Interdisciplinary Professional Development Program for Teachers

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ABSTRACT

This professional development program has been designed to increase the integrated science content, pedagogical, and technological knowledge of teams of middle and high school teachers in Ohio. The selected schools are high need areas with an overall average from these school districts serving a population of 63% students who are economically disadvantaged. The 24 teachers participating in this program each year serve as catalysts and mentors to other teachers, and has driven curriculum change in these districts. This professional development program has effected these changes by using a three-phase research based approach to classroom educator training with hands-on experiences. Phase I is composed of a one week field experience followed by a week long laboratory experience. The field trip involves participants to the Atlantic Ocean to study the physical and biological processes that interact to form the modern ocean environment compared to the ancient ocean sediments preserved in the Atlantic Coastal Plain around the Duke University Marine Laboratory and research institute. The field experiences are founded in guided and constructivist based questioning content and pedagogical understandings.

Following the inquiry based field trip, participants gathered for a week of laboratory work, participating in inquiry based learning with samples collected from the field, and developing ideas to integrate inquiry with science activities into their own classrooms. Phase II involves a four-week long internet course designed to assist participants in developing classroom applications. The teams of classroom educators have developed, implemented and assessed inquiry based integrated science activities in their own classrooms. Phase III has an on-line course that incorporates Earth System Science with real world topics and scenarios. Support and contact with participants and project personnel is maintained during phase III of the project through frequent interactive web-conferences during the K-12 school year. Teachers participating in this program have been agents of change and have been assisting their districts with leading students to be more versed in the skills that are stressed by the National Science Education Standards and current efforts to improve STEM education.

Keywords: Hands-on /Inquiry-based learning, Professional development, Science education, Interdisciplinary program.

We developed an outreach program at Wright State University designed to provide a set of learning experiences that connect chemistry, geology, biology and mathematics for K-12 teachers throughout the state of Ohio. This outreach program is sponsored by the Ohio Department of Education to provide K-12 in-service teachers with inquiry-based experiences (AAAS, 1994; NRC, 2000). This article reports on the impact of the program on the teachers' content knowledge and self-efficacy in teaching science. Based on the analysis of pre- and post-tests and feedback questionnaire, this program successfully has assisted the teachers with augmenting their science content knowledge and confidence to teach science and math.

There were three phases of the outreach program. In Phase I, teachers visited the oceanic environmental laboratory in Beaufort, North Carolina during the summer, followed by a trip to an ancient ocean environments preserved in marine sediments of the Appalachian Mountains of West Virginia and Virginia. The teachers worked in pairs during the field trips and preformed the following assays: pH, dissolved oxygen, turbidity, salinity, alkalinity, temperature, and the concentration of phosphates, and nitrates in ocean, rivers, lakes and streams. In the field students also collected samples of rocks, soil, and fossils (sharks teeth).

Phase I:

The Investigations at the Atlantic Ocean in Beaufort, North Carolina focused on the interplay between the physical and biological factors of the seashore environments. The teachers profiled a section of the beach located along Shackelford Island (dunes, backshore, foreshore, and near shore); collected samples of shells, sand, soil, sharks teeth, and soil; calculated the speed of the shore current; and collected ocean water samples for analysis in the field. These data were then used in the lab experience portion of Phase II. The teachers investigated the sedimentary layers of sand on the beach and took digital photographs so they could compare the sediment found in the modern ocean with the sedimentary rocks found in West Virginia, and Virginia (ancient ocean). Students went out on an ocean research vessel to collect water samples at different depths of the ocean, estuary, and river. A trawl was utilized at different depths of the ocean to expose the students to various animals living in each zone. Table 1 illustrated data collected at Atlantic Ocean (estuary water).

The Appalachian field experiences included igneous, metamorphic, and sedimentary rocks which make up the Blue Ridge and Valley and Ridge regions of the Appalachian Mountains. Samples of the metamorphic and sedimentary rocks were once part of the Iapetus Ocean (father of Atlantis) were studied and compared to the modern Atlantic Ocean samples collected. Table 2 exemplified the data collected from the rocks the ancient oceans and their impact on water chemistry of the streams and rivers. The teachers were required to explain why there are differences in the pH and how the differences are related to the depositional environmental of both ancient and modern oceans (explain the significance of changes in pH near coal mines and the relationship between chemical composition of the sediments and water near the coal mines in Virginia and West Virginia.)

Phase II:

A five-day lab exercise compared the modern ocean to the ancient ocean during the summer. These inquiry-based experiences during the field trips and lab allowed the teachers to discover the nature of science and how scientific evidence is based observations. Students were engaged in experimentation and Inquiry-based investigations with all of the data and scientific observations that were collected in the field experiences. The lab experiences integrated the different sciences to analyze the various samples collected. The teachers were required to investigate the similarities and the differences among the water, sediment, rock and fossil samples collected. For example one group of teachers did an analysis of phosphate (modern versus ancient) and asked the questions: "Is phosphate present in the ancient and the modern ocean? " Fossils such as shark's teeth were analyzed at the modern ocean versus the ancient ocean to compare the phosphate concentration present. Table 3 illustrates the data that was collected and analyzed to study phosphate concentrations at different sites visited.

In addition, analysis of anion and cation concentrations in water samples led to discussions regarding changes in dissolved oxygen and other parameters in collected water samples through time, chemical weathering, the water cycle, and ocean salinity. Students compared the composition of sands versus the composition of the source rocks and predator-prey relationships among modern and ancient mollusks.

PHASE III: (FOLLOW-UP)

The Phase III is an asynchronous experience for the teachers during the fall had weekly assignments/ deadlines for interaction. Phase III, enhanced the teachers understanding of content and pedagogy by providing them with an online cooperative learning experience. This experience was inserted to assist with the development of classroom applications through utilizing peer interactions to enhance the hands-on activities in their own classrooms. Inquiry-based labs were developed such as: "What is the ideal pH for your garden soil?" "What is beach profiling- how to make a Pie chart to analyze grain size of sand?" These lessons incorporated math, graphing, geology, beach profiling, biology (plant life, turtles, clams, snails), and chemistry of water and soil.

Pre-test and Post-test were given to assess the content knowledge gained by the participating teachers. The average pre-test score was 51.3% and the average post-test score was 85.7%, resulting in a normalized gain of 0.71 for 141 teachers served with this hands-on experience course over a seven-year period of implementation. In addition participating teachers were served a questionnaire about their own science instruction as shown below, Table 4.

This professional development program has been found to be effective in developing appreciation for science process skills and inquiry-based learning. These three phases of the course build content knowledge in the various sciences and address the pedagogical understanding needed to meet the National Science Education Standards and current efforts to improve STEM education.

Table 1. Data for Estuary Water at Shackelford Island (Atlantic Ocean)

Depth/meters	**0.70**	**4.0**	**7.0**	**10.0**	**13.0**	**19.0**
Temperature/^{0}C	**23.0**	**22.6**	**22.4**	**22.2**	**22.0**	**21.0**
pH	**7.8**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**
Dissolved Oxygen (mg/L)	**7.13**	**5.93**	**4.12**	**4.07**	**4.12**	**4.57**
Salinity (ppt)	**26.4**	**26.7**	**26.9**	**22.0**	**22.0**	**27.1**
Turbidity (nephelometric turbidity units, NTU)	**63**	**64**	**68**	**69**	**69**	**69**
Nitrates (ppm)	**1**	**1**	**1**	**1**	**1**	**1**
Phosphates (ppm)	**2**	**2**	**2**	**2**	**1**	**1**
Alkalinity (ppm)	**80**	**85**	**90**	**90**	**100**	**120**
Hardness (ppm)	**425**	**425**	**425**	**425**	**425**	**425**

Table 2. River Water in West Virginia

Depth /m	**0.2**
Temperature /^{0}C	**25**
pH	**2.3**
Dissolved Oxygen (mg/L)	**4.0**
Salinity (ppt)	**6.0**
Turbidity (NTU)	**16.0**
Nitrates (ppm)	**0**
Phosphates (ppm)	**1**
Alkalinity (ppm)	**40**
Hardness (ppm)	**200**

Table 3. Phosphate Data of Field Sites Visited

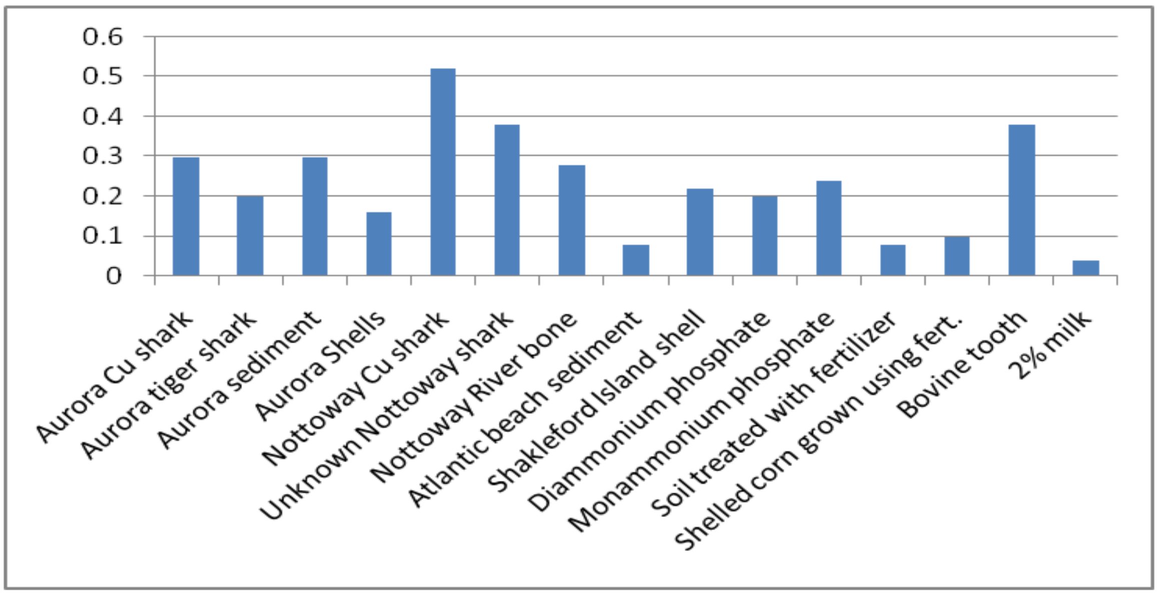

Table 4. Questionnaire About Teaching Science

1. Students learn science best in classes with students of similar abilities.

	Agree	No Opinion	Disagree
Pre-survey	29%	13%	58%
Post-survey	20%	0%	80%

2. I enjoy teaching science.

	Agree	No Opinion	Disagree
Pre-survey	60%	0%	40%
Post-survey	100%	0%	0%

3. I organize the curriculum around the textbook.

	Agree	No Opinion	Disagree
Pre-survey	20%	20%	60%
Post-survey	28%	0%	72%

4. The teacher should consistently use activities that require students to do original thinking.

	Agree	No Opinion	Disagree
Pre-survey	93%	0%	7%
Post-survey	100%	0%	0%

References:

1. American Association for the Advancement of Science. *Benchmark for Science Literacy*; Oxford University Press: New York, 1994.

2. National Research Council. *Inquiry and the National Science Education Standards, A Guide for Teaching and Learning*; National Academy Press: Washington, DC, 2000.

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