6.1 Virginia Demonstration Project Encouraging Middle School Students in Pursuing STEM Careers

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Jane T. Bachman
Naval Surface Warfare Center Dahlgren Division

Dr. Dena H. Kota
Naval Surface Warfare Center Dahlgren Division

Aaron J. Kota
Naval Surface Warfare Center Dahlgren Division

Abstract. Encouraging students at all grade levels to consider pursuing a career in Science, Technology, Engineering, and Mathematics (STEM) fields is a national focus. In 2005, the Naval Surface Warfare Center, Dahlgren Division (NSWCDD), a Department of Defense laboratory located in Dahlgren, Virginia, began work on the Virginia Demonstration Project (VDP) with the goal of increasing more student interest in STEM education and pursuing STEM careers. This goal continues as the program enters its sixth year. This project has been successful through the participation of NSWCDD's scientists and engineers who are trained as mentors to work in local middle school classrooms throughout the school year. As an extension of the in-class activities, several STEM summer academies have been conducted at NSWCDD. These academies are supported by the Navy through the VDP and the STEM Learning Module Project. These projects are part of more extensive outreach efforts offered by the National Defense Education Program (NDEP), sponsored by the Director, Defense Research and Engineering. The focus of this paper is on the types of activities conducted at the summer academy, an overview of the academy planning process, and recommendations to help support a national plan of integrating modeling and simulation-based engineering and science into all grade levels, based upon the lessons learned.

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Bachman, Kota, Kota

1.0 INTRODUCTION

Since 2005, the Naval Surface Warfare Center, Dahlgren Division (NSWCDD), a Department of Defense laboratory, has been working on National Defense Education Program's (NDEP) Virginia Demonstration Project (VDP) with the goal of increasing student interest in Science, Technology, Engineering, and Mathematics (STEM) education. One of the VDP STEM focus events is conducting a summer academy for middle school-age students. During this week-long event, students participate in a variety of STEM activities. Provided in this paper is an overview of the academy planning process and a focus on the types of activities selected and conducted during the academy.

1.1 Academy Planning

The planning for a summer academy event is a year-long process. Planning consists of coordination of the event dates, facility, mentors, schools, activity selections, mentor and junior mentor training, scheduling, supply and/or inventory, and execution. The first objective is to organize a STEM Academy Planning Team, consisting of scientists and engineers (S&Es), academia, and a middle school teacher.

1.2 VDP STEM Academy Planning Team

The team meets once a month, addressing planning activities identified in an academy timeline developed at Dahlgren. The main goals of the team are to select the academy dates, review and select the STEM activities, assign leads for each activity (most activities are conducted by the mentors, but during mentor training and academy week, the authors found it beneficial to have an assigned activity lead), selection of a facility to host the event, and train mentors and junior mentors. The planning team becomes the staff executing the academy event.

1.2.1 Director and Coordinator

The academy staff has a director and a coordinator. The director manages the collaboration between mentors, schools, facility, and training as well as leads the monthly planning team meetings. The coordinator handles the coordination between publications, supplies, equipment, tools, inventory, and academy scheduling.

1.2.2 Academy Training

The VDP STEM Academy Planning Team conducts a three-day training event for all mentors participating in the academy. In addition, the junior mentors receive training during one of the three days. All mentors receive ethical training as well as training on inquiry-based learning techniques. The academy schedule, rules, procedures, and activities are discussed with the mentors. Exploratory laboratory time is worked into the training schedule to give mentors additional time to spend on any one of the activities discussed. Mentors are exposed to all student activities, including team building.

2.0 ACADEMY ACTIVITIES

Each STEM activity is reviewed and selected by the planning team with the goal of providing a wide range of STEM activities that cover multiple careers for the students. Once an activity is selected by the team, an activity plan is derived and finalized for the mentor manual. Upon complete selection of the academy activities, a schedule is formulated for the week. Students this year were given the opportunity to explore STEM careers in life science, robotics, tower design/construction/design presentation, and data collection and analysis through water rocket activities. Students also participate in laboratory demonstrations, listen to guest speakers discuss their STEM careers, and learn about team communication and collaboration skills. There is very little downtime during the day for the students. Students are equipped with a summer academy student manual containing their activities and the information they need during the week.

Older students participate in a Junior Mentor program during the academy. Half of their day is spent carrying out academy administrative duties, while the other half is spent working on an assigned robotics project. Test engineers are one of the roles that a junior mentor serves when conducting administrative duties. This year, the project was to build a robot that could navigate a maze.

2.1 Activity Descriptions

- Team Building. Mentors are provided several team-building activities that they can help facilitate. The team derives a name and constructs a poster that will host their mission completion tags.
- Life Science. Two life-science activities are conducted to simulate the types of ongoing research at naval laboratories. Students learn about the spread of an epidemic and possible methods used by scientists to combat such types of warfare (see Fig. 1).

Figure 1. Life Science Activity

- Tower Building. This consists of several phases of work for the students. First, the student team decides on a design for their tower. Second, they construct the tower (see Fig. 2), followed by testing the strength-weight ratio. To conclude, the team formulates its design into a presentation that is given in front of an invited panel. At the conclusion of the team's presentation, the panel conducts a question-and-answer period.

Figure 2. Tower Construction Activity

- Water Rockets. Students construct a water rocket and conduct several trial tests to gather data. Following data analysis, the students decide on final measurements and conduct a final water rocket test to achieve the highest launch possible (see Fig. 3).

Figure 3. Water Rocket Activity

2.1.1 Robotics

The robotic activity contains eight missions. Mission rules are established to provide some boundaries; however, team creativity is encouraged. Robotics boards contain a challenge mat denoting the home base location, island, troop rotation, humanitarian aid drop area, ship rescue area, and dry dock. The 'Map the Underwater Surface' has its own table designed to represent underwater terrain. Teams can test as many times as they want (see Fig. 4) prior to a test engineer witnessing the final mission test.

Figure 4. Robotic Missions

- Rescue the Swimmer. Team members will need to rescue a swimmer. Starting from home base, the robot must be capable of maneuvering around the island, grabbing the swimmer from a known location, and bringing the swimmer to shore by any means. The robot may use any sensor available to the team including the rotation sensors built into the motors.
- Troop Rotation. Team members must transport troops from home base to a specific troop location across the water that already contains a group of troops on a platform. Troops must not touch the water during transport. The troops must be wholly within the drop-off area, and the robot may not run over them on the return trip. The robot must return the original troops stationed at this location to home base. There must always be a minimum of five troops at the designated location., and troops are not to be mixed during the transfer. The robot must use at least two sensors.
- Recover the Ship. Team members will recover the damaged ship and bring it back to home base by any means. If the robot turns the ship on its side or flips it, the mission must be reattempted. The robot must use at least two sensors.
- Create an Early Warning Structure. Team members will need to design a stationary early warning structure containing an NXT brick that will act as a signaling device. The structure will be placed where the lighthouse is located on the challenge board. A test engineer

will then start a robot from home base and direct its movement toward the tower. As a robot approaches the structure, a series of signals must indicate the distance from the robot to the tower. These distances should be broken into three range groupings each of which corresponds to a unique signal: more then 10 inches away, 10-4 inches away, and less than 4 inches. Teams may select whatever signaling method they would like. Examples include three colored lights, changing the NXT display, or variations in tone. Note: Each team should have, for the test engineer, a programmed robot able to approach the early warning structure at a slow-to-moderate pace during testing.

- Recover Beacon. Team members will need to detect and recover an infrared (IR) beacon located somewhere in the water. The test engineer may place the beacon anywhere within the beacon placement area (see map of robotics board). Each team searches the area and captures the beacon. The robot must use at least an IR seeker.
- Map the Underwater Surface. Team members will need to create a map of underwater terrain using the ultrasonic sensor and the data collection features of the robotic software. The map must provide depth and inches traveled in inches. It should be scaled properly and reported to a test engineer on graph paper.
- Dry Dock. The teams' robots will need leave from home base, drive up onto the top level of the dry dock, display a message, remain there for five seconds, drive off of the dry dock, and return to home base. The robots may use any sensor available to the teams including rotation sensors built into the motors.
- Humanitarian Aid. Each team must deliver five crates of humanitarian aid to the designated location. The robot may use any sensor available to the team including the rotation sensors.

2.1.2 <u>Academy Token Plan</u>

The VDP STEM Academy Planning Team generated a plan where tokens serve as the students' form of currency for the week. Each time a team attempts to complete a robotic mission, a token must be paid to the test engineer. The tokens provide students with an incentive program during their summer academy week. The role of 'token master' is served by a junior mentor who, under the supervision of the academy director, is in charge of distributing tokens. Teams begin the week with 10 tokens and the plan details events throughout the week in which teams can earn tokens based on their accomplishments and teamwork.

3.0 LESSONS LEARNED

Following the academy, the VDP STEM Academy Planning Team's first meeting is to identify the lessons learned and to discuss the "do's and don'ts" for next year. Below is a list of this year's lessons learned.

- Facility. A gym that provides enough space for the robotic boards and sixteen team tables is ideal venue for the event.
- Teams. Seven-member teams are less favorable than five-member teams.
- Career speaker. Guest speakers opening morning sessions with a 10-15 minute brief on their careers is beneficial.
- Early arrivals. Students can watch LabTV while waiting for other buses to arrive to the academy site.
- Robotics. Add robotics refresher training time for junior mentors.
- News flash. A daily academy news board that junior mentors can coordinate and monitor should be considered.
- Rocket launcher. Teams discovered that this year's launcher operated better than last year's (see Fig. 5).

Figure 5. Water Rocket Launcher

- Internet access. Student teams use the Internet for research into tower building and for generating their briefs.
- Junior mentor project. The academy team agreed that the maze navigation was a good project for this group.
- Laboratory demonstrations. The academy team used this activity, which the students enjoyed, as one of the focal points (see Fig. 6) on the last day of the academy.

Figure 6. Student Laboratory Demonstration Participation

4.0 CONCLUSION

The NDEP VDP STEM Summer Academy program provides middle school students with "hands-on" activities that contain challenges in both robotics and engineering problems. Teaming middle school teachers with practicing S&Es at NSWCDD is one way the VDP STEM Academy generates student interest in math and science. With respect to integrating modeling and simulation (M&S)-based engineering into the program, the planning team used simulation in two life science activities: directing students build a tower model and organizing the robotic challenges so that the students built and programmed a robot to simulate a Navy initiative using sensors and motors. The academy team recommends the following considerations:

1) Involve a math and/or science teacher of the targeted grade early in the activity decision-making process. The teacher can assess the activity with the skill set the students have and determine whether the M&S activity is acceptable.
2) Run through the exercise prior to the planning team's activity review.
3) Generate an M&S activity plan to include purpose, design, analysis, and test.
4) Prepare training material for the mentors that includes all pertinent information regarding the activity.
5) Evaluate the results from first use of the M&S activity, and determine if adjustments are needed or if the activity should be removed from the curriculum. The VDP STEM Academy planning team decided to change the junior mentor robotics project to maze navigation this year, which the junior mentor team successfully concluded.
6) Create team roles that allow students to hold a responsible lead for the team. Roles may include data manager, team supply manager, robotic maintenance manager, and water rocket data recorder.
7) Collect feedback from mentors at the end of the event and use for future improvements.

In conclusion, providing a working environment experience where students can sense the why, what, and how things are done through interaction with S&Es and math and science teachers can benefit them when they begin making career decisions.

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