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Learning Science through Research

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Abstract- The Learning Science through Research program enhanced middle and high school science education by linking it with state-of-the-art research through a two-part program. The program's professional development workshops for secondary science teachers provided background information on ocean sciences and related research through a 3-day summer workshop and a 1-day workshop, which directly addressed the student research experience. The program's second component, the student lessons, included pre-and post-trip classroom activities and a field trip to our research facility. This research experience provided students with the opportunity to conduct experiments using first-rate instrumentation and technology. The program engaged over 2500 students in the process of inquiry by conducting research activities related to locally relevant coastal ocean environmental problems.

Keywords- Science Education; Science Research; STEM

I. INTRODUCTION

Recent studies have suggested that we, as a Nation, are falling behind in science and mathematics, particularly at the upper levels of secondary education[1] and, in fact, the situation has worsened over the past five years[2]. Relatively few students relate to scientific concepts or understand scientific processes[3]. The rejuvenation of our education system in the fields of science, technology, engineering, and mathematics (STEM) remains a priority in the United States[4,5]. Leaders in the science and education communities suggest that to initiate this reform, we must provide stimulating, hands-on activities for students that are research-based and that link our already world-class research in the diverse science disciplines to the classroom[6,7,8].

Partnerships between research and formal education institutions can establish the necessary links to open-ended, real-world explorations that make science come alive for students and can help bridge the gap between current scientific research and the secondary classroom, ultimately improving student achievement in STEM disciplines[9]. Without relevant programs to enhance student achievement, students may have difficulty mastering the rigorous content of science and mathematics disciplines. Students learn science by doing science that is rich in concepts, skills and processes. The spill over into student achievement in the other content areas cannot be underestimated.

To make science interesting and to capture student's interest in today's world, science must cross disciplines and be presented in exciting, lively forms[10]. Ocean science holds a unique position in science education in that it crosses all of the STEM disciplines in one area of study, which is locally relevant to over two thirds of the Nation's population. The use of the local environment as a context for learning can improve student performance (11), therefore, activities designed to engage the student in problem solving through hands-on, locally relevant experiments can enhance students' interest in STEM disciplines.

II. THE PROGRAM

The *Learning Science through Research* program served to enhance science education in local schools by linking it with state-of- the-art research over a period of four years. The two-part program provided middle and high school science teachers (10) from local districts (Talbot, Wicomico and Dorchester County Public Schools in Maryland) with background information on ocean science research conducted at the University of Maryland Center for Environmental Science Horn Point (UMCES HPL), Cambridge, Maryland, USA research laboratory and their middle and high school students (2500 over four years) with field experiences based on this research. The goal of the program was to establish an inquiry-based research experience for middle school students that incorporated UMCES HPL science research, supported the school district curriculum, and were locally relevant. We focused on five specific research areas that were chosen by the school districts: photosynthesis and seagrasses ecology, dead zones, ocean observing systems, wetlands and sea level rise and aquatic microbes food webs (please see http://www.teachoceanscience.net/teaching_resources/stem_lessons/ for details.

The objectives were to:

- match school curricula and content with UMCES HPL research projects
- provide teacher professional development in content and implementation of research projects
- conduct research experiences for students at UMCES HPL
- conduct follow-up activities in the classroom.

The program was designed with a *develop, implement, evaluate* and *refine* model for implementation to assure a well-developed, sustainable program. The components included teacher professional development, student learning activities, and extensions of activities (Table 1).

TABLE I. COMPONENTS OF THE LEARNING SCIENCE THROUGH RESEARCH PROGRAM

*Summer Teacher Professional Development Workshop (3 days)
*Teacher Professional Development for Student Learning Activity (1 day)
*Student Learning Activity Preparation (3 days)
*Student Learning Activity Field Trip (1 day)
*Student Learning Activity Reflection (3 days)

A. *Summer Teacher Professional Development Workshops*

A 3-day summer teacher workshop for science teachers from our partnering school districts was implemented to improve teacher understanding of ocean science and current research conducted on this topic. The first two days of the summer workshop consisted of presentations by scientists, hands-on research activities and field trips to provide the teachers with a comprehensive understanding of ocean science research. The final day focused on the application of the content material to the classroom.

B. *Teacher Professional Development for Student Learning Activity*

The second component of the teacher professional development was a 1-day in-service workshop conducted within one month of the student field trip to UMCES HPL. These workshops specifically focused on the Student Learning Activities, where teachers received instruction on pre- and post-trip activities and on the experiments conducted during the students' field trip to UMCES HPL. The teachers followed the same agenda as their students and conducted the field trip experiment and data analyses. Finally, teacher input and comments were used to refine the Student Learning Activities as needed.

C. *Student Learning Activity*

Over the duration of the program we developed and refined the Student Learning Activities based on the curriculum of local school districts and on feedback provided by the teachers. Each activity consisted of three components:

1) *Preparation (3 days)*

Teachers prepared students for the field trip by conducting pre-trip lessons in the classroom. They capitalized on the information they received in the Professional Development activities described above. For example, in our *Photosynthesis and Seagrass Ecology* activity, teachers prepared students by conducting three lessons prior to the field trip. The topics for these lessons included 1) light requirements for photosynthesis in plants, 2) oxygen production in photosynthesis and oxygen consumption in respiration and 3) general submerged aquatic vegetation (SAV) ecology from online slide presentations. Similar pre-trip lessons were developed for each Student Learning Activity associated with the five research areas mentioned above.

2) *Action (1 day)*

Next, the teachers brought their middle and high school students for a one-day field trip to UMCES HPL to conduct research-based experiments in teams of 4-5 students. The experiments focused on data sharing, research skills, use of research equipment and technology.

3) *Reflection (3 days)*

Finally, teachers reviewed the data collected from the field trip experiment with their students upon return to the classroom. Teachers made sure that all students shared their experimental data, completed all calculations, graphed data where appropriate, and formed conclusions based on the results. Connections to environmental issues were also made to promote a sense of stewardship. Although teachers received detailed instruction concerning all data analysis and interpretation, additional support was provided for this reflection period through classroom visits from UMCES HPL staff, where results from experiments were explained in the context of the research areas.

III. PHOTOSYNTHESIS AND SEAGRASS ECOLOGY: A STUDENT ACTIVITY

Our *Photosynthesis and Seagrass Ecology* activity serves as an example of how this type of program linking a research institution with local schools can be implemented. Several faculties at UMCES HPL focus on aspects of seagrass biology and ecology in their research, while Maryland state education standards require middle school students, our target grade level for this activity, to learn fundamental concepts associated with photosynthesis and respiration. Based on the expertise of UMCES HPL researchers and the needs of educators to address school curricula, we designed an activity that is age appropriate yet scientifically rigorous to supplement classroom material with hands-on learning.

As outlined above, the Learning Science through Research program involves pre-trip preparation, a student field trip to UMCES HPL, and post-trip follow-up. In this case, prior to the field trip, teachers learned about seagrass ecology during the three-day summer workshop and they helped us revise the student activity during the one-day in-service workshop. In the weeks leading up to the student activity, teachers covered photosynthesis and respiration in their life science classes and taught several lessons on how these concepts can be applied to seagrass ecosystems. As a result of the pre-trip activities, teachers developed background knowledge in the activity topic and were then able to provide effective instructional scaffolding to prepare students for the field trip, as evidenced by the preparedness of the students during the field trip activities.

The field trip activity was structured so that students carried out the same investigative process used by scientists. We started by presenting the students with a problem. In this case, they viewed a short (5 min) documentary film (http://www.teachoceanscience.net/teaching_resources/education_modules/seagrass/get_started/), which discussed how seagrasses have disappeared from their local estuary and that the water has become more turbid due to various forms of pollution. Next, we facilitated a discussion to highlight their relevant background knowledge and to develop, as a group, a hypothesis stating why the seagrass disappeared based on this information. Though the wording of the hypothesis varied with each group, generally students postulated that because seagrass requires sunlight to photosynthesize, the plants disappeared due to lack of light in turbid water. We then challenged the students to prove their hypothesis quantitatively.

The next step was for students to carry out an experiment that provided evidence to support their hypothesis. They placed equal-sized seagrass shoots into three bottles of water, one of which was completely shaded, while another allowed 50% light penetration, and the third was unshaded. They used a hand-held water quality sonde to measure and record the initial dissolved oxygen concentration in each bottle and; after incubation in the sun for several hours, they measured and recorded final oxygen concentrations. Finally, students calculated the change in oxygen in each bottle. Results showed an increase in oxygen in the unshaded bottle, a slight increase in the half shaded bottle, and no increase in the dark bottle (in fact oxygen decreases in this bottle due to respiration), which demonstrated that shading negatively impacts photosynthesis in seagrass.

Finally students participated in an interactive demonstration in which they physically acted out several concepts related to the decline of seagrass (http://www.teachoceanscience.net/teaching_resources/ocean_science_curriculum/ocean_and_humans_are_connected/). Students learned that excess nutrients and sediments entering local waters from human sources in their watershed have resulted in increased turbidity. This naturally led to a wrap-up discussion in which we guided students in relating the real-world observation of reduced water clarity to the results of their experiment. In the end, they understood that elevated turbidity, represented by shaded bottles, has a detrimental impact on seagrass photosynthesis and is thus a likely cause of seagrass decline. During this discussion, we also encouraged students to list actions they can personally take in order to minimize their own contribution to these forms of pollution.

Following the field trip, teachers asked the students to write a simple scientific paper to formally report and discuss the results of the experiment. In the paper, students developed a brief introduction by drawing from the concepts covered during the field trip and additional references provided by teachers, they graphed their results, and they explained the significance of their results by translating the field trip wrap-up discussion into their own words. The post-trip follow-up assignment allowed students to organize the complex concepts learned, it encouraged students to be accountable for their learning, and it allowed teachers to evaluate students' learning.

IV. CONCLUSION

The Learning Science through Research program engaged students in the process of inquiry in the same manner employed by professionals in the STEM fields. By conducting the activity at an established research institution and asking a question related to a locally relevant ongoing problem, over 2500 students have gained a more in-depth sense of how their learning is applicable to real world issues. Teachers reported (personal communication) an increase in student learning as a result of the program and were very satisfied with the outcomes as was evident in their return year after year. Although evaluation was not a direct part of this project, one school district (Dorchester) reported a 13 point increase (from 2007-2010) on the 8th grade Maryland middle school science assessment (MSA), in part due to the impacts of this project. In addition, the process of training and working closely with teachers was critical to such a program. As they helped develop the student activity, their confidence in implementing more open-ended research-based lessons in their classrooms increased (personal communication with teachers). The Photosynthesis and Seagrass Ecology activity is just one example of how this type of program can be implemented. Numerous possibilities exist for linking research to school curricula, and the rewards for all involved—from students and teachers to research scientists and graduate students—are unlimited.

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REFERENCES

[1] TIMSS 2009. Trends in International Mathematics and Science Study. 2009 (http://nces.ed.gov/timss/).

[2] National Academy of Sciences. 2010. Rising Above

a) the Gathering Storm, Revisited: Rapidly Approaching

b) Category 5. http://www.nap.edu/catalog/12999.html.

[3] American Association for the Advancement of Science, *Project 2061*. (http://www.project2061.org).

[4] National Academy of Sciences. 2007. Rising Above the Gathering Storm. National Academies Press, Washington, DC.

[5] Obama, B. 2009, http://www.whitehouse.gov/the-press-office/president-obama-launches-educate-innovate-campaign-excellence-science-technology-en).

[6] National Research Council. 1996. *National Science Education Standards*. Washington, DC: National Academy Press.

[7] Lubchenco, J. 1998. Entering the century of the environment: A new social contract for science. *Science*. 279: 491-497.

[8] Colwell, R.R. 2009. New Year, New Administration, New Opportunities. *Bioscience*. Vol. 58, no. 11.

[9] Silverman, P.M., 2009. "The Research Dynamic: A Professional Development Model for Secondary School Science Teachers," *CBE Life Sci Educ* 8(2): 123-130.

[10] Wallis, C. and Steptoe, S., 2006. "How to bring our schools out of the 20th century," *Time* (10 December), at http://www.time.com/time/printout/0,8816,1568480,00.html.

[11] Lieberman, G.A. and L.L. Hoody. 1998. Closing the Achievement Gap: Using the Environment as an Integrating Context for Learning. State Education and Environment Roundtable. Science Wizards, Poway, CA. 106 pp.