Evaluating the Ocean Explorers Project: First Year Results

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Abstract

This paper will present evaluation findings of the Ocean Explorers project, a three year effort funded by the Information Technologies for Students and Teachers program of the National Science Foundation. The goal of the project is to introduce information technologies to middle and high school teachers in California. The paper will review characteristics of the teachers who are participating in the project and evaluation results from the geographic information systems (GIS) workshops conducted during the project's first year of operations. In particular, the paper will discuss participating teachers' expertise and comfort level with GIS at the beginning of the project, strategies the project has used to increase their knowledge and comfort levels, and lessons learned from implementing the strategies. Another focus of the paper will be the barriers teachers experience in implementing GIS as an instructional technology and how the project is attempting to help teachers overcome those barriers.

Introduction

Beginning in 1998, the Center for Image Processing in Education (CIPE) and Channel Islands National Marine Sanctuary (CINMS) began collaborating on a number of efforts that have engaged K-12 teachers in the use of geographic information systems (GIS) to teach ocean science. The first tangible product of these efforts was *Mapping an Ocean Sanctuary*, a set of six lessons for high school instruction that helps students: (1) employ GIS to study how populations of marine life are influenced by ecological conditions in CINMS; (2) collect geophysical and ecological data during field studies at CINMS and use GIS to map and analyze the data; and (3) understand how the natural systems of CINMS are influenced by global, regional, local, social, political, and management variables. The MOS materials, funded by a grant from the Geosciences Education program of the National Science Foundation (NSF), were released in February 2003, packaged as a 128-page spiral-bound lesson book with accompanying CD-ROM.

The philosophy of the MOS project was to create instructional materials in which students learn about GIS as they study ocean science. The guided-discovery approach taken in the materials provides educators and their students with engaging explorations of real ocean science data that model research conducted by scientists working for CINMS and other organizations. The materials scaffold the introduction of information technology (IT) to the educational community by providing support and a template to simplify use of a complex IT tool.

The materials produced by the project also attempt to make the study of ocean science with IT tools interesting, relevant, and fun. Using ArcView GIS software developed by the Environmental Systems Research Institute (ESRI), students display, query, and analyze multiple layers of data found in interconnected maps, tables, graphs, and graphics. Using the materials, students investigate how the diversity, distribution, and health of marine mammals, fish, invertebrates, and avian species in the sanctuary are influenced by (1) geophysical characteristics such as sea surface temperatures, currents, bathymetry, and global events such as El Niño; (2) human use of CINMS for recreation, shipping, and fishing; (3) regulatory actions such as the creation of no-take marine reserves; (4) hydrologic events such as storm water runoff from urban and rural regions on the mainland; and (5) catastrophes such as oil spills, airplane crashes, and shipwrecks.

Ocean Explorers

In 2003, the approach to learning embodied in MOS was expanded upon by Ocean Explorers, a large professional development and materials development project funded by the Information Technology Experiences for Students and Teachers (ITEST) program at the NSF. Ocean Explorers was created to help teachers overcome barriers to the educational implementations of GIS identified during testing of the MOS materials: teachers do not have time to learn GIS, gather data, and construct GIS-based activities for their students; teachers have gaps in their science and technological backgrounds that make it difficult for them to implement GIS as a tool to facilitate learning; many teachers do not have easy access to computers that can be used for inquiry-based research projects; bureaucratic obstacles at schools prevent teachers from experimenting with new software programs and instructional approaches; teachers often operate alone in a community of skeptics when they try out new technologies and instructional approaches; and political initiatives that promote rote memorization over deep learning require teachers to perform cost benefit calculations when implementing new technologies and teaching methods in the classroom.

Ocean Explorers is unique because it gives support to a select group of educators over an extended period of time. A three-year project, Ocean Explorers introduces GIS, digital image processing and analysis (IPA), and ocean science as ways of engaging students and incorporating information technologies (IT) into science and mathematics education. The project has formed teams of teachers that will serve as local user groups for the exploration of GIS and IPA as educational technologies. Teachers participating in the project are receiving mentoring, software, equipment, funding, and training on how to design inquiry-based activities that support achievement of state and national science, technology, mathematics, and reading standards. Ocean Explorers has recruited twenty teams of three to five teachers—currently 71 teachers in all—from middle and high schools in California and Arizona, thus creating for each participant a local cadre of peers implementing the new technology. Each team has committed to participation for the entire duration of the three-year project. Likewise, the project has committed to support and mentor each team for three years.

In its first year, Ocean Explorers provided each team with basic and advanced training in GIS and IPA, focusing on how teachers can engage students in activities that show how the technologies can be used to study the ocean. Project workshops were held on beaches, aboard vessels, and on the Channel Islands. "Ocean science and IT" institutes were also held during the summer of year one, providing teachers with grounding in transect sampling, water quality and beach assessments, marine life observations, and documentation techniques commonly employed in ocean science. CIPE's *Mapping an Ocean Sanctuary* materials and ESRI's Mapping Our World book and CD-ROM (Malone *et al.*, 2002), were used as the primary teaching materials at the workshops and institutes.

During the first year of the project, training was also provided on how to employ the Understanding by Design methodology of Wiggins & McTighe (1998) to begin with targeted reading, mathematics, science, and technology standards (the "Content standards for California public schools" [California Department of Education, 2002]) in developing educational activities for students. From the standards, the teams will create activities and assessments that involve students in IT-based learning about the ocean in a manner that supports federal, state, and local mandates for satisfactory achievement by students and schools. The activities and assessments will be developed with mentoring and assistance by project staff and education specialists and scientists from Channel Islands National Marine Sanctuary.

During the summer of year two, each of the twenty teams will test its project with a group of five to ten students. Testing will also take place in the participants' classrooms during the fall of year two, after which the projects created by the teams will be prepared for publication by CIPE. Capping off the project will be presentations by all of the teacher-teams at the 2006 ESRI Education User Conference in San Diego.

Evaluation Methods

Evaluation of Ocean Explorers has been conducted by WestEd, a nonprofit research, development, and service agency originally established by the U.S. Department of Education. A mixed-methods approach to data collection was employed in the first year of the project evaluation. The following research techniques were used:

1. A "pre-project" survey was distributed to all participants before any project activities took place. The survey was designed to gather baseline data about the demographics of the participants and their students, characteristics of their teaching situations, and their comfort level with the technologies employed in the project.
2. Pre- and post-workshop surveys were implemented at all professional development workshops held by the project. The purpose of the surveys was to document changes in knowledge about and attitudes toward the technologies being used by the project.
3. Participants were asked to respond, online, to open-ended questions about what they were gaining from the project, the obstacles they face in implementing the technologies and instructional strategies promoted by the project, and any problems they had encountered while participating in the project.
4. To learn about how the project conducts its activities and to gather feedback from the participants, the WestEd evaluators conducted participant observations during selected Ocean Explorers activities.

Evaluation Results

The results of the first-year evaluation of the Ocean Explorers project indicate that it has been successful in achieving many of the original project objectives. The evaluation results, as they pertain to seven objectives addressed during the first year of the project, are presented in this section.

Objective 1: Recruit 60 educators from targeted schools to take part in the project by working with county and district personnel specializing in science, technology, engineering, and mathematics (STEM) education.

During the recruitment drive that began in October 2003 and ended in September 2004, Ocean Explorers received inquiries from dozens of teachers who were interested in the project. Initially, however, recruitment of teachers proceeded slowly. The initiation of Ocean Explorers California coincided with a period of political turmoil in the state government and in the educational community. The impact of the No Child Left Behind legislation was being felt at underperforming schools and many school principals were reluctant to grant release time for professional development activities outside of mathematics and reading instruction. To recruit more participants, the project expanded its target region beyond the originally proposed region of Los Angeles, Ventura, and Santa Barbara counties. The current reach of the project is the entire state of California.

The current participant list includes teachers from public, private, and charter schools in California, representing communities as far north as the San Francisco Bay region and as far south as San Diego. Two teachers from Arizona are also included in the project. The teachers have been organized into 20 teams. Some of the teams include educational consultants, computer specialists, and administrative personnel.

As of the fall of 2004, the roster of participants was 58% female, 7% Asian, 3% Black or African-American, 15% Hispanic or Latino/Latina, 74% White or Caucasian, and 2% Multiracial. Forty-four percent of the educators teach in grades five through eight; 64% teach in grades nine through twelve (many of the participants teach across the middle school and high school categories). Nearly three-quarters of the participants are seasoned teachers with six or more years in the classroom. Sixty percent of the educators teach ocean science, but only 21% had used GIS in their teaching before the Ocean Explorers project. Most of the teachers had mastered at least basic computer skills (Table 1).

Table 1: Percentages of educators responding “often,” “occasionally,” “seldom,” and “never” to a question pertaining to common uses of computer technology.

Please indicate the frequency with which you engage in the following activities (personally or professionally): (✓ one answer for each item)	N	Often	Occasionally	Seldom	Never
Using computers for word processing	67	96	3	-	2
Communicating with others over the Internet	67	87	9	3	2
Using computers for research	67	78	15	3	5
Downloading data from the Internet	67	70	18	9	3
Integrating data into a computer database	67	33	27	30	10
Using a handheld computer/personal digital assistant (PDA)	66	20	9	18	53
Participating in on-line courses	67	18	33	30	19
Using a global positioning system (GPS) unit	67	10	31	30	28
Using geographic information systems (GIS) software	66	9	14	20	58
Using image processing and analysis (IPA)	67	5	10	22	63

The teachers also reported correspondingly high levels of comfort with computers, though most were not highly comfortable with geospatial technologies (Table 2).

Table 2: Percentages of educators responding “very comfortable,” “comfortable,” “uncomfortable,” and “very uncomfortable” to a question pertaining to teachers’ comfort level with common uses of computer technology.

Please describe your level of comfort with the following information technology (IT) skills: (✓ one answer for each item)	N	Very Comfortable	Comfortable	Uncomfortable	Very Uncomfortable
Using computers for word processing	67	93	6	2	-
Communicating with others over the Internet	67	90	9	2	-
Using computers for research	67	73	24	2	2
Downloading data from the Internet	65	63	29	8	-
Participating in on-line courses	67	39	48	10	3
Integrating data into a computer database	67	27	46	25	2

Using a handheld computer/personal digital assistant (PDA)	66	15	35	35	15
Using a global positioning system (GPS) unit	66	15	49	27	9
Using geographic information systems (GIS) software	66	6	41	33	20
Using image processing and analysis (IPA)	66	3	38	39	20

The pre-project survey results suggest that the teachers were familiar and comfortable with most common uses of technology such as word processing, Internet surfing, and email when they joined Ocean Explorers. As anticipated, most of the teachers were not highly proficient in geospatial technologies and IT tools such as computer databases that provide the foundation for GIS.

Objective two: Employ existing instructional materials to introduce teachers to GIS and IPA, two current information technologies that empower teachers to involve students in inquiry-based explorations of authentic data and dynamic systems.

As noted above, the Ocean Explorers project used a combination of existing and newly created materials in its year one professional development activities. With respect to the use of existing materials in workshops conducted by Ocean Explorers, the evaluators had the following observations about what works best with teachers.

1. Teachers enjoyed receiving ready-to-use lessons that they can employ in, and adapt for, their teaching situation.
2. Workshops that focus on theoretical constructs or provide examples of how IT tools such as GIS and IPA may be used in classrooms generally are not as appealing to teachers as workshops that show a direct connection to classroom instruction.
3. Teaching IPA literacy separate from its integration with ArcView GIS software was frustrating to many participants. They wanted tools and procedures that mesh well with ArcView GIS software.
4. Even with the support of well laid out materials, many teachers had difficulty mastering essential GIS and IPA concepts. The problems encountered by teachers were primarily associated with (1) a lack of understanding about how to navigate computer file and folder hierarchies and (2) the difficult task of conceptualizing exactly what GIS software is doing when it accesses databases to create visual representations on a map. However, most teachers in the project were very diligent in attempting to master the concepts and most succeeded at developing at least basic geospatial analysis skills.

Teachers particularly valued the quality of the workshop materials provided to them and the time given for hands-on practice with the software. One teacher said the most beneficial part of a project workshop was that "...[the] Introduction to GIS—the MOS and MOW—[was] very well written and after working through them completely by myself I will [felt] very comfortable using the lessons in my Marine Biology class." Several teachers commented on the value of the hands-on nature of the workshops.

Objective three: Help teachers use the analytical power and visualization capabilities of GIS and IPA to explore ocean science in a way that dynamically illustrates how natural processes on Earth exist as interconnected systems.

Anecdotal data from the first and second years of the project indicate that Ocean Explorers has been successful in conveying the analytical power and visualization capabilities of GIS and IPA to the participants. Some of the best evidence in support of this claim is a listing of the kinds of activities participating teachers are doing with their students:

- using GIS to measure shoreline erosion along the California coast over time with sequential aerial photographs

- establishing georeferenced sampling points to monitor sandy beach and rocky intertidal zone conditions along the coast near their schools using the Long term monitoring program & experiential training for students (LiMPETS) protocols developed by the National Marine Sanctuary Program of the National Oceanic and Atmospheric Administration (National Oceanic and Atmospheric Administration 2003)
- conducting chemistry geocaches where students use GPS to locate landmarks on their school grounds and then answer questions about the chemistry of an item found at the landmark before moving on to the next cache
- involving students in summer studies of marine biofouling by establishing georeferenced sampling points at marinas, hanging settling plates from docks, and studying the vertebrate and invertebrate communities that establish themselves on the plates

Additional data comes from quotes harvested from video interviews conducted with participants on one of the project's 2004 summer institutes on Santa Cruz Island, California:

This summer workshop has been amazing. We got to go out and learn how to track a course with GPS and mark points. We went on a hike where we took digital images and marked the GPS points. We took those images, plotted them onto a photo image map, and made a project out of it. I can see that the possibilities of how I'm going to use this technology in my classroom are just about endless.

My favorite part of the workshop was the integration of both the real and the two dimensional computer world. Science that you don't know is like magic. In the past, I've come down on the magic side of things because it usually involves less math. What's been neat about this workshop is that it has forced you to do some real science.

I'm a middle school science teacher from Santa Monica, California. I teach sixth, seventh, and eighth graders, primarily science, with a lot of language arts support. We're doing this so that we can weave science and geography together. The primary benefit of the Ocean Explorers project for my classroom is that I am better able to use technology and geography as vehicles for weaving lots of different types of science together. We have a spiraling curriculum that goes through physical, life, and Earth science. The value of the geography, in particular, is that it lets you wed science to human impacts, to the technology part which is exemplified by ArcView. I'm going to use it as the glue that holds various subjects together.

Objective four: Engage teachers in learning about Earth systems by providing a framework for them to conduct field studies about ocean science in their region, link these studies to space-age perspectives afforded by remote sensors orbiting the Earth, and understand how global processes affect ocean conditions close to home.

Participants in the Ocean Explorers workshops gained valuable skills for conducting field studies and linking the studies to GIS and IPA-based research projects. The primary professional development goal for the first year of the project—getting participants to the point at which they can create a GIS project on their own and add data to it—was accomplished at the Ocean Science and IT institutes held during the summer of 2004. The evaluation indicates that the applied nature of the summer institutes—in which the teachers were expected to apply and practice skills they had learned during previous workshops—was exciting for the more GIS proficient participants and threatening for those struggling to learn the new skills. Teachers who had attended GIS workshops conducted by CIPE before the Ocean Explorers project tended to view the summer institutes as "aha!" moments where all the pieces of how to "do" GIS started coming together. Novice GIS users whose first exposure to GIS had been at the Ocean Explorers workshops held during the spring had more difficulty integrating and applying the skills and knowledge being taught by the project. Some of this difficulty had to do with the learning environment present at the institutes: because teachers were downloading their own data and creating their own GIS projects, the summer institutes were more chaotic than the introductory GIS and IPA workshops. At times, the small workshop rooms available at the summer facilities became extremely noisy hubs of activity. A large part of the difficulty seemed to be related to the incubation time required to take novice GIS users from

introductory GIS exercises to the much more difficult task of assembling data and constructing projects from scratch. Novice users struggled a great deal with the task of organizing files and folders on a hard drive and understanding how a software program such as ArcView acquires and uses data. Repeated practice in creating and using projects over a period of many months seemed to be the best antidote to the confusion experienced by novices.

Objective five: Organize the original cohort of 60 educators into teams of three to five participants who can support each other through the professional development, activity development, field-testing, and publication phases of the project.

For the most part, the project has been successful at organizing teams of three to five participants. Minor difficulties have been encountered with group and interpersonal dynamics associated with maintaining the active participation of 71 teachers over an extended period of time. The team format appears to be most effective when (a) all teachers are from a single school; (b) the individual leading the team is very committed to the goals of Ocean Explorers; (c) the team leader has supervisory authority over the other team members (i.e., the supervisor is a department head); and (e.) the teams are composed of teachers who have adequate technical skills to succeed in the project. Teams that are facing challenges generally have the following characteristics: (a) one or more members are from a different school than the others; (b) the skill levels of the team members vary considerably; and (c) the team members teach at quite different grade levels.

Objective six: Identify and develop a leader from each team who will communicate directly with the project, coordinate team activities, and motivate the teams to complete project tasks.

Team leaders were identified during August and September 2004 and all teams currently have a leader. The process of identifying team leaders proceeded about as expected by the project staff. In most teams, a leader was easily identified. He or she was typically the individual who "got the ball rolling" at his or her school and recruited other teachers to join the project. In a small number of cases, team leaders were identified by the project. Although this technique was successful in some cases, it also created friction in a few cases.

Objective seven: Introduce the team leaders to the backwards design methodology of Wiggins and McTighe (1998) so that they can help their teams design explorations of ocean science that promote development of IT literacy and skills, and facilitate achievement of targeted STEM education standards.

An Understanding by Design workshop led by a consultant from the Association for Supervision and Curriculum Development was held in October 2004. Although project staff members were concerned about whether the three-day Understanding by Design workshop would hold the attention of the participants, the concerns were unjustified. The team leaders were thoroughly engaged during the workshop and have commented at length about how the Understanding by Design approach has changed how they think about their teaching practice.

Conclusions

Ocean Explorers, which is completing its second year of activities, has successfully laid the foundation for the primary goal of the project: having teachers develop learning activities that support accomplishment of targeted California educational standards. The biggest challenges facing Ocean Explorers are retention and motivating participants to complete the difficult process of developing an educational activity, testing it, and seeing it through to publication. So far, retention has been less of a challenge than anticipated. Only a few participants dropped out of the project during the first year. To help foster a culture that motivates participants to work hard and stick with the project, Ocean Explorers is exploring ways of leveraging the influence of the successful teams and overcoming some of the challenges facing the less effective teams. Some possible strategies include (a) employing the high performing teams as mentors for the less effective teams; (b) reshuffling membership among the low performing teams to create groups of teachers who have greater affinity for one another; (c) mentoring low performing teams on how to get "unstuck" from current challenges; (d) examining the research

literature and other sources to uncover strategies that are used to manage participants in long-term professional development projects; and (e) involving the project advisors, some of whom are former classroom teachers, in brainstorming strategies for overcoming challenges that reduce the effectiveness of some teams.

To provide data that can be used to inform decision making about how to cultivate a culture of success, the evaluation strategy for Ocean Explorers is currently being restructured to include case study analyses of selected teams as they participate in the project. The purpose of the case study analyses will be to identify the environmental variables and team dynamics and strategies that lead to successful implementation of GIS in school settings. Although a broad evaluation of Ocean Explorers will still be conducted by WestEd, greater emphasis will be placed on an in-depth exploration of how the project's strategies were implemented at selected school sites. To conduct this exploration, WestEd will visit selected schools, interview teachers, students, and administrators, observe teachers as they use the techniques promoted by the project, and measure the impact of project methods and technologies on student learning and motivation.

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