evaluate their learning. Students identified a long gap between the initial growth mindset exercise and the reflection essay. They recommended revisiting their learning strategy following each exam as a way to reflect on their studies and implement changes throughout the semester. The importance of developing a growth mindset and learning from feedback continued in MA104 for AY 18-2 with the main cohort of core math students. Developing a growth mindset in cadets should be a common theme across all of three core math programs and at an institutional level.

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