"PREPARING FOR A SOLID FINANCIAL FUTURE THROUGH MATHEMATICAL MODELING"

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1. INTRODUCTION

Often times in introductory mathematics courses, the entire focus of course projects is placed on helping students learn the mechanics of and theory behind mathematical concepts. This is completely appropriate, but depending on the audience, may provide little enduring value for the student. This is particularly true for students who are not pursuing a degree in a Science, Technology, Engineering and Mathematics (STEM) field. Many of these students approach math as a "gen ed" class, just one more seemingly unnecessary obstacle they need to overcome before they can sink their teeth into their major courses. As a result, students can sometimes appear unmotivated or even apathetic towards math. This paper proposes that by carefully constructing projects to have direct impact on the students' lives, instructors can combat that attitude, and even if that is unsuccessful, still have the unmotivated student more prepared for adulthood after completing the project than they were when they began.

1.1 THE UNITED STATES MILITARY ACADEMY CORE MATHEMATICS PROGRAM

Before describing the design of these projects, some background information is necessary. The United States Military Academy (USMA) at West Point, NY, has a somewhat unique approach when it comes to its mathematics program. All students at USMA are required to take three courses in the "Core Mathematics Program": MA103: *Mathematical Modeling and Introduction to Calculus*, MA104: *Single Variable Calculus*, and MA206: *Probability and Statistics.* This means that even humanities majors who neither enjoy nor are interested in mathematics are still required to take three semesters of college-level math. This paper focuses on projects given to students in MA103, which is typically taken the very first semester of their freshman year.

USMA's mission is "To educate, train, and inspire the Corps of Cadets so that each graduate is a commissioned leader of character committed to the values of Duty, Honor, Country and prepared for a career of professional excellence and service to the Nation as

[1] The views expressed herein are those of the authors and do not reflect the position of the United States Government, the United States Army, or the United States Military Academy.

an officer in the United States Army."[2] Every course taken, including mathematics, works toward this overarching goal. In order to achieve this, the Department of Mathematics developed the "Core Mathematics Program Goals"[3] (See Figure 1). Developing these characteristics in students helps prepare them to be adaptive thinkers, able to think through problems and analyze complex situations.

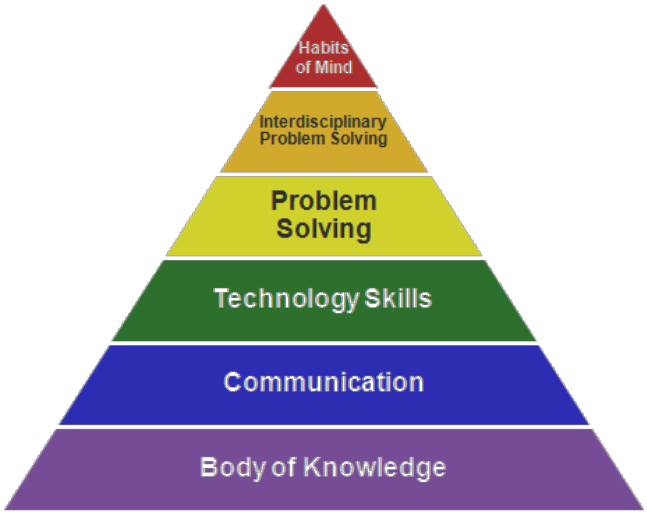

Figure 1: USMA's Core Mathematics Program Goals

1.2 USMA'S MATHEMATICAL MODELING PROCESS

MA103 was very much designed with the Core Mathematics Program goals in mind. As its name implies, the course focuses on mathematical modeling, and it introduces a wide variety of mathematical topics such as linear and nonlinear recursion equations, Markov processes, network flow problems, and social network analysis, to name a few. A central theme to the course, however, is the USMA Mathematical Modeling Process (MMP) (See Figure 2).[4] The MMP is used throughout the course to give students a framework from which to approach ill-defined problems.

A typical assignment in MA103 might give the students a real world scenario with a little bit of background information, but would intentionally leave out some key information necessary to complete the analysis. This requires the students to recognize what key components are missing and make reasonable assumptions to address these information gaps. The students then choose an appropriate mathematical models learned in the class and use it to model the scenario. The final step is for the student to interpret and evaluate their results, and repeat the process if it is determined that any assumptions need to be

[2] United States Military Academy. "The West Point Mission." www.usma.edu.
[3] Department of Mathematical Sciences, *Core Mathematics* (West Point, NY: United States Military Academy, 2016), 11.
[4] Department of Mathematical Sciences, *Modeling in a Real and Complex World* (West Point, NY: United States Military Academy, 2016), Figure 1.4.

changed, or the model is not behaving as expected. This can be a lot to ask of a first semester freshman, especially one who is not particularly interested in STEM to begin with.

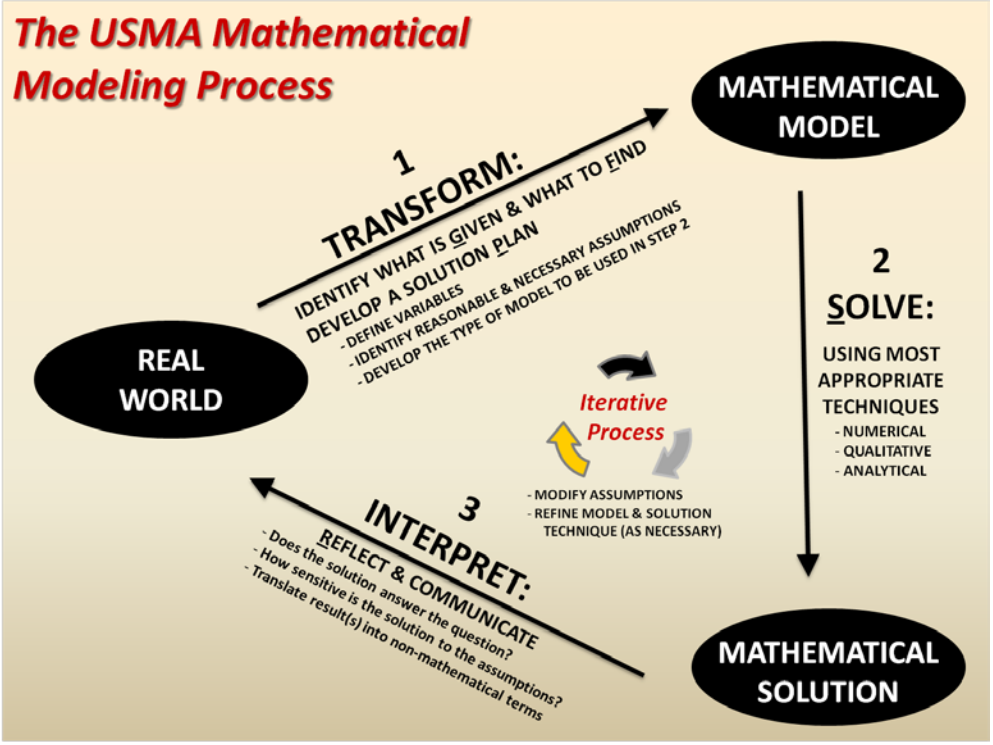

Figure 2: The USMA Mathematical Modeling Process.

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2. PROJECT SELECTION

2.1 PROJECT CHARACTERISTICS

Choosing projects which students find interesting or applicable can help draw the attention of otherwise uninterested students. Figure 3 illustrates how five different characteristics of projects can motivate the MMP and achieve the Core Mathematics Program goals. Some of these characteristics, such as ill-defined guidance, are not hard to achieve. A greater challenge is finding real-world problems which students will really buy into.

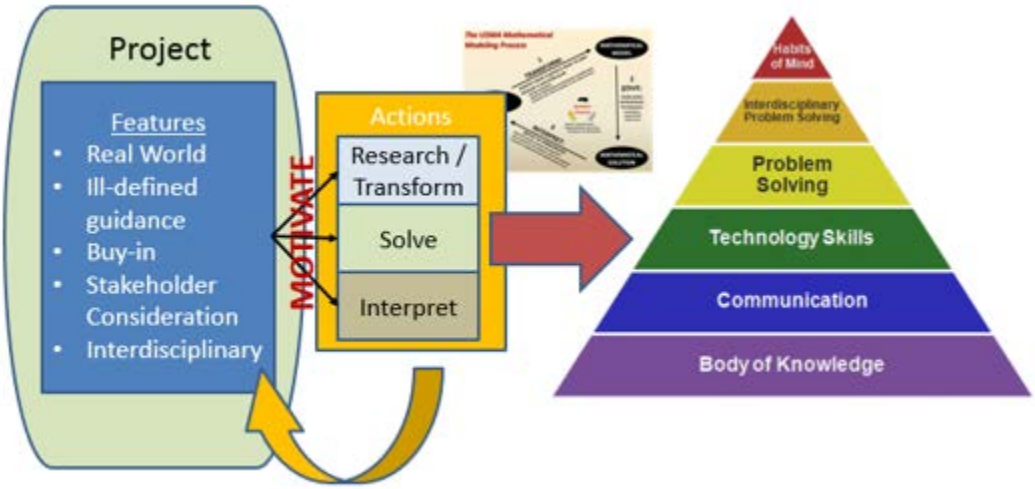

Figure 3: Relationship between project features, MMP, and Core Mathematics Program Goals.

One key concept here is the difference between an application and a real world problem. There are plenty of application problems that can be used in a mathematics course. Unfortunately, however, many of these problems are not "real world" problems from the perspective of the student. For example, modeling a ball being dropped off of a tall building near the surface of the earth with zero wind resistance is a great application which is useful in demonstrating how integrals and derivatives can be used to find the position, velocity, and acceleration functions. From a student's perspective, however, this is a canned scenario which could not be further from the "real world." It would be more ideal to find modeling scenarios which apply to the student's life, either currently or in the near future.

2.2 FINANCIAL PROJECTS

In addition to motivating mathematical learning objectives, well-designed projects can also help students learn about non-mathematical topics which will help prepare them for adulthood. Although there are many potential topics which can achieve this, one obvious choice to focus on is financial models. Many students arrive at college (and subsequently graduate) completely illiterate on financial topics. Concepts such as saving, investing, and understanding how debt works can be daunting for students who have never so much as opened a checking account. By designing projects which force students to model these topics, instructors can achieve mathematical learning objectives while simultaneously teaching students how to manage their finances.

Another great benefit to having students model financial scenarios is that financial modeling can be incorporated into almost any introductory level mathematics course.

Probability and statistics, calculus, and even basic algebra can be used to model topics like stock market performance and loan balances. In the fall semester of 2017, MA103 assigned students two mathematical projects which directly related to the students' immediate futures: analyzing a car loan, and analyzing military retirement.[5]

3. PROJECT EXAMPLES

3.1 MODELING A CAR LOAN

The first project gave students a scenario where they play the part of a Platoon Leader whose subordinate has just purchased an expensive vehicle using a high interest loan. The project asked them to answer several questions, such as whether the Soldier can afford the payments, how long it would take the Soldier to pay off the loan, and the total amount the Soldier would spend on the vehicle. Additionally, the assignment required students to determine, as a new Lieutenant, what vehicle they will be able to afford to buy themselves.

The wording of this problem made students quickly realize that this assignment was more than just a thought exercise. They were researching and modeling a real scenario they will find themselves in upon graduation. Since this was their first project in the course, the prompt asked specific questions, and the problem required minimal research beyond military pay and the prices of different vehicles. Some had no knowledge of how car loans work, and also had to do research to understand that process. The problem also fit directly into the course material up to that point and tied in directly with in-class exercises. The project had a narrow scope and students were required to write their analysis in a paper.

3.2 MODELING MILITARY RETIREMENT

The second project given to the students asked them to do a comparison of the Army's Legacy Retirement System and the newly released Blended Retirement System[6]. Specifically, it asked them to advise a Senior Cadet preparing to commission into the Army by recommending which retirement system they should opt into. It additionally required students to do a similar analysis and make a recommendation for a senior noncommissioned officer, as they will likely have to actually do in just a few years. Just like the car loan project, this project was very much "real world" for the students.

As this was the second project assigned, more was expected of the students. Although the prompt was clear enough that the students knew what their goal was (i.e., determine which retirement system is more beneficial for military personnel in a given situation), no guidance was given on how to achieve that aim. This project required much more research than the first project, but some recommended sources were provided to help the students get moving in the right direction. Also, although portions of the problem fit into the

[5] These projects were developed by the MA103 Course Directors, MAJ Ryan Slocum and MAJ Russell Nelson, USMA

[6] For more information on the Legacy and Blended Retirement Systems, see http://militarypay.defense.gov/BlendedRetirement/

framework of the course, students were required to develop their own mathematical models and come up with ways to model the total value of a retirement system, familiarizing themselves with concepts like inflation and the time value of money. Due to the complexity of the project, students completed the project with a partner. Also, rather than writing a paper, students had to brief the results of their analysis, giving them practice at swaying someone's opinion using an analytical argument. Some students even invited upper-class students who have to actually make the decision of which retirement system to choose in just a few months.

4. CONCLUSION

Engaging non-STEM students in mathematics courses can be challenging. Even if an instructor can get them to buy-in to the benefits of analytical thinking, students still may be spending a lot of time learning material they will, realistically, never use in their day-to-day life. Instructors can alleviate this problem by designing projects which require students to learn about real-life situations they will find themselves in, while still achieving all desired mathematical learning objectives. Although this paper provided a few financial examples that were successful, instructors can use this same thought process to design projects on any applicable topic which will help prepare students for adulthood. This approach can not only get students to buy-in to the mathematics, but it can also leave students with useful knowledge and/or skills which they can use in their daily lives going forward.

References

Department of the Army. *Modeling in a Real and Complex World*. West Point, NY: United States Military Academy, 2016.

Department of the Army. *Core Mathematics*. West Point, NY: United States Military Academy, 2016.

United States Military Academy. "The West Point Mission." http://www.usma.edu/about/sitepages/mission.aspx. May 16, 2017.