INTERDISCIPLINARY ACADEMIC PROGRAM: MATHEMATICS AND TECHNOLOGY

Reginald P. Shelton[1]
Jason T. Sharritt
Department of Mathematical Sciences
United States Military Academy
West Point, NY 10996
reginald.shelton@usma.edu
jason.sharritt@usma.edu

At the United States Military Academy (USMA), our ideal graduate has the ability to think about and solve problems that span across several disciplines. Most instructors have a background in military service and have been in the military a minimum of eight years. These instructors know the importance of being able to solve complex, undefined, real world problems. This has sparked our movement towards building an interdisciplinary academic program. However, creating this interdisciplinary program is much more difficult than just saying you want to have one. This paper will discuss the legacy interdisciplinary curriculum at USMA, our recent curriculum change, and our first attempts to continue to bring interdisciplinary learning into our curriculum.

Traditionally, at USMA, we had a core curriculum that all students had to go through. We knew that unless a student validated a core program class, in their first year of academics they would take an introduction to modeling course, a calculus course, two chemistry courses, a psychology course, an information technology course, two history courses, a composition course, and a literature course. These courses cover several domains, stretching our students' abilities to process a wide range of topics.

Fourth Class	Modeling	Chem	Psych	History	Comp	
	Calculus I	Chem	IT1	History	Lit	
Third Class	Calculus II	Physics	Philosophy	Pol Sci	For Lang	
	Prob/Stats	Physics	Phys Geog	Econ	For Lang	
Second Class	Engineering Sequence 1	IT2	Elective	Int'l Rel	Leadership	Elective
	Engineering Sequence 2	Elective	Elective	Elective	Adv Comp	Elective
First Class	Engineering Sequence 3	Elective	Elective	Law	Mil Art	Elective
	Elective	Elective	Integrative Experience	Elective	Mil Art	

Figure 1: USMA c/o 2018 Core Academic Program

[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.

The stability in the core program allowed us to set up an interdisciplinary program over the course of the first two semesters that culminated in a project that touched each of the domains. Students are tasked with leading a platoon (small group of soldiers) that is setting up a forward operating base (FOB) to support a humanitarian aid mission. It is their duty to determine the best way to understand and interact with the indigenous people, use social media as a tool to data mine, power their radios, and set up shifts for their soldiers with the intent to accomplish the humanitarian aid mission.

In a group of 4-5, students combined their knowledge gained from their various courses to create a concept of operations (CONOP). The project started with a lab in chemistry where they tested the different aspects of batteries including the ability to hold a charge and recharge time. They would then create and use a discrete dynamic function that modeled battery usage. Once this was complete, they used this information to set up shifts for their soldiers to go off the FOB to conduct their duties in support of the humanitarian aid mission. Their missions were arbitrarily set, so the soldiers would be sleep deprived. The students are then charged with understanding the signs of and combating sleep deprivation.

Humanitarian aid is arbitrarily set to be provided to one group of indigenous people while the FOB resides within the borders of a second indigenous people group. The students are tasked with understanding the nuanced relationship between the two groups and create a CONOP that does not violate a relationship with either group. Finally, the students are asked to review social media to determine if there are any subcultures within the groups of people that they will need to plan their operations around. All of this was presented through two mediums: a paper and a briefing.

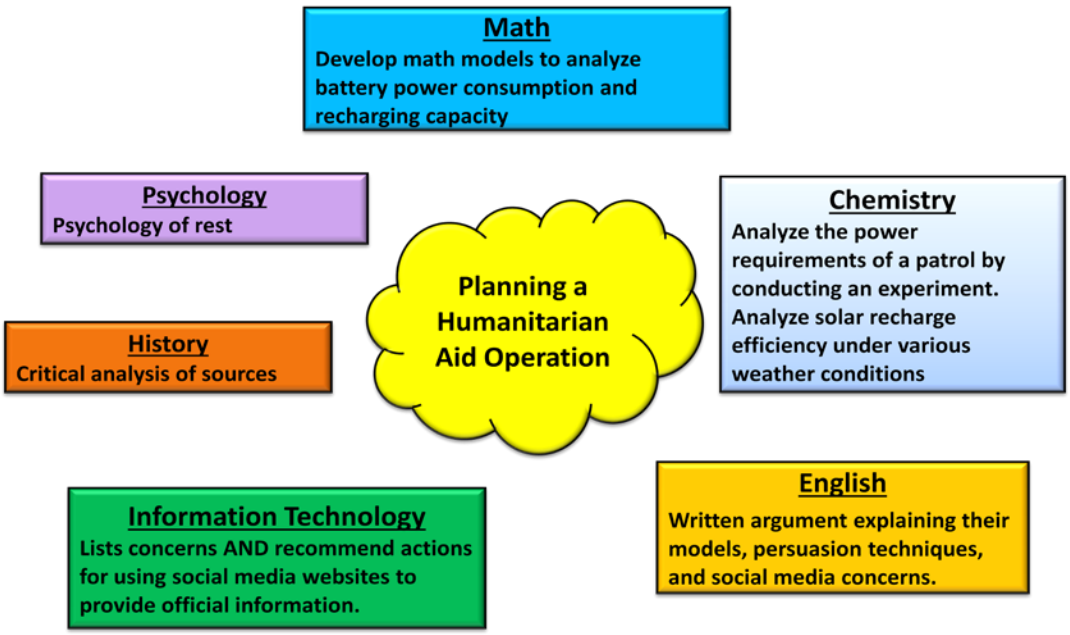

Figure 2: Class of 2018 Freshman Year Interdisciplinary Project

As you can see, the interdisciplinary program was well planned and well thought out. We tried our hands at setting up an interdisciplinary program in the second year of instruction similar to that seen above in the first year of instruction. Traditionally, in the second year of instruction, students take their calculus II, probability and statistics, physics, geography, philosophy, political science, economics, and foreign language courses. Again, since all courses were mandatory, it was relatively easy to set up an interdisciplinary project that would encompass all of the courses the sophomores took.

As they say, all good things must come to an end and unfortunately for our interdisciplinary program, USMA is going through a curriculum change. The class of 2019 (just finished freshman year) have a new academic program where they do not have to take Calculus I and II. Students now only have to take one of the two calculus courses. They also no longer have to take five science courses. Instead, they only have to take four. This now creates a large population of students that will not traverse the traditional core academic program. This has caused us to rethink our interdisciplinary program.

Fourth Class	Modeling	Chem	Geog	Psych	History	Comp	
	Calculus	Phys	Chem	IT1	History	Lit	Select Major
Third Class	Prob/Stats	Scie	Phys	Philosophy	Pol Sci	For Lang	
	Elective	Geog	Scie	Elective	Econ	For Lang	
	Engineering Sequence 1	IT2		Elective	Elective	Leadership	
	Engineering Sequence 2	Elective		Elective	Mil Art	Int'l Rel	
First Class	Engineering Sequence 3	Elective		Elective	Elective	Law	
	Elective	Elective		Integrative Experience	Elective	Officership	

OR

Figure 3: USMA c/o 2019 Core Academic Program

The Math Department ran two pilot programs this past academic year to continue to build upon the previous success of the interdisciplinary curriculum. In our math modeling course, we ran a single pilot section of robotics. We used the Arduino Robotics Ecosystem. Students were charged with building and programming the robot. Their programs included spatial awareness and a "Walk the Log" competition. The students competed in an Indoor Robot Obstacle Course (IROC) at the end of the semester where there robots competed in the given tasks. The students also explained how robotics could be used beyond what was discussed in the course.

Figure 4: Student with Arduino Robot

The IROC was a huge success. The students were able to talk to the Dean of the Academic Program in a one-on-one basis to brief what they had done with their robot throughout the semester. The cadets enjoyed the opportunity.

Figure 5: Student briefing instructor

From military applications, such as surveillance and reconnaissance, to civil applications, such as recreational drones and self driving cars, our dependence on robots has dramatically increased. We chose robots because of this proliferation of robotics applications over the past fifteen years. We are predicting that our students will graduate into a military where it will be increasingly necessary to understand how to use and robots and understand the nature of how these robots work.

In the pilot robotics course, we went beyond the nuts and bolts of how to build and program a robot. We stretched the thinking of our students by having discussions on the ethical use of robots and how the proliferation of robotics will affect our economy. We brought in a speaker from the Law Department who discussed "Robotics, Artificial Intelligence, and the Law of Armed Conflict" and a speaker from the Social Science Department to discuss "The Economic Implications of Self-Driving Vehicles." The students identified these talks as successes in the program and so we will try our best to keep them in the program in the future.

While these talks demonstrated the capabilities for robotic programming to be an interdisciplinary program, it was not all that we can do. In fact, when we run the beta pilot program, we are going to expand it to two sections instead of one and we are going to reach out to the Electrical Engineering and Computer Science (EECS) Department. We are going to try to select our population in the beta program from students that are simultaneously taking information technology. In this course, EECS instructs students how to program and code. We want to leverage these skills in the robotics program. There could also be a chance that these sections could do a wiring tutorial in the information technology course. Again, we would try to leverage the wiring tutorial to for our purposes in the robotics lab. Reaching out to the EECS Department is tied to one of the things we would like to be able to do better in the future. Our students struggled with the programming outside of class and so we want to make sure they have resources in both the Math and EECS Departments.

Our biggest concern with this program is the feasibility to roll it out to a course that has students with varying mathematical capabilities.

The second pilot program we ran this academic year was in our Calculus II course. This program was a technology week. The goal was to make students more independent learners when it came to coding in Mathematica. In our Calculus II course, we discuss several different applications of mathematics to the physical and social sciences. In the pilot program, students had to create and application in Mathematica that would solve one of these mathematical application to the physical and social sciences. These applications included a spring-mass model, population growth model, Newton's Law of Heating and Cooling model, and mixing model.

The goal was to build in application that automated the solution process for one of the four models. All a user would need to do is put in the given parameters from the problem

they were trying to solve and the application would solve the model for them. At the end of technology week, we allowed the students to use the application to take a quiz. Those that understood their application and how it worked, should have been able to complete the quiz in 5-10 minutes. However, completing the quiz was much more difficult is a student did not understand how their application worked.

During the week, instructors provided several problems for students to validate their application against. Each student had at least four problems to use to validate their application was working properly before coming to class. This program drew on the students previous core classes of information technology and geography or physics.

Again, this program is in its infancy and there are many things that we can do to increase its level of legitimacy. One of the things that we are discussing for next semester is adding more disciplines, such as the use of Lagrange Multipliers in Economics. Additionally, Technology Week rolls right into our course project. There is an opportunity to build an interdisciplinary project scenario around the topic of our students applications. We will be looking into that in greater detail this summer.

The initial feedback we received for this second program was that it was a great success. The semester that we ran this program, we had our students that typically struggle with math mixed in with students that excel at math. Many of the students said that while it was challenging, they enjoyed being challenged in this way. As we move forward, the Calc II course will only be offered to students with strong mathematical backgrounds and science, technology, engineering and mathematics (STEM) majors. We anticipate these students should be stronger and so we are planning to change our Technology Week ideology slightly. The students will change topics mid-week instead of working on the same topic all week long. This ideology was run in one section of advanced students with mixed review last academic year.

As we have learned this past academic year, there are a plethora of opportunities to use technology in math courses to provide an interdisciplinary learning environment. Running an interdisciplinary program is very difficult. One of the keys is to have buy in from other disciplines. We recognize that it will easier in Calculus courses because of the prerequisite nature of Calculus. Many of our STEM partners feed off of the foundations we lay in Calculus and we can exploit that. We exploit it by using technology to deepen our students understanding of mathematical concepts through interdisciplinary applications.