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Methods for Marine Ecosystems Research Through the Use of PDAs With Preservice Teachers

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ABSTRACT

Science teachers are charged with the task of providing students in grades K-12 with opportunities that will enable them to make sense of science and develop habits of mind. One goal of science education is to prepare well-rounded citizens who are scientifically literate. Through inquiry-based learning, students formulate questions, perform investigations, and construct new understandings.

It is important for preservice science teachers to be introduced to current techniques, discoveries, and debates in the field of science. The use of personal digital assistants (PDAs) can provide K-12 students with increased opportunities for exploring and learning through scientific investigations. In order for these devices to be successfully integrated into classroom instruction, changes in teaching methodologies must be adopted. This paper presents a model lesson that can be used to guide preservice teachers in the use of PDAs for studying a marine ecosystem. The field experience takes place on the shoreline of Long Island Sound at Stratford Point, in Stratford Connecticut.

Keywords: Education Technology, Science Literacy, Handheld Computers and PDA.

INTRODUCTION

The growth of the Internet and the appearance of new technologies have become the catalyst for the emergence of a global knowledge economy. In a global knowledge economy, a combination of ideas, innovation and the application of technology are valued sources of economic growth and development [19; 28]. Scientifically literate citizens, who are equipped with the skills and knowledge for solving complex problems, are critical to sustaining and improving the quality of life, enhancing democratic societies, and maintaining the global economy.

According to the United States Department of Education [24], traditional academic and vocational education programs do not offer training that will adequately prepare students for the demands of postsecondary education or the contemporary workplace. Problem-solving, collaboration, and the development of information and communication technology (ICT) skills are a few of the knowledge economy competencies that must now complement a student's current academic skills in the areas of language, mathematics, and science [3; 19].

DEVELOPING SCIENCE LITERACY

The role of science teachers is to help students develop the skills of observing, interpreting, and questioning. Teaching for knowledge and comprehension requires that teachers develop a framework of program goals that can be modified in response to individual student inquiries, experiences, and abilities. The ability to modify an existing science program enables a teacher to conduct an in-depth inquiry in response to student interest or to change directions in pursuit of a new goal. By supporting student questions and encouraging active participation, teachers can challenge students to accept and share the responsibility for their own learning.

Teachers must be able to exercise professional judgment when matching learning opportunities with learning styles. Lessons that are flexible, diverse, and challenging will engage the student in scientific inquiry and support the development of process skills. Individual work, small group collaboration, and whole-class discussions are additional instructional strategies that can be used for guiding the development of a student's conceptual understandings and abilities.

PROMOTING SCIENTIFIC INQUIRY

Science teachers are charged with the task of providing students with opportunities that will enable them to make sense of science and develop habits of mind [18]. Instructional approaches that involve direct experiences with natural phenomena have become collectively known as *hands-on science* [2]. These educational experiences actively involve students in the manipulation of objects. Research indicates that a combination of hands-on science and inquiry-based learning can prepare students to become lifelong learners [2].

Scientific inquiry requires students to make assumptions, use critical and logical thinking, consider alternative explanations, and defend a scientific argument [18]. Through inquiry-based learning, students formulate questions, perform investigations, and construct new understandings. Teachers can foster scientific inquiry by initiating an interest in topics that students may not have considered on their own. The knowledge that results from scientific inquiry is most useful when students organize it into concepts, generalizations, and unifying principles that lead to further investigation of objects and events in the environment [18].

SCIENCE EDUCATION

Science comprises our knowledge about the natural world and the processes through which that knowledge is acquired, synthesized, evaluated, and applied. One goal of science education is to prepare well rounded, clear thinking, scientifically literate citizens.

The *National Science Education Standards* (NSES) outline what students need to know, understand, and be able to do in order to demonstrate scientific literacy at different grade levels [18]. The NSES science content standards are divided into the following eight strands:

- Unifying Concepts and Processes in Science;
- Science as Inquiry;
- Physical Science;
- Life Science;
- Earth and Space Science;
- Science and Technology;
- Science in Personal and Social Perspectives; and
- History and Nature of Science.

Generally, each content standard is sub-divided into grade level clusters that include; K–4, 5–8, and 9–12. The first strand, *Unifying Concepts and Processes in Science* is offered across all grade levels since a student's scientific concepts and abilities must be continually developed. Outcomes within each content standard describe the understandings, skills and abilities that students are expected to possess by the end of the grade level cluster. For the purposes of this paper, content standards that relate to the strand *Life Science* will be discussed.

In the content area of Life Science, the NSES require that all students in grades K–4 obtain an understanding of the characteristics and life cycles of organisms and their environments [18]. Students in grades 5–8 build upon previous knowledge and are expected to develop a further understanding of: structure and function in living systems; reproduction and heredity; regulation and behavior; populations and ecosystems; and diversity and adaptations of organisms [18]. In grades 9-12, a student's understanding of organisms is based on abstract knowledge, such as the structure and function of DNA and comprehensive theories such as evolution. These understandings encompass larger and smaller scales such as the biosphere and molecules [18].

TEACHER TRAINING

Equipping preservice teachers with the skills and understandings that will enable them to implement contemporary visions of science instruction is a notable challenge for those in teacher preparation programs. Besides the skills, attitudes, and habits of mind that reflect national reform efforts, preservice teachers must also demonstrate subject area competencies [27]. The competencies that science teachers must possess encompass those that are required for all teachers along with those that are subject specific. Preservice science teachers, who will be instructing students in grades K-8, require a sound understanding of curricular content across a broad range of scientific disciplines. In contrast, it is necessary for grade 9-12 teachers to possess an in-depth understanding of curricular content in one or more particular scientific fields.

It is important for preservice science teachers to be introduced to current techniques, discoveries, and debates in the field of science. Educational theorists agree that certain kinds of learning should take place in the context of real world practice [6; 13; 14]. Members of the National Council for Accreditation of Teacher Education (NCATE) require that preservice teacher education programs include carefully planned, developmental learning experiences that enable a preservice teacher to assume increasing professional autonomy and responsibility [16].

The International Society for Technology in Education (ISTE) recommends that teachers gain proficiency in computer operations and learn methods for using technology to facilitate academic learning [11]. College level coursework in the area of educational technology is one way that preservice teachers can acquire the skills that will enable them to incorporate a variety of emerging technologies into the science curriculum.

PERSONAL DIGITAL ASSISTANTS

Personal digital assistants (PDAs) are small lightweight computers that can be held in a hand, or carried in a briefcase or pocket. PDAs are classified into two categories that include: handheld computers and palm-sized computers. Handheld computers are typically larger and incorporate the use of a liquid crystal display (LCD) and a miniature keyboard for data entry. Palm-sized computers have smaller LCDs and require users to enter data through the use of touch-screen technology and handwriting recognition programs. Handhelds had originally been designed for the purpose of organizing business contacts and meetings. However in recent years, these technologies have slowly made their way into the educational arena.

Many PDAs can be purchased with a docking cradle that attaches to the USB port of a desktop computer. This device provides users with the ability to synchronize data between the computer and the PDA. The synchronization of data between PDAs and PCs is important for insuring that documents or files saved to the computer and PDA contain the same information. Synchronization is also performed when installing software on the PDA. Additionally, users can use synchronization for creating a back up copy of their files on the PC. Backing up files is an important procedure since information can be lost when PDA batteries lose power.

Besides the use of the cradle, PDA users can also transfer (or beam) information to a PC or another PDA through an infrared communications port. Wireless methods for transferring data to and from a PC network are also available. These methods enable users to access their e-mail and the Internet.

There are a number of factors that must be considered prior to selecting a PDA device for classroom use. Most PDAs are equipped with features that include a:

- Microprocessor;
- Operating System;
- Memory;
- LCD Display;
- Input Device;
- Input/Output Ports;
- Desktop PC Software; and
- Batteries.

The microprocessors that power most PDAs range from 126 to 624 MHz. PDA users can choose between two types of operating systems, Palm OS™ [20] or PocketPC™ [17]. Basic programs such as the address book, memo pad, and operating system are stored in the device's read-only memory (ROM) chip while data and software programs are stored in the random access memory (RAM). Removable expansion cards are also available for some models that can be used to store additional programs and files.

All PDAs include a basic software package that is primarily targeted for business use. These applications include a date book, memo pad, calendar, and address books. The Pocket PC platform [17] contains versions of Microsoft Word, Excel, and PowerPoint that can synchronize with their counterparts on desktop computers. Users of Palm OS™ [20] systems can install the Documents To Go Office Suite [5]. Documents to Go supports Microsoft Word, Excel, and PowerPoint in addition to portable document format (PDF) and text files. Through the use of this software, files saved to expansion cards or received as e-mail attachments can also be viewed directly on the PDA without synchronization. Additional software titles are available for both operating systems. Many of these software titles can be obtained through the Internet and allow users to download and read books, manage student grades, and/or create charts and diagrams.

A variety of hardware accessories can extend the functionality of most PDAs. Full-size keyboards can be connected via the PDA's integrated docking connector, a wireless infrared connection, or Bluetooth adaptor. Dedicated keys enable users to quickly launch PDA applications and scroll through a document. When not in use, PDA keyboards can be folded-up for trouble-free portability and protection during travel.

Many current PDA models include built-in cameras that are similar to those found in cellular phones. Digital cameras are also available that plug into the built-in Compact Flash (CF) memory slot of older PDA models. PDA cameras enable users to capture pictures and record video just like a traditional digital camera. Image resolution ranges from VGA (640 by 480 pixels) to 2-megapixels.

TEACHING SCIENCE WITH PDAs

Affordability and portability have made PDAs a viable option for many science teachers. Students have the ability to use their handhelds as graphing calculators, word processors, databases, presentation tools, test preparation tools, reference resources and as a means of collaborating with their peers. Teachers and administrators can use handhelds for record keeping, scheduling, classroom management, and professional productivity.

According to the National Research Council (NRC) [18], technologies such as hand tools, measuring instruments, and calculators must be incorporated into the curriculum for the purpose of conducting scientific investigations. PDAs are useful for recording experimental data in the field that can be graphed and presented for classroom discussion. In addition to keyboards and digital cameras, wireless cards, integrated global positioning system (GPS) receivers with bundled navigation software, and scientific probeware are additional input and output devices that enable teachers to extend a student's learning experience outside of the classroom. The use of scientific probeware for gathering real time data enables students to explore and understand the world in ways that foster the cognitive and manipulative skills associated with the formulation of scientific explanations. Data loggers can collect long-term data that is produced through changes in the environment and climate.

PDAs and sensors provide students with increased opportunities for exploring and learning through scientific investigations. In order for these devices to be successfully integrated into classroom instruction, changes in teaching methodologies must be adopted. These changes are central to the educational reform envisioned by the NRC [18] and the authors of state curriculum frameworks [4].

METHODS FOR MARINE ECOSYSTEM RESEARCH

This section presents a model lesson that can be used to guide preservice teachers in the use of PDAs for studying a marine ecosystem. The field experience will take place on the shoreline of Long Island Sound at Stratford Point, in Stratford Connecticut. Long Island Sound is an estuary that is bordered by Connecticut and Westchester County, New York to the north, New York City to the west, and by Long Island, New York to the south [22].

A variety of technological equipment, computer software, and classroom supplies must be available for classroom and field-based research to occur. These resources include:

- Classroom computers with Internet access;
- One laptop computer for use in the field;
- A minimum of one Palm OS® PDA [20] for every two students that is loaded with the following software: iKWL [9], FlingIt [8], Adobe Reader for Palm [1], Data Pro [26], Notepad, Memo Pad, Calculator, Cells [7], Sketchy [10] Documents To Go [5];
- 500 mL plastic soda or water bottle with cap;
- One portable keyboard for each PDA;
- Logger Pro 3 software [26]
- Lab Pro Interface [26],
- Digital camera;
- Vernier Probeware for pH and temperature [26];
- Measuring tape;
- Extra batteries; and
- Paper and plastic bags.

In order for each preservice teacher to practice constructing and using scientific knowledge in the field, the following contextual teaching strategies have been incorporated into the instructional design of this lesson: relating, experiencing, applying, cooperating, and transferring. The primary goal of the lesson is to promote scientific inquiry through hands-on research experiences in marine science. The educational objectives of the lesson will require that preservice teachers:

- Define the terms ecosystem and pH;
- Report the geographical data of the area: latitude, longitude, state, county, and town;
- Collect samples and analyze water quality data through probes and graphs;
- Create a list of the plants, animals, insects, invertebrates and fish that are observed;
- Prepare a qualitative description of the habitat under investigation including references to conditions of the ocean, vegetation, and animal life. The description may include digital photos or drawings;
- Explain the role and effect of natural resource management through scientific explanations that are based on scientific inquiry, knowledge, and analysis; and
- Present their research findings to a group of peers through the use of PDA presentation software.

For the purposes of this discussion, a Palm Tungsten T2 handheld [20] is being used in a graduate teacher preparation course. The essential question posed to the preservice teachers will be "How does water quality impact the diversity of life in a marine ecosystem?" The field activities that are integrated into this lesson are appropriate for middle and high school age students and can be modified for younger children. Through field activities, collaborative research groups of preservice teachers will collect a variety of data that is related to water quality and marine life. This goal of this research will be achieved through the use of PDAs, scientific probeware and digital cameras. Prior to their field experience the preservice teachers will have:

- Been introduced to the methods for designing and conducting a scientific investigation;
- Become familiar with the NSES [18]; and
- Gained a basic level of proficiency in the use of PDAs in education.

Relating

In order to achieve the goal of the lesson, preservice teachers will require an introduction to the major concepts in the content area of science. In addition, background information will be offered that relates to the: care and use of equipment; safety precautions; recommendations for the use of technologies; clarification of ideas that guide the inquiry; and the scientific knowledge obtained from sources other than the actual investigation. To begin the lesson, each preservice teacher will download and install the iKWL™ software [9] to his/her PDA. KWL charts are graphic organizers that activate a student's prior knowledge. They are typically used to support problem-solving and decision-making activities. The use of KWL charts will enable individuals to determine what scientific information they know, what they would like to know, and what they have learned about a topic. In the context of this lesson, the KWL chart will be used for planning what sources of initial information should be gathered from the Internet. Through the use of the PDA infrared port, the KWL charts will be "beamed" between members of each research group. This activity will be followed by a class discussion.

Internet research will be conducted in a classroom setting and provide preservice teachers with an overview of; Long Island Sound [22], its history [12; 15], location [25], marine life, habitats, and the ongoing research by scientists through the use of data collection buoys [25]. Through the use of FlingIt™ software [8] individuals will construct a field guide by transferring Internet pages to their PDAs. The transfer of Internet pages can be accomplished through synchronization between the desktop PC and the PDA. PDF files can also be downloaded that will become part of the field guide. In order to read the files, it will be necessary for individuals to download Adobe® Acrobat® for Palm OS® [1].

Experiencing, Applying, and Cooperating

The field research component of this lesson requires that a class session be conducted at the Connecticut shoreline. This field experience will enable preservice teachers to perform observations and gather real world data through the use of technology. Prior to this class session, the course instructor will prepare and beam a lesson plan, activity worksheet, and presentation template to each participant. A brief discussion will accompany these materials and set the stage for the field experience.

The lesson plan will include an overview and delineate the general procedure for completing each field activity. Activity worksheets will contain guiding questions and an outline that will assist preservice teachers in gathering relevant observational data. After the preservice teachers have returned to the classroom, the presentation template will be used for reporting and discussing their research findings. At the conclusion of the lesson, these research findings will be shared with the class.

Once they have arrived at the shoreline, the preservice teachers will be divided into several small groups that will rotate through a series of activities. In activity one, the course instructor will provide an overview of the temperature and pH tests while demonstrating the use of the Vernier scientific probes, the Lab Pro Interface, and the Data Pro software [26]. Group members will be reminded that the pH probe will be used for measuring the level of hydrogen and hydroxide ions in the water sample.

Since PDAs can be accidentally dropped, this activity will take place at a safe distance from the ocean in order to prevent water and sand damage. For additional protection, each PDA will be enclosed in a plastic sandwich bag. The temperature and pH probes must extend outside of the plastic bag so that they can be immersed in the water sample.

The next step in activity one will call for each group to gather a 500 mL water sample by using their plastic bottles. Groups will then return to a central location and data will be collected that relates to time, temperature, and water quality. After the initial data has been recorded, the water samples will be saved and transferred to the classroom for further analysis.

Activity two will require that group members classify the living things that can be found in the ecosystem into categories that include; animals, insects, invertebrates, and fish. This activity will be accomplished through the use of the PDA notepad utility.

For activity three, group members will prepare a qualitative description of the habitat under investigation. The description must include references to ocean conditions, vegetation, and animal life. The only source of background information available to each research group will be the field guide that had previously been developed in the classroom. The collection of supplementary data will be achieved through the use of observations, digital photos and drawings. Observations can be recorded through the use of the PDA memo pad utility. A tape measure, the PDA calculator utility, and Cells software [7] will be used to gather and record relevant data. Drawings of plants, animals, insects, invertebrates, and fish can be completed through the PDA by using Sketchy software [10]. Digital photos can be taken as a source of additional data. Photos can be added to the presentation template after participants have returned to the classroom.

The fourth activity will require that group members collect two specimens that can be analyzed in the classroom. The first specimen will be an object that occurs naturally in the environment. The instructor will discourage the collection of live animals, birds, invertebrates, and fish and will suggest that living things be documented through the use of digital photos and sketches instead. The second specimen will be one that does not occur naturally in the environment. These specimens will be placed in a paper or plastic bag and returned to the classroom for further investigation.

Before leaving the research site, group members will be asked to complete their KWL charts. Information relating to what the students had learned will be recorded and used in the development of a lab report.

Transferring

Once the research groups return to the classroom, PDA data will be transferred to a desktop PC through synchronization. Logger Pro 3 software [26] will be used to collect, graph, analyze, and print research data that was gathered at the shoreline through the Vernier scientific probeware. Research data can also be exported to Microsoft Excel or saved as a text file. Digital pictures, graphics, or videos can be added to the lab reports.

By using a combination of the portable keyboard, the PowerPoint presentation template, and Documents To Go software [5], group members will collaborate in the development of a lab report that describes the ecosystem. Additional information will be gathered through the use of the *Soundbook*, which is available through Soundkeeper, Inc. [23]. This resource contains a comprehensive action plan for those interested in improving the water quality of Long Island Sound. Group members will use the Internet to conduct further research related to the specimens that they had collected at the shoreline. At the conclusion of the investigation, each group will project their lab reports to the class through the use of a multimedia projector. Each preservice teacher will then be asked to reflect on his/her experiences.

CONCLUSION AND FUTURE WORK

Science literacy is a necessary and achievable goal for all students. This research model for studying the marine ecosystem has demonstrated how the role of the instructor can shift from one of being a primary source of knowledge to one of being a facilitator of scientific analysis, synthesis, and evaluation. Institutions of higher learning can play a significant role in educational reform through their efforts to recruit and prepare prospective teachers. Programs that foster the development of pedagogical skills and the knowledge of science are vital for shaping a preservice teacher's perceptions of the nature of the subject and their attitudes toward the discipline.

Combining the use of PDAs with field research can provide opportunities for preservice teachers to: develop a personal philosophy of teaching and learning, reflect on their values and beliefs, and challenge their assumptions about the ways through which K-12 science education should be structured. Field experiences that are situated in the context of real world settings enable preservice teachers to practice the behaviors learned in their college methods classes. As a result of field experiences that are tied to curriculum design, development, implementation, and evaluation, preservice teachers can forge a link between theory and practice.

This model is part of a graduate level course in emerging technologies that is being offered through Sacred Heart University, in Fairfield Connecticut [21]. Future work includes the evolution of this model in response to technological changes and our growth in the understanding of how to use technology to improve the learning experiences of our preservice teachers.

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