An Integrative STEM Experience Onboard a Research Vessel

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ABSTRACT

The Grand Valley State University Annis Water Resources Institute (AWRI) operates a unique outreach program onboard its research and education vessels that provides STEM experiences for K-12 students. Since 1986, over 144,000 students and others have experienced Lake Michigan and adjoining waters through AWRI's Water Resources Outreach Education Program. Offered aboard two research and education vessels, the program mainly serves school groups. Trips can be customized for all ages from fourth grade through adults. Onboard the vessel, students conduct hands-on water quality testing for a variety of parameters. Data from individual trips is aggregated with data collected by other groups and it is available for classroom use. Since 1996, the AWRI has hosted middle school students from a local school district that has 47.1% minority population. The majority of these students have never been out on the water on a boat until this trip. As "scientists" during their trip, they are able to have an authentic STEM experience that helps to spark their interest in STEM fields.

Keywords: STEM, Conference Proceedings, K-12 Outreach

INTRODUCTION

AWRI operates two specially designed and outfitted research vessels that accommodate student groups who participate in hands-on water quality testing in Lake Michigan and its adjoining waters. Since 1986, over 144,000 students and others in grades 4 and up have participated in onboard programs. The vessel season is late April through mid-October. In 2.5 hour cruises led by two certified K-12 teachers, students are the "scientists" conducting water quality analyses.

From the inception of AWRI's science cruises, the goals of the program have been to foster student interest in science, provide a hands-on experience with scientific instrumentation, and serve as a central experience for further exploration of water-related issues in the classroom. Outcomes of the vessel experience are science-related, but they fall within the realm of environmental education as well. The program fosters a greater understanding and appreciation of the Great Lakes environment and increased scientific knowledge for informed decision-making. Stimulation of critical thinking, increased problem solving skills, and science concept development are other anticipated outcomes.

LITERATURE REVIEW

In depth studies of aquatic education programs are limited but major research has been led by Dr. Rosanne Fortner of The Ohio State University (Fortner *et al*, 1991). Positive attitudes about the oceans and Great Lakes were correlated with higher knowledge scores, but there was overall a low level of marine knowledge among students living in a coastal zone. Ohio students knew more about the ocean than the Great Lakes (Fortner and Lahm, 1990). An evaluation of program impacts of Michigan Sea Grant's onboard Great Lakes Education Program revealed a highly significant increase in Great Lakes knowledge and a significant increase in girls' positive

attitudes toward the Great Lakes (Williamson, 1999). Similar gains have been documented by other Great Lakes schoolship programs. Strong associations have been found between involvement in informal/nonformal science and intentions for further study of science (Tamir, 1990/91).

Novelty and the field trip quality are important educational variables (Orion and Hofstein, 1994). Adequate preparation of students in the cognitive, geographic, and psychological aspects of the trip helps to minimize the distraction of a novel experience (Orion, 1993). Focusing students prior to the experience, fostering responsibility and awareness during activities, and debriefing are all important elements of this type of the experiential (hands-on, process-oriented) learning cycle. Our instructional video for the program helps to prepare students for their experience on the vessel and guidance by our team of science instructors keeps students on task.

METHODOLOGY

In this onboard integrative STEM experience, students to explore biological, physical, chemical, and socio-political aspects of water quality as they assume the role of scientists. Water quality is defined in terms of physical, chemical, and biological parameters with respect to a certain use. For instance, acceptable water quality for warm water fishes would not be optimal for cold water fishes, and standards for drinking water differ from those for boating and recreation. No single factor alone indicates good water quality, and water quality in a body of water can vary with the season and location. Long-term water quality measurements from well-defined locations are needed to tell if conditions are changing or remaining the same. Water quality measurements in turn provide the scientific foundation for policy and regulatory decisions.

Specific water quality parameters addressed in the vessel experience are:

Biological – plankton, invasive species, benthos

Chemical – pH, dissolved oxygen, conductivity, alkalinity, phosphorus, nitrate

Physical – depth, transparency, turbidity, color, waves, currents, temperature

Students use a variety of instruments as they take their measurements that range from sophisticated turbidity meters and pH probes to simple water quality testing kits. They learn about precision and accuracy as they make replicate measurements. The onboard science instructors lead a discussion on the significance of the findings. The aggregate of data that has been collected is reviewed to answer the question about what the quality of the water is that day.

As outlined in the *Framework for K-12 Science Education* (National Research Council, 2012) three dimensions (practices, crosscutting concepts, and disciplinary core ideas) are part of a high quality science education. On cruises, students engage in scientific investigations (practice) that link domains of science (crosscutting concepts) while exploring core ideas related to water. They also have the opportunity to explore the meaning of the data, data quality issues, and implications for stewardship of freshwater resources. An educator's guide that covers water quality parameters in more depth and an alignment document with current science standards are available. Student data sets for analysis can be used back in the classroom.

Although the program is open to any classes, the vessel program has targeted local disadvantaged youth. In 1996, AWRI recruited an area school system that has a 47.1% minority population and almost all students are eligible for free lunches. This is the first time that many of these local urban students have been on the water and experienced Lake Michigan, even though they live within a few miles of the lake. They are able to participate in an authentic STEM experience that highlights research happening right in their own community.

Presently, the vessel program is evaluated through teacher surveys and informal discussions with students. Teacher focus-groups and pre-post tests have been other evaluation instruments. The evaluation results indicate a high degree of teacher satisfaction with the program in both the delivery and meeting educational standards. Student knowledge gains as measured through pre- and post-tests have been significant. As with most single-event field trips, it is a challenge to fully evaluate the future impact on students. However, anecdotal evidence through thank you notes from students and comments from teachers indicate that they regard their vessel experience as a significant real world STEM experience.

CONCLUSION

Getting students out on the water and into an environment where scientists work is a unique way to engage students in STEM activities. This experiential and integrative STEM program aligns well with the focus of the *Framework for K-12 Science Education.*

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AUTHORS' INFORMATION

Dr. Janet Vail manages the outreach and education programs at the Grand Valley State University Annis Water Resources Institute. She has a Ph.D. in Science Education with a specialization in environmental education. Dr. Vail is the Michigan Coordinator for Project WET (Water Education for Teachers) and is author of two units for the Michigan Environmental Education Curriculum Support project.

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