Mathematical Special Forces at West Point

Captain Ian McCulloh and Cadet Stephanie Mikitish, USMA, Department of Mathematical Sciences

SGM Martin wipes the sweat from his brow as he reviews the infiltration and exfiltration capabilities of the six differently qualified Special Forces (SF) teams. He needs to familiarize himself with the capabilities of each team. Then he can advise 2LT Vargas, the battle captain, which soldiers would be best qualified to handle each mission. Unfortunately, there is a problem. The Plans NCO, SSG Ching, has not told the Operations NCO, SSG Primack, what the mission objectives are. SSG Primack knows the locations of each mission's targets, but he cannot contribute his information until he knows which missions are most important. As SGM Martin looks at the faces of the other three soldiers that make up the Forward Operating Base (FOB) of the 1st Battalion, 11th Special Forces Group (Airborne), he thinks, "This is not exactly what I bargained for when they signed me up for Math 103."

In reality, 2LT Vargas, SGM Martin, SSG Primack, and SSG Ching are not (yet) part of the Special Forces. All four are currently 4th Class cadets – freshmen – at the United States Military Academy (USMA). They have no actual experience as officers commanding troops. In fact, neither they nor the rest of the cadets in their MA103 class even knew how a Special Forces FOB planned missions until 26 August 2004.

On that day their instructor facilitated a problem-solving practical exercise wherein cadets role-played different positions in an FOB. Students were organized into small groups of four or five. Their task was to plan seven different SF missions. Each cadet was given different information pertaining to his/her role in the FOB, capabilities of the SF teams, and constraints bearing on the problem – essentially an assignment problem with six SF teams and seven missions. The constraints were the types of missions and the capabilities of the SF teams: not every team is capable of performing every mission. The cadets had to assign missions to the SF teams without the luxury of sufficient time to evaluate all possible assignments.

The Department of Mathematical Sciences at USMA has recently revised the structure and content of the core mathematics program. This change better supports the USMA academic goals – specifically, helping cadets with "becoming capable problem solvers and developing [the ability to] deal with the issues of the military profession and society" [2]. To this end, instructors dedicate the first two weeks of MA103, the core freshman math course, to problem solving. By placing an emphasis on applied mathematics, through modeling and the use of effective strategies for solving problems, cadets learn to solve complex and often ill-defined problems. Students who can firmly grasp sound problem-solving techniques are better able to understand fundamental ideas and principles in mathematics, science, technology, and engineering [1, 2, 3, 6].

The issue of defining and teaching a problem solving process can be as challenging as the problem itself. George Polya initially proposed a general problem solving process in 1945 [4]. Polya's process is characterized by four main steps: Understand the Problem; Devise a Plan;

Solve the Problem; and Look Back. The problem is defined in the first step. As part of "Understand(ing) the Problem," one organizes the given information, constraints, and assets and attempts to identify similar problems that might have been solved already. "Devise a Plan" requires developing one or more approaches to solving the problem based on the information organized in the previous step. The "Solve the Problem" step is self-explanatory. Finally, the "Look Back" step not only reviews the solution for potential errors but also looks for improvements to the solution. To fully understand this process, cadets apply problem-solving to some tangible yet open-ended problem. Forty-eight out of fifty cadets (surveyed after the exercise) remarked that an application of Polya's method was very helpful for their understanding of a problem-solving process. In addition, the cadets also felt that the exercise was fun and relevant to their future careers as Army officers.

In this exercise, the class was divided into groups of four or five students. Each of the students took on a role that corresponded to a position in the FOB of a Special Forces battalion. The four roles included the battle captain, the intelligence officer, the operations NCO, and the plans NCO. The battle captain was responsible for leading the team in assigning seven different missions to six different notional SF teams. The other three members of the FOB each had unique information that they had to share with the group in order to effectively assign missions. The intelligence officer reviewed the imagery of the target areas and a target intelligence packet containing six pages of notional information about the target area. The salient information was the terrain and weather effects that would dictate appropriate means of infiltration for each target. Table 1 shows the potential methods of infiltration for each target. Water infiltration requires an SF team to be certified as Self-Contained Underwater Breathing Apparatus (SCUBA) or as Marine Operations (MAROPS). High Altitude Low Opening (HALO) infiltration requires a team to be qualified in free-fall parachute techniques. Table entries of "Any" indicate that any SF team can infiltrate the target to complete the mission.

Mission Target	Infiltration Technique
Target 1	Water
Target 2	Water
Target 3	Any
Target 4	HALO
Target 5	Any
Target 6	Any
Target 7	Any

Table 1. Intelligence Officer's Infiltration Constraints

For the intelligence officer, this collection of required infiltration capabilities represents the constraints bearing on the problem.

The operations NCO was given a similar set of constraints. He knew which of the fictional SF teams could conduct missions, what their infiltration capabilities were, and what missions they were best qualified to perform. Each of the six SF teams was trained in two SF missions and in different infiltration techniques. Table 2 displays the team capabilities; mission codes are taken to represent particular SF missions.

SF Team	Infiltration Capability	Trained Missions
142	MAROPS	DA, SR
144	--	DA, PR
151	HALO	UW, SR
154	--	DA, SR
164	--	CT, PR
166	SCUBA	CT, SR

Table 2. Operations NCO's SF Team Capability Constraints

The plans NCO looked over three separate task orders containing seven missions. The task orders also contained a great deal of coordinating instructions and other information that did not bear on the group's problem of assigning the missions. This required the group to identify what was important for understanding their task of assigning missions to SF teams. Figure 1 shows a diagram that matches SF teams with potential missions based on the requirements, capabilities, and constraints described above.

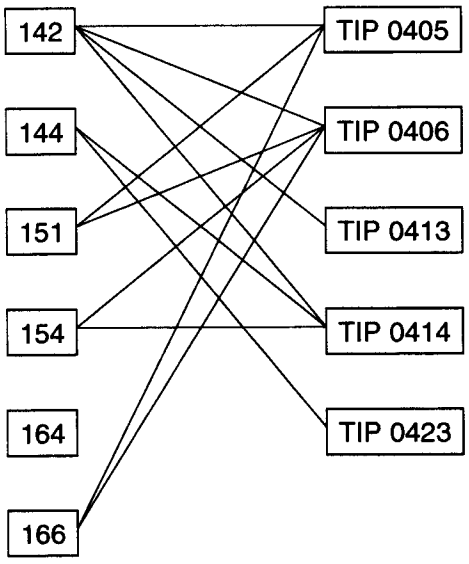

Figure 1. SF Teams Matched with Potential Missions.

Group members had to communicate effectively in order to succeed at this exercise. Failure to sort out important information and share it with the group could significantly slow down the problem of assigning Special Forces teams to missions. The most crucial step was defining and understanding the problem. Teams that tried to take shortcuts around this step were not successful and found that they were better off following the problem-solving process taught in class. Next, the FOBs would devise a plan for assigning the missions to the SF teams. The proposed plans varied from trial and error to the use of network theory. When the groups finished carrying out their plans and assigned all missions to SF teams, the groups were able to look over their decisions. In some cases, they revised their solutions and made them better. As a mathematician, it was very satisfying to see that the students who used an analytical technique did not have much need to revise their plan. On the other hand, cadets using trial and error needed to make several revisions and in some cases never developed a completed plan in the fifty minutes allotted for the exercise.

So, what was this assignment like from a student's perspective? Overall, it was a very effective lesson for demonstrating the benefits of using a problem-solving process. For the first two weeks, the only topic covered in MA103 was the problem-solving process. In some ways this process makes finding answers too simple. Since many fourth class cadets could solve the problems in class with relative ease, writing out the steps was just an exercise in documentation. Therefore, it was easy to just go through the motions, instead of actually solving the problems in a systematic way. However, learning how to

solve problems systematically is an important skill for an officer to know. Therefore, this exercise provided a way to show the relevance of the problem-solving process in the military.

The Special Forces exercise showed the fourth class cadets how vital effective problem solving is. Since most fourth class cadets were unfamiliar with how to organize information and assign troops to missions, the exercise forced them to break the complex information their instructor provided them with into simpler pieces. In other words, they had to pay attention to every detail in their information sheets, and share the relevant data with the other members of the FOB. Then they had to collectively plan out the missions. If one member did not supply the necessary information, or the group left out important details, the planning process stopped. Thus, students learned why effective planning makes problem solving easier. After the exercise, nearly all of the cadets participating in the exercise commented that the Special Forces Problem was the single most effective means of teaching them the problem-solving process. More importantly, in an anonymous survey, over ninety-two percent of the cadets participating in the exercise now believe that mathematics is critically important to their success as a future Army officer. Thus, the Special Forces problem was an excellent exercise that engaged cadets, motivated them to have fun with mathematics, and instilled a great foundation in problem solving that will foster success throughout their core mathematics program at West Point.

REFERENCES

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