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Using Handheld Computers and Probeware in Inquiry-Based Science Education

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Abstract

Handheld computers and probeware have the potential to support inquiry-based science projects in K-12 education. Teacher training is important for effective integration of inquiry-based learning to provide students with rich and authentic learning experiences. This article describes the implementation and results of a project designed to train teachers to use an inquiry-based approach to science education with the help of emerging handheld technology. The project included training of elementary and middle school teachers on methods of inquiry-based science, integrating handhelds and probes, and development of inquiry-based science lessons. It was intended that the teacher participants model development and implementation of inquiry-based science lessons using handheld computer technologies.

Introduction

National and state science standards stress the importance of integrating technology and inquiry-based learning into science education. "Inquiry into authentic questions generated from student experiences is the central strategy for teaching science" (National Research Council, 2000, p. 173). The National Science Education Standards note:

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (National Research Council, 2000, p. 13)

Teacher knowledge and skills incorporating inquiry-based science and technology are essential for student achievement. Professional development activities can provide teachers opportunities to develop lesson plans that are inquiry-oriented and utilize the potential of technology. Ubiquitous computing in the classroom describes a notion in which a computational environment surrounds the student for active and inquiry-based learning. van 't Hooft and Swan (2004) emphasize the need for systematic research in ubiquitous computing to analyze the impact of everyday classroom integration of less visible and more human-centered learning tools.

Emerging handheld computer technologies have the potential for "ubiquitous computing" and for computer supported collaborative learning (Rochelle & Pea, 2002; van 't Hooft, Diaz, & Swan, 2004), teaching inquiry-based science and assessment (Penuel, Tatar, & Rochelle, 2004), writing activities (Russell, Bebell, & Higgins, 2004) and higher level thinking if used appropriately (van 't Hooft et al., 2004). Rochelle and Pea (2002) report that handheld devices have been used to increase collaborative learning as a classroom response system, participatory simulations, and collaborative data gathering. Teachers reported student collaboration and productivity increased due to the “beaming” capabilities and mobility of handhelds (van ‘t Hooft et al., 2004).

Norris and Soloway (2004) advocate “a handheld-centric classroom, where each child not only has his/her own personal, handheld computer, but also has access to networked PCs, probeware, digital cameras, etc.” (p. 281). Handheld devices, due to their size and portability may increase immediate accessibility and manipulation of data in and out of the classroom. Teacher access to affordable technologies with less total cost of ownership with handheld computers can be a realistic alternative to 1:1 computing to meet the challenges of technology integration and student achievement (Norris & Soloway, 2004; van ‘t Hooft et al., 2004).

Through the use of handheld computers, students may initiate and explore “a more authentic and deeper immersion in technology, not as a separate curriculum, but as an integrated part of [the] curriculum.” (van ‘t Hooft et al., 2004, p. 308) . Authentic learning and deep learning can be enabled through inquiry-based projects where students collect and analyze data connected to their real-life experiences. Teachers can utilize handheld computers and probeware to build inquiry-based learning experiences for their students.

Probeware describes the use of probes and sensors connected to computers (whether handheld or desktop) to collect and display real-time measurements of environmental parameters such as temperature, light, motion, force, sound and electrical power (Tinker & Krajcik, 2001). Handheld devices allow students to collect and analyze data of their immediate observations that is focused and detailed (Tinker, Staudt, & Walton, 2002). Thornton (1997) demonstrated that high school students’ intuitive ideas about motion, velocity, acceleration, and force become more accurate when using probeware than using any other instructional strategy, including lectures, problems, or traditional lab. Integration of handheld technologies in science education can help learners experience abstract concepts in a meaningful manner through manipulating and exploring concrete forms of learning in an inquiry-oriented lesson (Roschelle & Pea, 2002).

Students can use handheld devices to collect and analyze immediate real-life data. The National Science Education Standards encourage teachers to focus on inquiry-based learning for students to formulate their own questions, and collect and analyze data derived from real-life experiences (National Research Council, 2000). Teacher education and professional development programs need to promote inquiry-based learning. Professional development that focuses on improving teaching through inquiry achieves several simultaneous objectives (p. 109):

- It provides teachers with learning experiences different from the more traditional college course or inservice workshop to include one-on-one experiences such as coaching, collaborative work such as study groups, and "job-embedded" learning such as action research.
- It focuses on important aspects of teachers' practice, including the organization and presentation of curriculum, student work, and teaching dilemmas.
- It helps teachers think carefully about how their students come to understand important science concepts through inquiry, what help their students need in developing the specific abilities of inquiry, and what learning experiences can make the work of scientists "real" to their students.

The Standards suggest that teachers need to be “well-versed in inquiry and inquiry-based methods” “to use inquiry thoughtfully and appropriately in their classrooms” (National Research Council, 2000, p. 87). This article describes a professional development project designed for elementary and middle school teachers for integrating handheld computers and probeware in inquiry-based science education. The Eisenhower Professional Development Program, the Ohio Board of Regents and The University of Akron sponsored the project.

The Project

Teacher training on teaching inquiry-based science using technology can support learning environments for improving student achievement. This project involved training of elementary and middle school teachers on standards-based science content integrating handheld computers and probeware. It was intended that teacher participants would be exposed to resources about teaching inquiry-based science using handheld computers and probes and then would be able to model appropriate strategies in their classrooms and districts. During a two-week training, teacher participants learned about water quality indicators such as pH, water temperature, dissolved oxygen, and pollution levels.

The teachers learned how to use a Palm handheld and how to collect and analyze data using various probes. It was intended that these teacher participants would be able to model development and implementation of inquiry-based science lessons using handheld technologies and help to disseminate the idea of ubiquitous computing. Palm handhelds and probes were distributed to the participants who completed the requirements of the project. Each participant received a Palm OS® Zire 71 handheld computer, 1 pH sensor, 1 temperature sensor, 1 dissolved oxygen sensor, and the LabPro interface to connect the probes and the Palm handheld. pH probes measure ph level and can be used in chemistry, biology and water quality monitoring in middle school classes. The dissolved oxygen (DO) probes measure dissolved oxygen concentration in water samples and can be used in biology, chemistry, ecology and integrated science courses ("Sensors," 2005).

The project included multiple goals which were implemented through several phases:

1) Expose teachers to rich standards-based science content, methods of inquiry-based science delivery and the integration of technology in the teaching-learning process.

2) Improve access to emerging technologies for school districts, especially those districts with underserved and underrepresented populations.

3) Develop science lessons that integrate an inquiry-based approach to learning using current and emerging handheld computer technologies.

4) Develop a website to disseminate information and share the lessons developed by teachers to other elementary, middle school, pre-service and inservice teachers in Ohio.

Phase 1 included the recruitment of the participant teachers, development of the training program for the teachers and development of a syllabus and a website for sharing project information ideas and lesson plans.

Phase 2 included a two-week summer training for the participants, which was implemented on the main campus and a branch campus of a higher education institution. The content of the training was based on the National Science Education Standards (NRC, 1999) and the Ohio Science Standards (2000). The training included topics such as: scientific investigation, how to use a plant key, conducting observations for data collection, collecting qualitative and quantitative data, how to communicate data and how to make and support conclusions with evidence. The training also involved learning to use handheld computers and various science probes for collecting and analyzing data. The teachers learned about water quality indicators such as pH, water temperature, dissolved oxygen content and pollution level. The teachers were asked to develop an inquiry-based lesson plan integrating Palm handheld computers and probes. They were asked to work on the lessons with teams from their school building. The lessons were developed for a specific content area need, based on student academic achievement in particular topics. Grant writing was also included in the two-week workshop for the teachers to help them find funding and support for their future classroom projects.

Phase 3 included teachers' implementation of the inquiry-based lessons in their classrooms. It was intended that the lessons would engage students in inquiry-based science content and enhance the students' interest in developing an understanding and appreciation of science. Teachers created inquiry-based science lessons integrating handhelds and probeware and implemented their lessons in their classrooms. This phase included a mid-year follow-up training. Seven teachers implemented their lessons integrating Palm handhelds and probes in their classrooms during the Fall semester while some teachers implemented their lessons during the following semester. The lessons the teachers developed and/or implemented were placed on the project Website to provide examples to teachers interested in integrating handhelds in their classrooms.

Phase 4 included the collection and analysis of the data as well as the summative evaluation of the project.

Purpose of the Study

The professional development program evaluation included several instruments to collect data. For the purpose of this article, the researchers used data derived from the evaluation to answer the following questions:

- What is the teachers' perceived proficiency in inquiry-based science lessons using handheld computers and probes?
- How accessible are computer and handheld technologies in the schools selected for the professional development program?
- What are the teachers' perspectives on the professional development program with respect to handheld computers and inquiry-based science teaching?
- What are the teachers' experiences and perspectives on inquiry-based lessons using handheld computer technologies?

Project Evaluation Methodology

Participants

A total of 24 teachers, 13 female and 11 male, participated in the professional development program. One teacher dropped out the program during the second week of the training. The teachers were recruited from partner school districts with preference given to high need school districts based on the state proficiency scores. Curriculum directors worked with the project leaders to identify potential science teachers. Each school was required to send three teachers from the same building so the teachers would collaborate and support each other during or after implementation of their lessons. It was intended that professional development could be sustained by providing teachers a supportive and collaborative environment.

The demographic data were collected using the Eisenhower Program preliminary participant survey. Seven teachers were from rural, 11 from suburban, and six were from urban schools. The majority of the teachers (17) worked in middle schools, five worked in intermediate, and two worked in high school. Ten of the teachers taught science only, four were in self-contained classrooms, seven taught science as well as one or two other subject areas, and the other three teachers taught special education, social studies and health/physical education/OWA. Six of the teachers worked in buildings where between 40-68% of the students were on a free or reduced-cost lunch program.

Data Collection and Procedures

Pre and Post-Test Instruments

The data for evaluating the project were collected using multiple instruments aligned with the goals of the project. A survey instrument of 15 questions on a 5-point Likert scale (1=Not proficient to 5=Very proficient) was implemented as pre and post-test in the first and last day of the two-week training. This instrument was developed to assess teachers' perception of their proficiency on a range of items such as implementing inquiry-based lessons, using Palm handhelds, environmental content expertise and using spreadsheets to organize and analyze data. The pre-test included an additional 10-item survey that assessed the accessibility to technology in the participant teachers' schools. For the post-test, two feedback questions about the content of the training were included: "What worked?" and "What could be improved?"

Twenty-three teachers who had participated in the Fall semester follow-up session were surveyed again using the same 15 questions that appeared on both the pre and post-test. The main purpose of the follow-up meeting was to showcase and discuss the inquiry-based science lesson plans the participants had developed. The survey was repeated in order to investigate whether teacher self-perceptions of their proficiency toward technology and inquiry-based science had changed since the training. The survey also included open-ended questions with respect to the participants' experiences on implementing the inquiry-based lessons using handheld devices. Out of a total of 12 lessons developed, seven teachers had implemented their lessons in their own classrooms during the Fall semester. These teachers were asked to list the benefits of their lessons for student learning and to report problems, if there were any, with implementation of the lessons. The remaining five teachers reported that they would implement their lessons in the following semester. These teachers were asked to report barriers to implementing their inquiry-based lessons.

The Eisenhower Professional Development Program Surveys

To assess the effectiveness of the professional development program, the Dwight D. Eisenhower professional development program pre/post activity surveys were implemented. The Eisenhower Professional Development Program annually awards Federal funding to states for the purposes of strengthening teacher preparation programs and providing high quality in-service professional development for practicing teachers and educators. These surveys, the preliminary participant survey and the follow-up participant survey, took place at the beginning and end of the training. The Eisenhower program preliminary participant survey assessed the teachers' perceptions of themselves as teachers by a Likert scale (1 = Strongly agree to 5 = Strongly disagree). In the second part of the preliminary participant survey and the follow-up survey, the teachers responded to pairs of statements on a continuum of 1 to 5 (one end of the continuum described traditional teaching and the other end of the continuum described characteristics based on the National Science Standards). These pairs of statements addressed: the role of the teacher, student work, instruction, students' role in the classroom, students' learning, teachers' ability to encourage students, and student assessment. The Eisenhower program follow-up participant survey also included a section that rated the professional development provided by the project. In this article, teachers' reports with respect to their perceptions of the professional development are discussed.

Evaluating the Lessons

The participants worked in teams and created 12 science inquiry-based lesson plans. For the project evaluation, 10 lesson plans were evaluated in terms of clarity, concepts, creativity, focus, and integration of technology. These lessons were assessed based on the criteria adapted from the model of student-centered projects developed by Challenge 2000 (Penuel & Means, 1999). The Challenge 2000 project had adopted a model of project-based learning using multimedia to implement projects and use technology effectively to enhance and support student learning. A checklist was developed from the Challenge 2000 criteria to evaluate the handheld inquiry-based science lessons.

Data Analysis

Mean responses were calculated for the items in the administered survey. The qualitative data was used to understand teachers' perceptions of the effectiveness of the professional development program. The data was also used to explore teacher strategies and needs for developing and implementing lesson plans that are inquiry-based and incorporate technology. Each open-ended question was analyzed by using thematic data analysis for patterns which were coded inductively to construct themes.

Results

Perceived Teacher Proficiency

The data analysis with respect to perceived teacher proficiency in developing and implementing inquiry-based lessons using handheld devices revealed the following findings: Based on the pre-test implemented at the beginning of the two-week training, the participants felt moderately proficient to proficient in developing and implementing inquiry-based lessons. The pre-test revealed extremely low means (*M* = 1.21, 1.42) were computed for proficiency incorporating Palm handhelds in lessons and proficiency in using science probes respectively. Other small means (*M* = 2.33, 2.50, 2.63, 2.46, 2.42) described teachers' proficiency in using a Palm handheld (*M* = 2.33); proficiency in teaching the relationship between water temperature and dissolved oxygen (*M* = 2.50); proficiency in teaching the different environmental conditions that affect temperature, pH and dissolved oxygen (M=2.63); proficiency in teaching the relationship between soil pH, oxygen and plant health (*M* = 2.46); proficiency in teaching the relationship between pollution levels and dissolved oxygen (*M* = 2.42).

Post-test responses did not demonstrate marked differences in three items of the instrument (Table 1). These items were a) proficiency in using inquiry-based lessons, b) proficiency in using technology, and c) proficiency in teaching the basic concepts of science. The subjects felt moderately proficient to proficient with respect to these three items. Differences in the post and follow-up tests suggest that teachers' perceptions of their proficiency increased in interval on the scale. The two low means at the pre-test for "proficiency incorporating Palm handhelds in lessons and proficiency in using science probes (1.21, 1.42) were calculated as 3.80 and 3.81 for these items at the post-test. This indicates that teachers did not feel proficient before the two-week training, but felt moderately proficient to proficient after the training. There was not a large discrepancy between post-test and follow-up mean responses.

Table 1: Mean Responses Calculated from the Pre, Post and Follow-Up Tests

Item	Pre-Test	Post-Test	Follow-Up
1. Familiarity with inquiry-based lessons	3.71	4.33	4.24
2. Proficiency in developing inquiry-based lessons	3.30	4.00	3.88
3. Proficiency in using inquiry-based lessons	3.54	3.88	3.88
4. Proficiency in technology	3.59	3.88	3.97
5. Proficiency in using a Palm handheld	2.33	4.02	4.38
6. Proficiency in using science probes	1.42	3.80	3.79
7. Proficiency in integrating technology into lessons	3.00	3.96	3.94
8. Proficiency in incorporating Palm handhelds into lesson	1.21	3.81	3.24
9. Proficiency in teaching the basic concepts of science	4.08	4.38	4.35
10. Proficiency in teaching the relationship between water temperature and dissolved oxygen	2.50	4.08	3.79
11. Proficiency in teaching the concepts of pH	3.04	4.33	3.85
12. Proficiency in teaching the different environmental conditions that affect temperature, pH and dissolved oxygen	2.63	4.00	3.82
13. Proficiency in teaching the relationship between soil pH, oxygen and plant health	2.46	3.86	3.65
14. Proficiency in teaching the relationship between pollution levels and dissolved oxygen	2.42	3.83	3.65
15. Proficiency in using spreadsheets to organize and analyze data	3.00	3.63	3.76

The ten questions implemented at the beginning of the two-week training inquired about the teachers' accessibility to various computer technologies in their schools. The means of accessibility (1 = No access, 5 = Very accessible) showed that the Palm handhelds (*M* = 1.50), the science probes (*M* = 1.29) and graphing calculators (*M* = 1.67) were the most inaccessible. Computers in the classroom (*M* = 3.83), productivity software (*M* = 4.04) and instructional software (*M* = 3.54) appeared to be the most accessible (Table 2).

Table 2: Technology Access at School

Technology	Mean
Computers in labs	3.13
Computers in classes	3.83
Palm handhelds	1.50
Science probes	1.29
Video projection equipment	3.42
Digital cameras	3.46
Productivity software	4.04
Instructional software	3.54
Graphing calculators	1.67
Professional development in technology use in classroom	3.17

Teacher Perspectives of the Professional Development Program

Thematic data analysis was used to examine teachers' perspectives and experiences from teachers' responses to the open ended questions. All teachers responded "yes" when asked if they benefited from the professional development program. All of the participants indicated that the experience of using handheld devices and collecting data in the field using inquiry-based science methods was very helpful. The teachers commented that the integration of the handheld technology with inquiry-based science fieldwork and data analysis helped them understand how they can utilize technology in their teaching for multiple purposes. For example, one teacher reported, "Bouncing back and forth between scientific background and palm [handheld] technology brought everything into a full circle." Other comments included that the fieldwork and probe readings helped the participants understand the influence of pH on the environment and incorporation of handheld devices into science curriculum.

Teachers commented that the training focus of pH, dissolved oxygen and temperature was helpful for their professional development and can be connected to many science concepts and issues. One participant noted that actually performing experiments that they will be doing with the students was an important part of his or her training. A few of the teachers indicated that the peer-interaction and collaboration embedded in the training was very helpful for them to network and learn from each other. The teachers reflected that a team-teaching approach allowed the participants to learn from the expertise and different teaching style of the workshop instructors.

Implementing Inquiry-Based Science

Responses from the 15-item survey implemented in the Fall follow-up meeting did not demonstrate marked differences with respect to the participants' self-perceptions of their proficiency after the two-week training (Table 2). Open-ended questions were given to the participants to reveal their experiences and perspectives of the inquiry-based lessons integrating handheld computers and probeware. Participant teams had developed 12 inquiry-based lessons integrating Palm OS handheld computers and probeware. The lessons specifically focused on the National Science Content Standards for the appropriate grade level. The lessons varied according to grade level and provided students the opportunity to grapple with authentic, real-world problems. All of the lessons incorporated local environmental areas or created classroom environments from which to collect data. For instance, one lesson tested pH levels on Hydrangea plants, another studied water quality in a local pond, and another lesson created an aquatic environment in the classroom so that students could measure various quantitative factors. During the follow-up session, several participants indicated that they had modified previous instructional strategies used to teach specific concepts (i.e. globe protocols previously used to test water qualities) to incorporate handheld tools. The integration of technology was addressed as learners explored the use of handhelds and probes to gather data and disseminate their findings in the form of presentations, graphs, charts, spreadsheets, and Venn diagrams.

The data analysis from the teacher responses identified the need for more time to spend on troubleshooting and importing data into a spreadsheet. One teacher remarked that the professional development program needed to include more hands-on time on the desktop computer and handheld computer synchronization process as well as more troubleshooting techniques for problems. Several teachers stated that there is a need for more variety of experiments and ideas to integrate handheld devices into their teaching. The teachers suggested that the professional development program should include a broader spectrum of handheld software and probes, and where to find relevant software and hardware. The participants suggested incorporating physical science and earth/space science concepts into the professional development program. The teachers indicated an interest in getting training on the use of other probes such as light and electrical probes. One teacher suggested student involvement in the workshop and a set of handheld computers to sign out for classroom use.

Seven teachers reported that they implemented their lessons before the Fall semester follow-up meeting. The teachers said that the LabPro interface device used up a lot of batteries and that it was hard to keep up with supplying and funding batteries. One teacher mentioned he experienced problems with batteries dying and the interface not functioning properly. Teachers commonly reported that they had difficulty implementing their lessons due to the lack of availability of more than one set of handheld devices and probeware. For example, one teacher commented that they needed to have more equipment to implement lessons properly. Another teacher commented that a “roving” set of handhelds and probes could help teachers to distribute the sets in their schools. Teachers suggested having an abundance of batteries available on hand to smoothly run the interface. A few of the teachers found calibration errors in the Palm handheld computers. However, they considered this to be an “authentic problem” which gave the students opportunities to differentiate between accurate and inaccurate readings.

The teachers who had implemented their inquiry-oriented science lessons with handheld devices reported on the perceived benefits of this type of integration for student learning. They valued the fact that students could collect, read, and analyze real-life data and perform graphing instantly. One teacher wrote that using handheld devices enabled students to obtain quick results with accurate data collection and analysis. Another teacher reported that it was easy for the students to read and analyze the results of the data they have collected. The process of collecting and analyzing real-life data helped students with their understanding of science concepts. Teachers commonly observed that students had a greater understanding of the concepts, specifically the pH concepts. The inquiry-based lessons with technology provided reinforcement of the content related to pH, graphing and reading data. One teacher commented that data retrieval using technology increased students’ observation, hypothesis building and analysis skills. However, one teacher wrote that pH was a difficult concept for 5^{th} graders to understand.

All teachers reported increased student motivation and excitement by using technology to learn the science concepts. One teacher wrote “increased motivation to learn concepts measured by Palm handhelds” to describe his observations with respect to perceived student benefits. Another teacher said “excitement in learning science with technology” and “hands-on work” help students recall their science lab experiences. The novelty of the technology helped to make the students interested in technology and science because students realized handheld devices can be used not only as an organization tool, but also in academics. Teachers reported that using handheld computers and probes helped students form an increased understanding of computer applications, technology integration in the classroom, comparing advantages and disadvantages of technology and the impact of technology on society.

Discussion

This project presented a professional development opportunity for elementary and middle level teachers to increase their content knowledge regarding environmental quality indicators (e.g. pH, dissolved oxygen, temperature), use of handheld computers and probes and data collection methods. The teachers were highly interested in participating in the training to learn about integrating handheld devices into science curriculum.

The teachers rated themselves as moderately proficient to proficient on using inquiry-based lessons, using technology and teaching the basic concepts of science. The technology accessibility survey indicated that teachers do not have sufficient access to handheld devices such as handheld computers, graphing calculators and probes in their schools. This explains the extremely low means calculated in the pre-test for teacher proficiency incorporating handhelds in lessons and proficiency in using science probes. The other small means computed at the pre-test with respect to teachers' proficiency indicate that teachers felt somewhat proficient to moderately proficient with respect to these items. These findings explain the teachers' need and interest in learning about using handheld devices and the environmental quality indicators. Teacher observation with respect to increased student understanding of science concepts using handheld devices indicates the importance of technology access in the schools. Lack of access to various handheld devices and tools may have influenced integration of the environmental quality indicators and concepts in science lessons. Further research may reveal whether there is a correlation between teachers' knowledge of these concepts and access to tools that they can use to teach these concepts. Factors that influence teacher proficiency and integration of these concepts into inquiry-based lessons can be helpful to understand teachers' professional development and technology needs.

The participants in this project were able to use their expertise and training to successfully develop grade-level appropriate lessons for their students. Several teachers indicated that they had modified previous lessons to integrate handheld devices and probes. Seven teachers implemented their lessons and the remaining teachers reported that they would implement their lessons in the future.

Teacher participation in this professional development program indicates that teachers had interest in adopting handheld technology for their classroom use. The Concerns-Based Adoption Model (CBAM) can be used to understand participants' concerns with adopting handheld devices and to understand the levels of use and integration of these tools into inquiry-based science projects. CBAM holds that people considering and experiencing change evolve in the kinds of questions they ask and in their use of whatever the change is (Loucks-Horsley, 1996). Teachers may be at different stages of concern and different levels of use in the adoption of technology and inquiry-based learning. An insight into teachers' stages of concerns and levels of use of a curriculum idea or innovation can inform professional development designers of ways to effectively implement their training.

Access to technology resources, time and classroom management may support a seamless integration of inquiry-based learning with technology. Research on the total cost of ownership of handheld technology can help appropriate technology integration into curriculum. It is critical to do further research to determine the extent of cost advantages of using handheld technology and determine under what conditions the cost advantages occur. Teachers' experiences with handheld devices and the associated problems related to hardware and battery life indicate that handheld computer technology is still evolving. Overcoming these barriers to technology use can result in further adoption of handheld technology.

Teacher reports on their experiences and observations of benefits to student learning indicate that technology can support inquiry learning based on real-life data and reinforce student learning. The incorporation of ubiquitous computing tools can help teachers design multifaceted activities that enable theory to be put into practice. These activities increase student observation skills, hypothesis building and analytical skills.

Palm Education Pioneer (PEP) study findings show that inquiry-based science tasks are particularly effective for handheld computer use (Vahey & Crawford, 2002). Professional development programs need to pay close attention to teachers' conceptual understanding of inquiry-based learning and how to assess inquiry-based learning. Huber and Moore (2001) argue that hands-on learning does not guarantee inquiry learning and suggest that teachers need strategies that allow them to move forward toward implementing the National Science Education Standards' vision for inquiry-based science instruction.

Penuel et al. (2004) researched teacher work practices and classroom activity structures in context using handheld-based wireless technologies. They found that teachers incorporated instruction that followed a mixed model which was often hands-on and engaged students in cooperative activity, but not "inquiry-based in the way that the National Science Education Standards emphasize." (p. 359) Professional development and collaboration endeavors are essential for exposing teachers to handheld computers and ubiquitous computing. These professional development programs can incorporate follow-up activities to support different levels of technology use for instruction. Teacher understanding and cognition of technology-enhanced instruction for inquiry learning is important for utilizing the potential of handheld devices. Further research should examine teachers' understanding of inquiry-based learning, role of technology integration, assessment of inquiry-based learning, and under what conditions handheld technology support inquiry-based learning.

Conclusion

Handheld computers and probeware have the potential to support inquiry-based science projects in K-12 education. Teacher training is important for effective integration of inquiry-based learning to provide students with rich and authentic learning experiences. Access to technology and ubiquitous computing devices can support inquiry-based learning. Professional development programs can expose teachers to methods and strategies to integrate inquiry-based lessons using handheld tools. Research need to follow-up on the outcomes of teacher training in order to sustain professional development efforts.

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A Method for Describing Learning Interaction with Content

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Abstract

Text, graphics, animations, simulations and discussion boards are some of the tools made available to online instructors to meet course objectives. The way in which students interact with these different modalities in the online environment is a new area for educational researchers. This research presents a method for exploring learner interaction with content when presented in the online environment. The method presented in this article is based on the experiential cycle of learning. The researchers suggest that online courses designed for all learners and that encourage multiple entry points are better equipped to advance theories for how people learn online.

Introduction

The development of online teaching and learning is not a quick and simple process (McCormack & Jones, 1997). Surveys of websites for teaching and learning (LaRose & Whitten, 2000; Mioduser, Nachmias, Oren, & Lahav, 1999) showed that the majority of websites do not meet some of the early expectations of the medium. In particular, one survey by Mioduser and colleagues (1999) showed conclusively that most current educational websites were not making use of the pedagogical approaches favored by educators and researchers. They suggest that issues associated with the current approaches to developing, implementing and supporting online teaching and learning were contributing factors to this problem. This method provides online instructions and researchers with a consistent and comprehensive approach to online course design to positively influence cognitive and affective aspects of online learning.

In terms of social cognitive theory, it is the immediacy of interaction between students (LaRose, Gregg, & Eastin, 1999) and peer groups in face-to-face interactions that can provide affective and cognitive rewards in a learning experience. Claims have been made that such immediacy, facilitated in the face-to-face classroom, was hard to match in distance education, and leads, in some cases, to feelings of isolation (LaRose & Whitten, 2000; Moore, 1989). This problem of immediacy between students has been remedied through the use of the asynchronous discussion boards (see Figure 1).

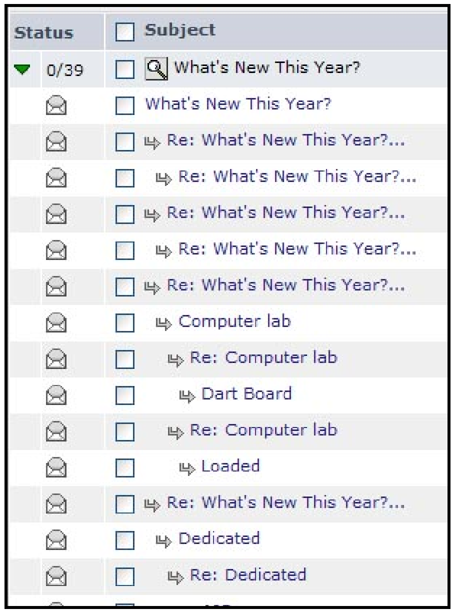


Figure 1: Asynchronous Discussion Board Sample

When participating in a discussion board in an online course, students and instructors are expected to engage in text-based dialogue. When students reply to others in a timely fashion, immediacy of interaction between students is satisfied. We suggest that the immediacy of interaction between students and content is equally, if not more, important to facilitate student understanding of concepts at high levels of cognition. One solution has been suggested by computer scientists who have built intelligent tutoring systems that pose questions to students, usually in form of true/false or multiple choice type questions, and based on the student responses, provide immediate feedback.

Although important in advancing the concept of individualized instruction, intelligent tutoring systems do not directly link in a meaningful way back and forth to the curriculum content. Even more constricting is that the way in which the intelligent tutoring systems align curriculum and the instructional design. The goal of the present method is to address the issue of immediacy between students and content where the content is designed to best meet the needs of the students. The way in which students interact with the content and how they perform on assessments would then affect the presentation design, adapting it in some way to the individual's needs.

Individualized Needs

What are an individual's needs in the online learning environment? When students interact within a course management system such as Blackboard or WebCT, their perceptions of the course content may vary from the traditional classroom experience. Most likely the course content is presented in a text heavy format, with some graphics. Although hyperlinking offers flexibility in moving between links within the course, the actual presentation of the content is static. Research conducted in the area of learning styles provides educators with insight into how people learn best in the traditional, face-to-face classroom experience (Bransford, Brown, Cocking, Donovan, & Pellegrino, 2000; Canfield, 1980; Dunn & Dunn, 1984; Kolb, 1984; Sims & Sims, 1995). In the online environment, issues of interface, navigation and multimedia add layers of complexity; simply applying traditional theories of learning styles may not be enough (James & Gardner, 1995). Although critics of learning style research argue against categorizations and reliability, there are about 21 different learning style instruments (Sims & Sims, 1995) and even more learning style theories. A review of the literature reveals that there is no single way to define learning styles but they can be generally described as "an individual's preferred approach to organizing and presenting information" (Riding & Rayner, 1999). From the traditional classroom perspective, different learning styles models, concentrating on various aspects of the learner have been suggested, such as personality (Briggs & Myers, 1977; Keirsey & Bates, 1978), information processing (Felder-Silverman, 1988; Kolb, 1984; Witkin, Moore, Goodenough, & Cox, 1977), and instructional and environmental preference (Canfield, 1980; Dunn & Dunn, 1984; Hruska-Riechmann & Grasha, 1982). Curry (1983) represents the relationship between learning style instruments as a three-layer system, similar to an onion (see Figure 2).

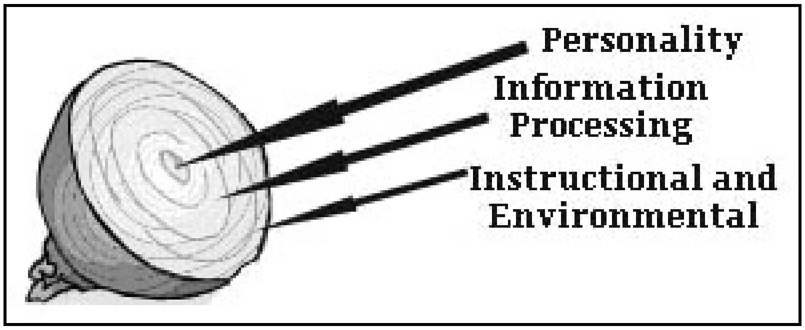


Figure 2: Curry's Onion Model

Curry (1983) proposed the "onion" model for categorizing cognitive/learning styles in which "learning behavior is fundamentally controlled by the central personality dimension, translated through the middle strata information processing dimension, and given a final twist by interaction with environmental factors encountered in other strata" (p. 14). It was expected that instructional preference was the least stable across time and the most easily influenced level of measurement in the learning environment (Curry, 1987). Identifying a learners' style in the traditional classroom had been conducted through the use of self-report instruments. Self-report instruments have been scrutinized for issues such as reliability and validity (Garner, 2000; Sewall, 1987) but are used as guides for developing learning experiences that cater to the diverse spectrum of learners.

The new environment for instruction, namely the online environment, presents learners with a new context for processing information. New tools and ways of interacting present learners with opportunities for learning in ways unattainable in the traditional, face-to-face classroom. Learning style theory, specifically Kolb's experiential cycle of learning, was selected to explore the transfer of such a theory to the online environment.

Kolb's Learning Styles

The Kolb Learning Style Inventory is perhaps the best known of its type (Instructional/Environmental) and is based on Kurt Lewin's Experiential Learning Theory. Kolb states that people prefer to *grasp* information either through apprehension or comprehension (Kolb, 1984; Kolb, Rubin, & McIntyre, 1979). In effect, he is saying that the grasping activity is either concrete or theoretical, or someplace in between. Once the information is grasped, people *transform* it into knowledge either through intention or extension. In other words, they need to think about it or they need to try it out. A simple example occurs when you get a new piece of software. Do you immediately rip off the shrink-wrap and try it out or do you read the manual first? As shown in Figure 3, these two dimensions, with their extremes, identify four quadrants that Kolb labels as diverging, assimilating, converging, and accommodating.

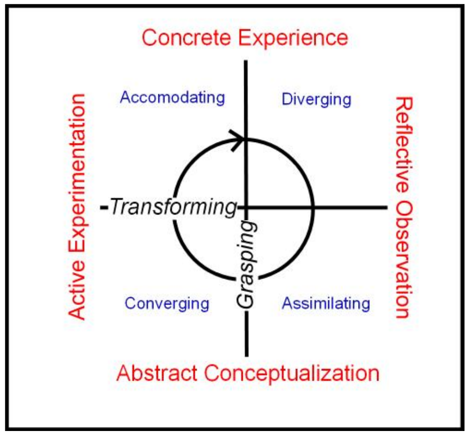


Figure 3: The Four Kolb Learning Styles

A diverging learner grasps information from concrete experience and transforms it into knowledge through reflection. A converging learner is more comfortable with grasping theoretical constructs and then transforms those constructs into knowledge through experimentation. Hence, diverging learners asks the "Why" questions; they like to reason from concrete specific information and to explore what a system has to offer. They prefer to have information presented to them in a detailed, systematic, and reasoned manner and combine feeling and watching by viewing a problem from various perspectives. On the other hand, converging learners ask "How". They gain knowledge by understanding the details about the system's operation and combine experiential thinking and doing learning modes. While lecture works well for divergers, convergers prefer a more hands-on approach.

Kolb says that a learning experience designed for a specific learning style is optimal for the short run. However, he is also concerned about long term effects on problem solving and advocates that people learn to work in different ways to expand these skills. The Kolb Learning Cycle includes activities from all four quadrants. Starting with Concrete Experience, the cycle moves through Reflective Observation, Abstract Conceptualization, and ends with Active Experimentation. The idea here is that each learner finds something attractive to his or her style, but is also exposed to the way other people learn. This exposure may result in gaining additional tools or styles for learning. McCarthy (1987) extends Kolb's cycle with her 4MAT system. She divides each of Kolb's quadrants in two, introducing consideration for left and right brain processing techniques.

Kolb's Learning Style Instrument (LSI) initiated a starting point for designing online instruction. When considering individual differences in learning, the criteria for selecting a well-grounded model necessitates considering issues, such as reputation, time, descriptiveness and prescriptiveness. The Kolb (LSI) consists of 12 self-report items. Kolb described not only how learners are categorized, but also how instruction should be adapted for each learner category; that is, apart from the descriptive information (i.e. learners are categorized into "active" and "reflective"), the model provided prescriptive guidelines, which led to specific rules for designing instruction and adaptation (i.e. what types of educational content should be selected for active and reflective learners). This research did not set out to categorize online learners, but to experiment with the experiential cycle of learning, and make suggestions for instructional methods. The transfer of these methods has not been situated in the online environment, nor have learners been asked to self-report their perceptions of their learning style in the online environment. Transferring Kolb's suggestions for instructional methods to the online environment raised additional issues of validity. Selecting a media type that aligns with Kolb's suggestions for an instructional method in the face-to-face classroom was challenging. The assumption made by some researchers in the area of adaptive hypermedia (Carver, Howard, & Lane, 1999; Danielson, 1997; Paredes & Rodríguez, 2002; Peña, Marzo, & Rosa, 2002) is that learning styles and therefore, instructional methods transfer to the online environment and use learning style instruments to pre-screen their students. This pre-screening then determines the presentation of content with which the student will interact. Because so little is known about how people learn online, we suggest exploring this notion in more depth. To do so, we propose an all-style approach to designing instruction, introducing a variety of tools for different purposes.

Meeting Learning Objectives Online

To meet a particular learning objective in the online environment, a variety of tools are available to instructors. Some tools, such as a threaded discussion board and whiteboards are available through the course management systems. Others, such as animations, graphics and simulations must be created or shared. As a result, the "learning object" was born. Learning objects are any entities, digital or non-digital, that can be used, re-used, or referenced during technology-supported learning (Rawlings, Van Rosmalen, Koper, Rodriguez-Artacho, & Lefrere, 2002). An example of a repository for learning objects is the Multimedia Educational Resource for Learning and Online Teaching (MERLOT) website. MERLOT provides educators with resources found on the web that are peer-reviewed, however, the site does not indicate where and how the objects are used. When learning objects are integrated into an online learning experience, students interact with it. This interaction may vary from person to person. Research conducted by Richard Mayer explored the effects of different representations of content on students' performance on retention and transfer tests (Mayer, 1999). In his research on multimedia learning, he concluded that narrated animations were more effective than animations with text, for example. To explore student interaction with content when presented in a variety of ways, a comprehensive, all-style approach to designing instruction is described.

The Method

Learning styles, issues of interface, hyperlinking and multimedia design were incorporated into our approach for designing online instruction. The purpose of this method is to not only explore student interaction with content, but to inform the development of new technologies (such as adaptive hypermedia tools) that aid instructors in tailoring course content to individuals (Brusilovsky, 2001; Brusilovsky & Maybury, 2002; Hillman, Willis, & Gunawardena, 1994). Over time, it is expected that the presentation of content will adapt to meet the needs of the student in some way. McCarthy's (1980a; 1980b; see also Gray & Palmer, 2001) all-style approach to designing instruction was developed for instructors who teach in face-to-face classrooms. This eight step process (or "wheel") guides instructors in the development of a lesson to meet a particular learning objective (see Figure 4).

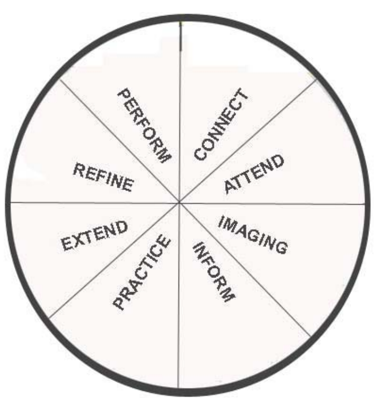


Figure 4: McCarthy's 4MAT wheel approach.

This is a comprehensive way for an instructor to meet a particular learning objective and to include elements for all learners. For the purposes of this research, one cycle of the wheel (the eight events) were considered one learning object. A description of each element is given in table one.

Table 1: McCarthy's Instructional Events

Connect: create a concrete experience
Examine/Attend: reflect on the experience and analysis
Image: integrate experience and reflection into concepts
Inform: define theories and concepts
Practice: work on defined concepts and givens
Extend: experiment and add something of oneself
Refine: analyze application, judge results of experimentation
Perform: apply learning personally and share with others

McCarthy (1987; 1996) developed this approach to designing instruction to address all types of learners. Oftentimes, instructors use one method of instruction, unintentionally neglecting some learners. When exercising McCarthy's approach, a more comprehensive and structured way to design instruction is expected. Because of Kolb's cyclic approach to learning and correlation to McCarthy's instructional design method, they were selected to guide this research. McCarthy's approach was selected as not only an instructional design tool for the online environment, but translated into a navigation tool as well. This cyclic approach to instructional design was transferred to the online environment to begin exploring patterns of navigation and diversity in interactive elements to describe how people learn online.

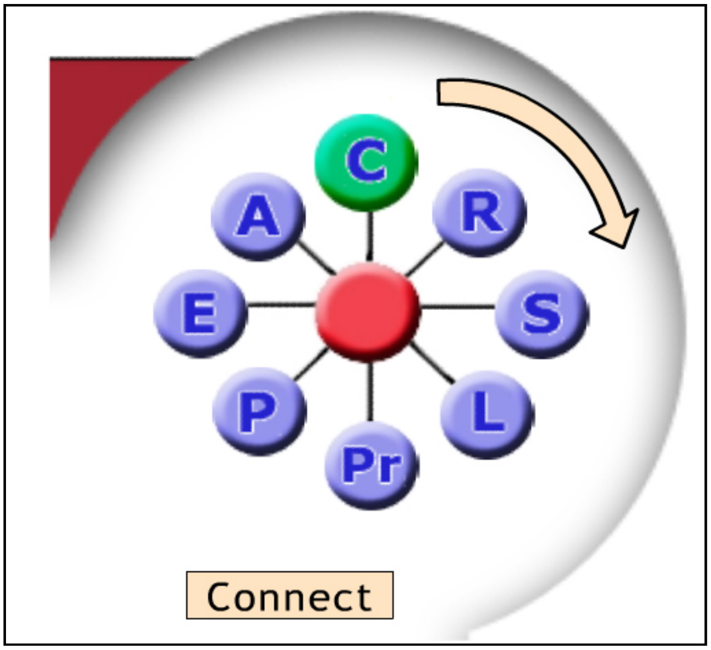
The Approach

McCarthy's eight instructional events were transformed into language students would understand (Table 2).

Table 2: Instructional Events for Student Perspective

Connect (C): create a concrete experience, engage prior knowledge
Reflect (R): externalization of thoughts and conceptions regarding experience.
Share (S): compare other perspectives
Learn (L): define theories and concepts
Practice (Pr): work on defined concepts and givens through reinforcement exercises
Personalize (P): manipulate and interact with defined theories and concepts to extend their meaning
Experiment (E): make observations about experiment
Apply (A): Apply learning to new situations (sets context for next cycle)

In its original state, McCarthy's events were developed for instructors. In this case, the cycle serves three purposes. First, it is an instructional design tool for instructors. When repurposing content for the online environment, instructors have a systematic way of creating meaningful experiences for learners that are not text-heavy and discussion board dominant. Second, students interact with the eight events to reach a particular learning objective as defined by the instructor. Over time, students are expected to anticipate what may be included in the "connect" event. Third, the eight instructional events were transformed from the "wheel" to a navigational map (see Animation 1) and called the "OctoPlus".



Animation 1: OctoPlus wheel (click image to play)

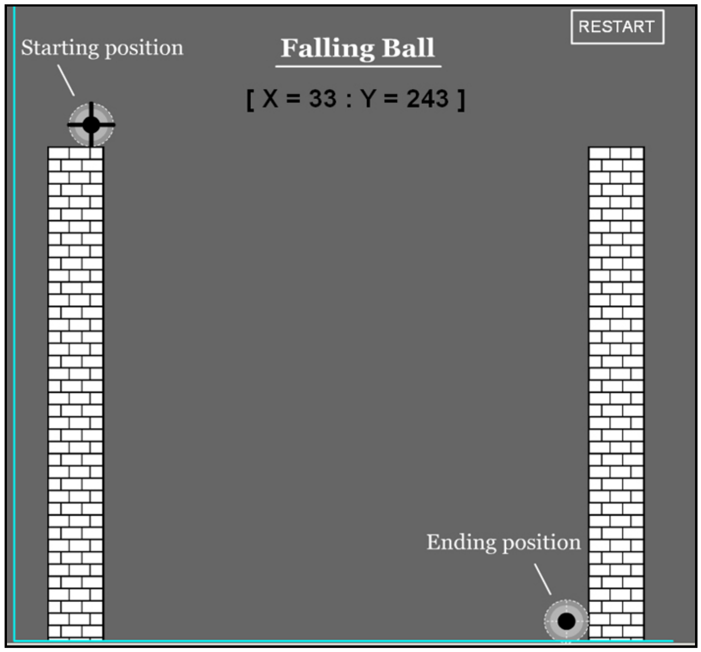
Each letter of the OctoPlus is an instructional event, representing a different instructional method. Each letter links to a webpage that may include text, graphics, animation, simulation, or video for example. Initially, students are encouraged to visit each event starting with “C” for connect, and then work clockwise. Over time and depending upon a studentss online learning style, student navigational patterns, interaction with multimedia and performance on assessments may vary. The integration of instructional design and navigational structure through this visual representation was influenced by Horn’s notion of visual language (1998). Horn describes hypertext as a language where visual cues influence a user’s mental model. In this case, each OctoPlus represents a “package” of content and assignments for a particular learning objective. As a result, the eight elements together create a learning object. The combination of instructional design elements provides educators and researchers with a way to isolate media events within a learning experience to better understand how people learn online. As a result of the student interaction with the content, performance on assessments, and instructor feedback, through adaptive hypermedia techniques, the instructional event or elements within the event may adapt over time.

Instructional Design

Each OctoPlus begins with an introductory page and ends with a wrap-up assessment. The introduction page briefly describes the activities within each event. At this time, a student can get a sense for what to expect and make a decision as to which event or events he or she may visit first. Before moving on to the next OctoPlus, the student must complete the quiz located in the wrap-up section. This will assess whether the student has met the particular learning objective set out by the instructor. The eight elements of the cycle are described below.

Connect

The connect page engages students prior knowledge of the topic. This page provides instructors with a way to gauge student understanding of the content. To engage students in the learning experience, you may include a video or simulation (see e.g. Animation 2). As a result, students are actively engaged in the experience and motivated to learn more. Relating the content to a real-world experience may also help students retain and assimilate knowledge with their existing schema.



Animation 2: Falling Ball (click image to play)

Reflect

There are a variety of ways that students can reflect on their experiences in the online environment. Students can post to the discussion board, email a private message, or respond to a quiz-like question. Reflection on a task or learning experience is crucial (Zeichner & Liston, 1999) and is oftentimes included in many instructional strategies and repertoires. In the online environment, the threaded discussion board is the tool most commonly associated with reflection. The threaded discussion board could be used here.

Share

The instructional events, reflect and share support the need for immediacy of interaction between students (LaRose et al., 1999) and peer groups. Sharing their experiences with the class as a whole was the purpose for the next node of the OctoPlus. The QuikQuiz© could also be used here (Danchak & Pedersen, 2002). The QuikQuiz© is a java-based applet that checks for student understanding. This tool provides instructors with a way to quickly assess student understanding through a multiple choice question or short answer question. Not unlike a quick survey of hands in a face-to-face classroom, the QuikQuiz© provides the instructor and students with instant feedback. For example, when a user responds to the question posed, a display of the correct answer is given. Records of the users' answers are recorded for the instructor's review. If a user responds incorrectly, the instructor may decide to send an email to clarify the situation.

Learn

The content is presented in this section of the cycle. Mayer (1999) would suggest a narrated animation for this purpose. Depending on the content, this may or may not be the best media. Nevertheless, providing students with multiple presentations of the same content is suggested. If a narrated animation is also presented using text and graphics, for example, the student has the option of selecting from one of the two modalities (Animation 3). Over time, if a student continues to select the animation, proceeding cycles may in fact emphasize animations when appropriate as a way of adapting to the needs of the student.

Animation 3: Function A (click image to play)

Practice

This instructional event is designed to provide users with reinforcement exercises and as an assessment for the instructor. Students may be asked to submit an assignment or interact with an applet, for example. The idea here is to provide students with more of the same types of activities described in the *learn* section.

Personalize

To assimilate the information learned so far, students may be asked to reflect (see e.g. here) on what they have learned so far. This may be done through a text, or other media. As a result, students are expected to personalize the information for their mental model.

Experiment

Students are asked to extend what they have learned so far and make observations about those extensions. A simulation applet would be appropriate for this event. Students may be given the opportunity to manipulate an applet to perform an experiment. In the research conducted by Mayer, the animations with narration were non-interactive in the sense that the learner could not manipulate the simulation of lightning formation (click here for an example). To extend this further, the integration of an action, such as temperature change could be included. As a result, the student could experiment with different cause and effect relationships.

Apply

Applying the knowledge gathered so far provides students with another purpose for learning the information. In some cases, students prefer to learn how the information they are about to learn is meaningful in the real-world. Applying what they have learned to a new situation not only increases students' chances for retaining the information, but also transferring this knowledge.

Animation 4: Magnifier (click image to play)

This method for designing instruction for the online environment provides students with multiple entry points into a learning experience. In addition, the events are designed around a specific learning objective and encourage a variety of learning tools. Students can navigate through the cycle at their own pace and sequence. This systematic method for developing comprehensive learning experiences provides designers and instructors with a learning theory-based approach to online instruction. In addition, researching learner interaction with content can be explored through avenues such as navigation patterns, time spent on pages, media usage, performance, preferences and learning styles.

Conclusion

With the exception of Mayer (1999), performance on assessment tasks have not been linked to how people learn from diverse instructional methods online. This eight page approach to designing and navigating content is a comprehensive way to develop learning experiences, integrating a variety of instructional methods into a lesson. Not all eight pages may be needed to meet a particular learning objective; however, future research will explore how different navigation and interaction styles affect student performance. As a result, depending upon an individual learner, the cycle will adapt to suit their needs, without jeopardizing learning.

Learning style research in the online environment is dependent upon a variety of issues that have not appeared in the traditional classroom. As a result, new methods for exploring this learning environment must be developed to inform new theories of learning. This tool for online course design, content management and navigation provides the online learning community with a new perspective. We recommend that instructors and instructional designers try out this method as a way of developing lessons to reach all learners. Other more linear approaches to online course design has not shown promise in advancing what is known about how people learn online; this cyclic approach may do just that.

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Situated Learning in a Ubiquitous Computing Classroom

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Abstract

This case study reports on a third grade class's use of ubiquitous tools during a science unit on forces and motion. The investigation documents the unique ways in which children can construct knowledge and create representations of their learning when afforded ready access to a variety of digital devices. Further, the study explores the way ubiquitous computing environments support meaningful student collaboration and the situated learning approach.

Introduction

According to the Ohio Academic Content Standards for Science Education (ODE, 2002), by the time students complete third grade, they are expected to be able to trace and measure motion, identify forces, predict changes when an object experiences a force, record their results, and communicate their findings to others. Students should also be able to recognize that science and technology are interconnected and "reflect on scientific practices as they develop plans of action to create and evaluate a variety of conclusions" (p. 80). Additionally, in order to adequately prepare students in the information era, teachers are highly encouraged to integrate technology into their curricula. Research has shown that learning with technology increases students' motivation, problem solving skills, and critical thinking.

This case study reports findings from an ongoing investigation of teaching and learning in ubiquitous computing environments. Participants for this study were twenty third graders and their classroom teacher. Findings from ethnographic observations and interviews document the effectiveness of a situated learning approach for elementary science instruction. It also identifies ways in which ubiquitous computing tools support student collaboration and knowledge construction.

The Situated Learning Approach

The situated learning approach is based on the premise that knowledge is not static, rather, it is situated in the actions of learners interacting within communities of practice (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Wilson & Meyer, 2000). In other words, situated learning asserts learning is connected to real situations in which knowledge is created and used. Thus, knowledge needs to be presented in an authentic context, and learning involves social interaction and collaboration (Andrews, MacKinnon, & Yoon, 2002; Kearsley, 2000). Brown, Collins, and Duguid (1989) state that designing authentic activities is important because "it is the only way they [learners] gain access to the standpoint that enables practitioners to act meaningfully and purposefully" (p. 36). To successfully develop situated learning activities, Anderson, Reder, and Simon (1996) identified four major premises: (1) learning is grounded in the actions of real-world situations, (2) knowledge only transfers to similar situations and is determined by the number of symbolic components that are shared, (3) learning occurs best with a combination of abstract instruction and concrete examples in everyday practices, and (4) instruction and learning need to take place in complex social situations involving people, situations, and tasks.

Situated learning's emphasis on social participation in communities of practice (Anderson, Reder, & Simon, 1996; Dillenbourg, 1999) is concurrent with research regarding how people learn in collaborative groups. From the perspective of collaborative learning, a group of learners work together to reach their goals in an authentic joint activity, and knowledge is therefore co-constructed through interaction. Research (e.g., Hollan & Stornetta, 1992; Koschmann, 1996; Soloway et al., 1999) has suggested that collaborative learning supports cognitive development through social interaction. A key framework used to explain the role of social interaction is Vygotsky's social cognitive theory. According to Vygotsky (1978), cognition is developed through social interaction, that is, students internalize the meaning and uses of mediating tools as they communicate and interact with others until they internalize the process (Lin & Laffey, 2004).

Accordingly, McDermott (1993) emphasizes the relationships between people as playing an integral role in the learning process. It is "in the conditions that bring people together and organize a point of contact that allows for particular pieces of information to take on a relevance; without the points of contact, without the system of relevancies, there is not learning, and there is little memory. Learning does not belong to individual persons, but to the various conversations of which they are a part" (p. 300). In short, students learn best when they learn skills and theories in the context in which they are used and communicate their interpretations and understandings to others.

The Integration of Technology with Science

Research has shown that technology can be used as a powerful tool to facilitate learning as well as student achievement. The 1996 U.S. Department of Education Report to the Nation on Technology and Education reported, "Through the use of advanced computing and telecommunications technology, learning can also be qualitatively different. The process of learning in the classroom can become significantly richer as students have access to new and different types of information, can manipulate it on the computer through graphic displays or controlled experiments in ways never before possible, and can communicate their results and conclusions in a variety of media to their teacher, students in the next classroom, or students around the world" (p. 8). In his article about technology in K-12 classrooms, Kleiman (2004) pointed out that many exciting technology innovations including virtual schools (e.g., Virtual High School), ubiquitous technology programs (e.g., SBC Ameritech Classroom at Kent State University), education programs to support inquiry-based teaching and learning (e.g., eMINTS National Center), and online professional development programs (e.g., EdTech Leaders Online) have taken hold since his first review in 1999.

The term, "ubiquitous computing" was first introduced by Mark Weiser at Xerox Palo Alto Research Center (PARC) to describe the methods of making technology available throughout the physical environment without users' awareness of it (Keefe & Zucker, 2003; Weiser, 1993). "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser, 1991, p. 94). Research in K-12 education has demonstrated that ubiquitous access to technology influences the learning process (Sandholtz, Ringstaff, & Dwyer, 2000) and student achievement. Apple Computer (2002) reviewed research findings on technology's impact in the classroom conducted over the past two decades and summarized that:

- Technology helps students master fundamental skills for future learning.
- Technology helps students become proficient users of technology.
- Technology prepares students with 21st-century skills.
- Technology motivates students to higher levels of achievement.

Although research on ubiquitous computing shows promising results, more research is needed to provide hard evidence of the benefits (Beaudry, 2004; Zucker, 2004). In addition, there are only few studies which offer systematic examinations of the instructional approaches used in science education that integrate technology. The Research Center for Educational Technology's (RCET) SBC Ameritech Classroom, which opened in Spring1998, is exploring ubiquitous computing at the classroom level. This classroom is equipped with enough Internet-accessible computers, including desktop and laptop computers for every student to have access to one, and enough handheld computers and mobile computing devices for students to take with them beyond the classroom (Swan, Kratcoski, van 't Hooft, & Diaz, 2004), a digital presentation system, distance learning capability via VTEL and Polycom technology, Interwrite School Pads with Bluetooth technology, digital audio recorders, an atmospheric data center, CD/DVD burners, scanners, printers, Graphire pads, digital still and video cameras, video editing equipment, four VCRs, a document camera, and a presentation control station. In addition, students can use an assortment of software programs and tools, including Microsoft Office™, Kidspiration™, Inspiration™, Animation Shop™, and graphics/video editing packages. Each year, local teachers (who are nominated by their administrators and subjected to a selection process) bring their classes to complete regular units of study in the classroom. The participating teachers and students spend half a day every day for six weeks in the classroom. Figure 1 depicts the floor plan of the classroom. In the SBC Ameritech Classroom, technology is viewed as a mediating tool for learning, collaborating, and communicating. Additionally, the SBC Ameritech Classroom has an adjacent observation room that includes four observation stations, four cameras, sixteen microphones, two analog VCRs, and four DVD recorders. Each observation station is equipped with a wireless laptop, an observation monitor, an AMX touch panel that controls the cameras and DVD recorders, and Sony studio recording quality headphones.

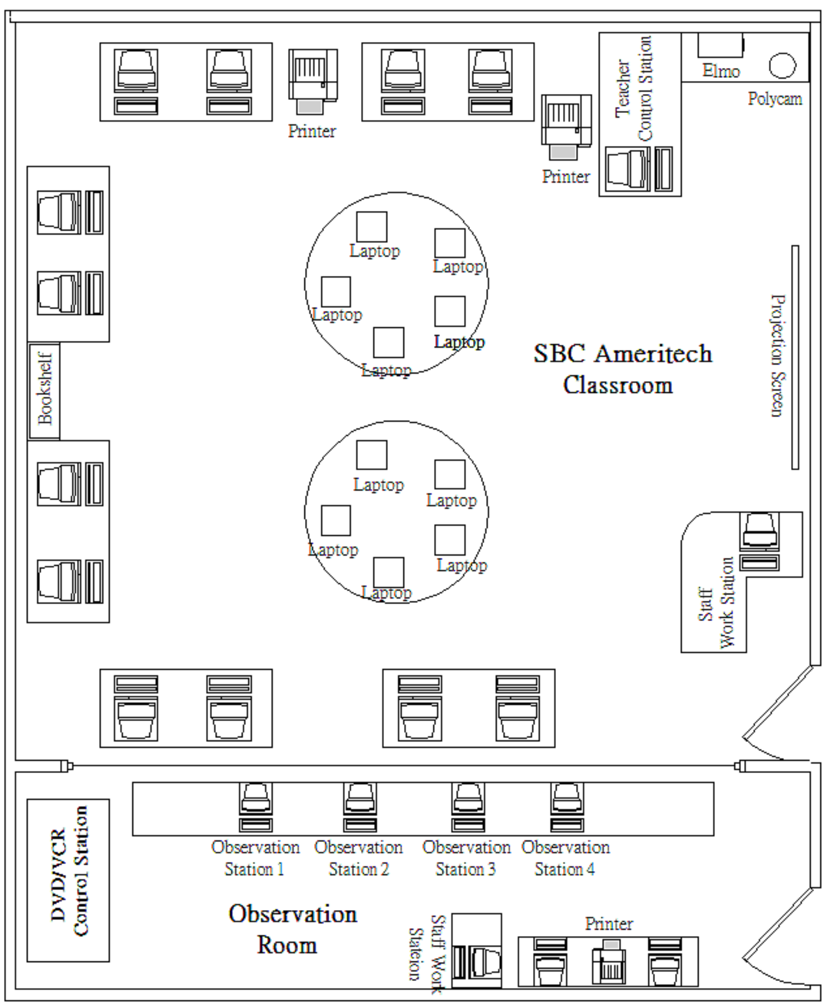


Figure 1: Floor Plan of the SBC Ameritech Classroom

In this case study, we report on a third grade class's use of ubiquitous tools within a situated learning approach to study force and motion in the SBC Ameritech Classroom. The following questions guided the investigation:

1. How does ubiquitous access to a variety of digital devices impact teaching and opportunities for learning?
2. What sorts of knowledge representations are afforded by ready access to a variety of digital devices that would not be possible otherwise?
3. How does ubiquitous access affect student learning and students' attitude/motivation toward learning?
4. How does ubiquitous access affect the social interactions around which knowledge is constructed and shared?

Methodology

Participants

The participating class was comprised of twenty third graders (6 girls and 14 boys) and included two students identified as gifted, six students identified as gifted in one or more categories, three students on IEPs for learning disabilities and two students on IEPs for speech/language services. All of the students were working at differentiated learning levels in all subject areas. The teacher had 26 years of teaching experience and had completed a six-week experience in the SBC Ameritech Classroom during the previous school year. At the time of this study, her class was also participating as one of the iBook Model Classrooms within their school district.

Data collection and analysis

This case study was exploratory in nature. Data collected to capture the classroom dynamics across the six-week unit included teacher interviews and reflections, student interviews, videotaped observations of peer interactions, and field notes. Data analyses focused on thematic analyses.

Teacher interviews and reflections. Teacher interviews were conducted throughout the unit and focused on the teacher's instructional approach and her own impressions/observations with regards to student learning, motivation, collaboration, and their use of technology. Teacher interviews were conducted in person and audio-recorded and transcribed. In addition, all teachers participating in the SBC classroom are asked to submit reflections on their SBC experience and this teacher's reflections were excerpted and added to interview files. Data from teacher interviews and teacher reflections was analyzed qualitatively, using constant comparison to detect emergent themes (Janesick, 1994; Lincoln & Guba, 1985).

Student interviews. Quasi-clinical interviews were conducted as students were working on the claymation movies with reference to that work. Specifically, students were asked to explain their work and the representations that were created. Students were also asked to discuss their technology preferences and how the technology helped them to learn. All interviews were audio-recorded then transcribed and analyzed qualitatively, using constant comparison to detect emergent themes (Janesick, 1994; Lincoln & Guba, 1985).

Videotaped observations. The class was videotaped daily across the five-day Claymation project. Observer field notes were also taken to supplement video data. The videotapes of the lesson were transcribed and sorted into the following five categories using Idea Works Qualrus™:

1. **Brainstorming/Storyboarding:** Students worked with their groups and discussed how they were going to represent "forces and/or motion" in their claymation movie.
2. **Producing:** Students shot successive photos on their clay characters.

3. **Editing:** Students edited the photos on a desktop computer.
4. **Presenting:** Students presented their Claymation movie to the class and their class buddies.
5. **Telling/Reflecting:** Students explained which types of forces and/or motion were represented in their Claymation movie.

Results

In the sections that follow, research findings are discussed relative to each of the research questions.

How does ubiquitous access to a variety of digital devices impact teaching and opportunities for learning?

Data obtained from teacher interviews documented the teacher's personal beliefs regarding teaching and learning as well as her impressions regarding the impact of ubiquitous technologies. During interviews, the teacher frequently discussed the importance of authentic learning experiences for facilitating learning:

> *I believe that students need their learning to be meaningful, real life experiences. They need to be engaged in their own learning and be able to explore. I believe that if students are engaged in their own learning, they will retain what they learn and apply it to their everyday lives… It is my goal to design engaging work for all of my students and to motivate them to learn. What better way to learn than through the world of scientific inquiry and technology? Their work may need to be modified or enriched, but if the subject peaks their interest, they will most likely have greater success.*

The teacher's previous experience in the SBC classroom helped shape her beliefs about the role of technology in teaching and learning:

> *The students [last year] were continuously engaged in learning [during] our science unit on weather. The technology intrigued them and kept them motivated using all of the software programs the classroom had available… [Therefore,] I try to integrate the computers, camera and software as much as I can… Technology can meet the needs of all types of learners.*

During interviews, the teacher discussed her use of various technologies during the six-week unit and the types of learning opportunities that were possible:

> *The technology allowed us to use emails and send messages via e-mail to each other and our parents. We do not have that capability at school. We also love using the Intel cameras and the cameras on the Palms. We discovered all kinds of ways we could use the cameras and special activities with the photos. We also used the cameras and animation software with our animation/claymation activities. It was also great for the students to have computers one on one…As we used the Elmo and the Palms more, I was able to think of more ways to incorporate them…They loved using the Palms for journaling and keeping data.*

Across the six weeks, the teacher frequently used the document projector during whole class lessons and/or when giving directions for small group or individual work. During the course of the Claymation activity, the teacher walked among the small groups to assist students in their work and scaffold student understanding of the curricular concepts of the unit (i.e., Newton's Laws of Motion).

Finally, the teacher also shared that the unlimited access and resulting excitement among students created some classroom management challenges. She shared, "They were always engaged when they were on the computers. Sometimes it's just at the point of not being able to get them off and getting their attention on somewhere else. But I was always able to get their attention by pulling down our big video screen, our big projection screen, and using the Elmo."

The teacher’s use of the projection screen in her instruction suggests that visualization tools not only facilitate learning but also engage attention. When interviewed regarding their impressions of the teacher’s use of the projection screen, most students reported that they enjoyed reading on the screen:

Jack: *It [the projection screen] helps us get the instructions.*

Dan: *We can brainstorming and put everybody’s ideas together on the big screen.*

Jane: *Reading on the screen helps me practicing my reading.*

What sorts of knowledge representations are afforded by ready access to digital devices that would not be possible otherwise?

Videotape transcripts provided rich documentation of the ways in which the students utilized various digital devices to create representations of their learning. Across the six-week science unit, the teacher collaborated with the art teacher and music teacher operating from the premise that, “If forces and motion are around us in the world, it is also in the music, art, and physics.” The students began the unit using Sketchy™ on their handheld computers to brainstorm animated cartoons demonstrating forces and/or motion. Sketchy™ is an animation drawing tool for handheld computers. In art class the students created their clay characters and backdrops for their movies. Back in the SBC classroom, the students used Intel digital video cameras to capture their clay characters’ movement one frame at a time. The ordered collection of frames (approximately 70-100 frames for each Claymation movie) were placed into Animation Shop™ and saved and compressed in a video file format (e.g., MPEG, AVI, WMV).

Case study data regarding student-created knowledge representations is further reported relative to the project phases determined through analysis of the video transcripts (i.e., brainstorming/storyboarding, producing, editing, presenting, and telling/reflecting.)

Project Phase I: Brainstorming/Storyboarding

Production of the Claymation movies began with the students working in small groups to design a scenario demonstrating forces and/or motion. Similar to a real movie production team, each group designated a director, a cameraperson, a musical producer, and an art producer. The students drew and shared their ideas using Sketchy™ on their handheld computers. Being able to visualize others’ mental thoughts seemed to be critical during the brainstorming process. Sketchy™ and the handheld computer’s screen served as a mind tool (Jonassen, 1996) to scaffold and support student communication, reflection, and knowledge construction. Further, the handhelds helped students to visualize and convey ideas, discuss and exchange interpretations, and revise their ideas in response to feedback from group members.

Video 1: Brainstorming (0:27; 1.8 MB)

The snapshots in Figures 2 and 3 illustrate students' use of their handheld computers and Sketchy™ to communicate their ideas visually. Figure 3 is an example of one group's Sketchy™ animation that resulted from group brainstorming and discussions. As a result of the discussions, the group decided to create a "motion" movie about how the dog, Tubby, wagged his tail (Video 2).

Figure 2: Group Brainstorming

Figure 3: Students Used Sketchy™ to Draw the Storyboard for Their Claymation Movie

Video 2: Storyboard Example (0:33; 2.1 MB)

Project Phase II: Producing

Once the groups designed the scenario for their Claymation movie, the students created the backdrops, clay characters, and objects in their art class. On the following day in the SBC classroom, the groups began work on their digital animations. The Intel digital video cameras were secured to the table by the SBC staff in advance to ensure that the students would get steady and consistent shots of their clay characters and objects. During the production phase, the cameraperson looked through the view window of the camera and directed his/her group members to make changes of their characters (Video 3). Conversations within the group regarding the movements and positions of the characters led to new ideas for better representation of motion and/or force in the Claymation movie. Negotiations and compromises were common among groups after an idea was proposed. For example, one group decided to add a new scene to its tail-wagging dog animation (Video 4). Figures 5 and 6 illustrate the process of producing a Claymation movie.

Videos 3 and 4: Production Phase (0:53; 2.5 MB and 1:13; 3.8 MB)

Figure 5: Students Used Clay to Make Their Animation Characters

Figure 6: Students Used Digital Video Cameras to Record the Movement of Their Clay Characters

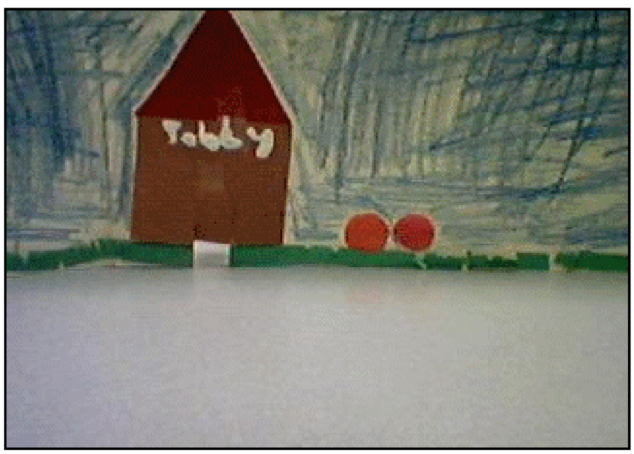
Project Phase III: Editing and Finalizing

Prior to the post-production (editing and finalizing) the SBC Ameritech Classroom staff demonstrated the steps of importing pictures from the Intel digital video camera to the Animation Shop™. The students then took turns rearranging the order of their photos, renaming the pictures, and finalizing their claymation on a desktop computer (Video 5).

Video 5: Editing

After viewing a segment created by one group, students learned the importance of keeping the camera steady while shooting the photos. Some groups even decided to bring the cameras back to their classroom and retake snapshots of their scenes. It appeared that the students were more likely to take extra time to improve the quality of their animations after reviewing others' work on the projection screen. Video 6 illustrates one group's conversation about producing a better Claymation movie, Tubby and Subby (Video 7).

Video 6: Finalizing (0:50; 2 MB)



Video 7: Tubby and Subby Claymation Video (0:07, 480 KB)

Project Phase IV: Presenting, Reflecting, and Telling

Across the unit, the class hosted three classes from their elementary building to join them in the SBC Classroom near the end of the six-week experience. Peer teaching and learning were evident on these days as the students taught their visiting peers how to use the handhelds and the Intel digital video cameras and worked with their peers using Kidspiration™ to create concept maps on force and motion. The class collaborated with their visitors to complete a webquest about simple machines. The students were most excited to present their Claymation movies to their visiting peers and explain the process of producing their movies (Video 8).

Video 8: Presenting (0:43, 1 MB)

How does ubiquitous access to a variety of digital devices affect student learning and students' attitude/motivation toward learning?

Triangulation of the data sources documented the impact of the ubiquitous technology on student learning, student technology literacy, and student motivation. Analysis of the videotape transcripts and student work documented attainment of specific scientific inquiry skills (Table 1).

Table 1: Evidence of Scientific Inquiry Skills

Scientific Inquiry Skill*	Evidence
Use appropriate tools to record and present observations.	Students used different tools in the process of production.
Share and discuss observations made by self and others.	Students shared their Sketchy drawings of forces and motion with peers.
Record and organize observations	Students used cameras to record the movement of their objects.
Communicate findings to others through a variety of methods.	Students created Claymation movies to demonstrate force and motion.

*Source: Ohio Academic Content Standards for Science Education, 2002

Data sources also determined that the ubiquitous technologies impacted student motivation and their attitude toward learning. The teacher reported:

> *I think students' attitudes greatly improved over the term of our experience at SBC Ameritech. They became highly motivated using the technology…they were very excited as we learned new and different technologies and software… My students definitely tried harder and didn't give up as quickly throughout their experience at SBC. Even if they had to do more (e.g. writing) they didn't complain, they just got to work! I also noticed through the video tapes and looking back to day one, that my students' behavior and attention span increased throughout our visit there. I learned that even the lowest of academic abilities and students who have learning problems are able to learn and be successful using technology. The barriers of "feeling inadequate" do not surface with computer use and other technologies. The students are all on*

an even plane…I learned that the students are definitely more motivated and engaged when using technology. They will try harder and most of the time will have better results with their work because they enjoy doing it using the technology.

Finally, teacher and student interview data as well as videotape transcripts documented the impact of the experience on students' technology proficiency. Throughout the six-week unit, the students had ready access to varied technologies, including handheld computers for brainstorming, digital video cameras for snapshots and recording, animation editing programs for post-production, and a document projector for presentation and telling. According to the National Technology Standards for Grades Three through Five, the students' fluent use of these technologies indicates that they are technology-literate students, a conclusion shared by their teacher:

The students were constantly teaching each other things they discovered/learned on the Palms, cameras or computers. They were even teaching me things…it was amazing! High students were working right along with my lower level students!

How does ubiquitous access affect the social interactions around which knowledge is constructed and shared?

Student interview data and observations determined some interesting findings with regards to the interactions around which knowledge was constructed. One of the main objectives of collaborative learning is "the promotion of social skills in conjunction with the academic task at hand" (Morrison, Lowther, & DeMeulle, 1999, p.11). During interviews and reflections, the teacher frequently commented on the effectiveness of ubiquitous access for creating contexts for meaningful collaboration but also reported that the students required guidance to work as a team, particularly at the initiation of a collaborative activity. To facilitate effective collaboration, it was necessary for the teacher to scaffold student understanding of the process by discussing specific roles and skills, such as taking turns, dividing the labor, and appreciating and respecting others' work, and cuing students with verbal reminders during small group work. For example, during the producing phase the teacher told one group arguing over the digital video camera that "We are having a problem of fighting over who gets to do what. So if you have problems with your attitude, just calm down and excuse yourself from your group and watch." She also suggested that groups elect two members to use the camera and one member to control the movement of the clay characters. Across the six-weeks, students learned to negotiate roles and responsibilities as they approached their collaborative work. During the post-interview, the teacher reflected on how the technology created a context for meaningful peer interactions and successful student collaboration:

They enjoyed the interactive activity and most of the students were very patient with each other… the students were there for each other and helped each other through their tasks.

Similarly, during interviews most students perceived collaboration as a helpful way to produce "better" work and to work more efficiently:

Audio 1: Collaboration (0:38; 630 KB)

Audio 2: Collaboration (0:21; 356 KB)

Finally, student interview data and observations also determined some interesting findings with regards to the interactions around which knowledge was shared. In the traditional classroom, student work is typically turned into the teacher who becomes the sole audience for the finished project. In this ubiquitous computing classroom, the students work was frequently shared with the entire class on the projection screen. While the "publicness" of the students' work supported collaboration and encouraged interaction, student interviews and videotaped segments revealed that the visibility that came with this new practice created some discomfort among a few students who tended to be more self-conscious. For example, after two boys showed us their drawings in Sketchy™, they turned to their partner and said, "Ok, let's see

Kay's [Sketchy]!" Kay turned off her handheld computer right away and ran, "Well, I am not finishing it, go away, go away, go away!" Similarly, another girl expressed similar concerns during her student interview when asked if she likes to share her work with the class:

> *Sometimes if it's finished, I like to. If it's not done, like I just start on it, then I don't like it. If I am proud of my work, I'd like to show it to other people; but if I am not, then I'd rather not.*

By encouraging students to share their work to others, students will more likely be motivated to create pieces they are proud to present. The teacher's ability to scaffold the sharing is critical for creating a classroom culture that promotes effective peer interactions for negotiating and constructing knowledge.

Conclusions and Next Steps

This case study documented the unique ways in which children can construct knowledge and create representations of their learning when afforded access to a variety of digital devices. Further, the study explored the way ubiquitous computing environments support meaningful student collaboration and the situated learning approach. The case study data suggest that the use of ubiquitous computing tools within a situated learning approach facilitated the students' attainment of curricular content, technology skills, and collaboration skills (Video 9 and Audio 3).

Video 9: Student Learning (0:29; 919 KB)

Audio 3: Teacher Reflection on Student Learning (0:58; 951 KB)

The creation of a Claymation movie required the students to decide "how to represent physical phenomena, causal processes, space, and time – all integral to understanding science" (Tatar, et al., 2003, p. 33). In addition, use of Sketchy™ on the handheld computers emerged as a visualization mind tool for brainstorming, thus facilitating student-created representations of real movement and change in an object that static drawings could not replicate. Moreover, the students displayed a greater interest in creating quality work during collaboration and after reviewing the work of their peers.

Our findings in this case study contribute to the literature regarding technology integration and elementary science instruction by documenting how ubiquitous computing tools can enhance knowledge construction as well as collaborative and situated learning. Such documentation may facilitate other teachers in moving toward more a collaborative, situated learning approach while utilizing various digital devices to support teaching and learning. Additional research is necessary, focusing on the usefulness of such approaches and issues of equity in such environments.

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Handheld Computers: No Child Left Behind's (NCLB's) Digital Divide Equalizers?

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Abstract

The No Child Left Behind (NCLB) Act of 2001 allows innovative uses of technology to eliminate the limiting traditional product-oriented curriculum. The technology goals relating to NCLB legislation recommend that teachers provide equitable learning opportunities that optimize learning and prepare students to perform efficiently and effectively on standardized tests. Handheld computers can be very useful classroom management tools for providing technological equity and bridging the digital divide. As part of an Ohio Board of Regents Technology initiative, university teacher educators were trained in the use of handheld computers. The participants discussed and/or demonstrated how the Palm computer software, the Vernier LabPro equipment, the cameras, portable keyboards can be used with their preservice teachers to bridge the digital divide.

Introduction

The No Child Left Behind (NCLB) Act of 2001 mandates choosing instructional materials based on "best practices" research and the U. S. Department of Education has set up a What Works Clearinghouse for information on resources that get results (Education at PalmOne, n.d.). This emphasis on accountability in educational institutions, from the prekindergarten through postsecondary levels, require instant access to the latest research findings, state standards, and online resources so that learning is optimized and students perform efficiently and effectively on standardized tests. Ideally, no child is to be left behind and schools in need of improvement must spend at least 10 percent of their Title 1 – Improving the Academic Achievement of the Disadvantaged – funds to assist teachers in achieving this goal (U.S. Department of Education, n.d.).

The NCLB Act makes it possible for school districts to transfer up to 50 percent of the federal formula-grant funds they receive under different parts of the law: Title II –Improving Teacher Quality and Educational Technology, and Title V – Innovative Programs. The technology goals relating to NCLB legislation recommend that teachers help students learn to show initiative, demonstrate cooperation, and evaluate themselves and others (Education at PalmOne, n.d.). These educators must learn to use the latest computer technology, train their students to obtain and use information technologies, communicate effectively, reason sensibly, plan, solve problems, and engage in self reflection (Heinich, Molenda, Russell, & Smaldino, 2002; Lever-Duffy, McDonald, & Mizell, 2003; Melloni, 2002; Norton & Sprague, 2001; Thorsen, 2006).

Information and computer technology can offer educators the opportunity to introduce students to new learning experiences. Innovative use of technology can eliminate the limiting assumptions of the traditional product-oriented curriculum and push curricular goals beyond their current boundaries (Heinich et al., 2002; Lever-Duffy et al., 2003; Melloni, 2002; Norton & Sprague, 2001; Thorsen, 2006). By providing instruction and meaningful practice, educators can use information and computer technologies to expand the curriculum in new directions for their students. As a result of limited school funds and scarce resources not all students have access to the latest educational resources and computer and information technologies. NCLB provides an unprecedented amount of flexibility for states to tailor and use their funds to focus on student achievement and what works to improve teaching and learning in order to close equity disparities.

Equity and Access to Technology

Equity is an essential issue for schools planning to implement instructional technology. Access to information and computer technology and opportunity to learn to use it appropriately are key factors for students' economic success both now and in the future (Costello & Stone, 2001; McBride-Stetson, 2004). Unfortunately, socioeconomic differences have the potential to create serious gaps when it comes to technology use. While students from wealthier households are likely to have access to a computer and high tech media such as broadband or digital subscriber line (DSL) cable, cellular telephones, handheld computers such as Blackberry, Palm, and Pocket Personal Computers (PCs), and digital still and video cameras at home, this is not true of students from poorer households (Forcier & Descy, 2002). Schools have a responsibility to help remedy this problem by providing access to high tech media to all students.

The situation in U. S. schools mirrors that of society as a whole. Poorer school districts and those with a higher percentage of minority students have fewer computers per capita and are less likely to have Internet connections than wealthier districts. According to Newby, Stepich, Lehman, and Russell (2000), the ratio of students to computers continues to improve, and efforts to bring the Internet to every school in the United States are well underway. Of course, this is a problem that schools cannot solve alone. Government, communities, and businesses must help schools provide needed access to information and computer technology. However, access is only one facet of the issue; concern about gender equity is another.

Equity within Schools

Gender research indicates that in the elementary and middle-level grades boys and girls are equally computer literate and tend to use the computer, video games, high tech handheld computers such as Blackberry, Palm Pilots and Pocket PCs equally (Costello & Stone, 2001; MacDonald, 2004; McBride-Stetson, 2004). Girls and boys appear to be equally enthusiastic when it comes to using the computer. However, as they move into high school, gender differences and unfair stereotypes begin to emerge. Although girls continue to refine word processing skills and other clerical skills, boys overwhelmingly populate the computer science and programming classes (MacDonald, 2004; Parkins, 2004).

Less affluent and less able students are likely to experience computers as a tool for remediation and drill and practice over basic skills. More affluent and capable students are likely to use computers in creative and complex ways. The role of the teacher is critical to the success of all students. Teachers must believe that all students can benefit from assignments that allow them to use computer applications and media that will lead to greater cognitive development and learning. Bull and Bull (2003) conducted an analysis of various software types and noted that computer gaming and software companies tend to market and emphasize male-dominated activities as games that often include violence and competition as motivation. These software characteristics tend to attract males. Therefore, careful student software selection is essential for addressing gender in the classroom.

School personnel and teachers need to guard against other biases in access to technology. In some schools, available computers are monopolized by a few users that may result from preferential laboratory scheduling for certain classes, historical patterns of use, or other reasons (Forcier & Descy, 2002). To some extent, this is natural; but, educators should make an effort to encourage numerous users. Teachers may unconsciously alienate students by allowing access to a classroom computer as a reward for students getting their work done early. This can create a pattern in which the rapid work completers are rewarded repeatedly and other students are excluded.

Limited Access

Student access to technology is dependent on the financial capabilities of their school or school district. Although student-to-computer ratios are steadily improving, many low socioeconomic schools have limited access to computers and the Internet.

The Universal Service Fund for Schools and Libraries, known as the “E-Rate”, was created in 1996 to provide discounted telecommunication services and equipment to public and private schools and libraries. The E-Rate program has connected more than 98 percent of all schools in the United States to the Internet (Bull & Bull, 2004; Sherriff, 2004). Although Congress and state governments took steps to increase access through the E-Rate and other technology grant initiatives, the gap is still significant. A new type of poverty has emerged.

The Digital Divide

According to the National Telecommunications and Information Administration’s (2004) report, Falling through the Net: Defining the Digital Divide, the digital divide is defined as “the disparities in access to telephones, personal computers (PCs), and the Internet across certain demographic groups” (p. 1). Lloyd Morrisett coined the term digital divide to mean “a discrepancy in access to technology resources between socioeconomic groups’’ (Robyler, 2003, p. 191). People excluded or segregated from access to information technology are also excluded from many other social goods. Thorsen (2006) defines the digital divide as “a popular term for the cultural barrier that of people who do not have access to technology and the Internet or the ability to use them effectively if they are available” (p.11). This includes not just access to technology, but also access to computer skills training, information technology, various economic opportunities, and the ability to fully participate in culture and democracy (Robyler, 2003; Thorsen, 2006).

Educators are concerned that this digital divide will create a form of technological and information eliticism. In a technologically oriented economy, people with more computer experience will obtain higher salaries while those with little or no computer experience will be disadvantaged (McDonald & Denning, 2004; Thorsen, 2006). The U.S. Department of Commerce documents the digital divide and reports a 25 to 30 percent increase in the gap since 1994 (U.S. Department of Commerce, 2004). Educators have a responsibility to ensure that all students have sufficient access to computers and the Internet, regardless of geography, education, gender, ethnicity, socioeconomic background, and disability (Costello & Stone, 2001; Landrigan, 2005; McBride-Stetson, 2004; Thorsen, 2006).

Although the U.S. Department of Commerce (2004) documents slight increases in minority access to technology, people with disabilities are only half as likely to have Internet access. Access to technology is more about the effective use and careful integration of technology into the curriculum than simply providing access or the acquisition of hardware and software.

Ensuring Access to Technology

How can adequate and equal access to technology be assured in our classrooms? Ongoing professional development allows and support teachers’ efforts to transform their practice and become computer literate. Teachers, school services personnel and teacher educators must be trained in computer technology use and strive to arrange equitable access and facilitate students’ use of technology. As teachers transform their teaching practices, they can focus on their students’ individual needs, including their cultural identities and insure that all students become a part of the classroom (Costello & Stone, 2001; McBride-Stetson, 2004).

Teachers face multiple challenges in technology-based education. First, they must strive to provide equal access and experiences to computer technology for all students, regardless of age, gender, ethnicity, socioeconomic background, and disability (Forcier & Descy, 2002; Roblyer, 2003). The handheld computer is an inexpensive way to engage students in developing technology skills and shortening the digital divide between the haves and have-nots. Teachers should plan the use of the handheld computer as they would any other media, with a clear set of objectives, appropriate preparation and integration into the curricular unit and evaluation method (Forcier & Descy, 2002; Roblyer, 2003).

Next, they must promote computer ethics in their classrooms by setting an example of ethical computer use and by using techniques such as role playing and simulations to examine and clarify ethical questions. If educators fail to expose students to the latest technology, a grave disservice has been wrought (Bitter & Pierson, 2002; Forcier & Descy, 2002; Murray, 2004; Roblyer, 2003, Thorsen, 2006). Computer proponents argue that information and computer technologies have the potential to enhance economic opportunity and equity. The size, portability, cost and versatility of the handheld computer makes it an effective tool for bridging the digital divide.

Handheld Computers

Personal digital assistants (PDA), pocket or Palm handheld computers (PHHC), are portable computing devices that recognize handwritten notes and translates them into word-processed documents through the use of handwriting recognition software. These written-to-word-processed documents are then transferred to a desktop computer for storage or further use.

Information may also be entered into the handheld computer using the on screen keyboard, a portable keyboard, or beamed (transferred) using the infrared port. Handheld computers are actually palm size computers that offer simplified office management tools, such as an appointment book, a calendar, and a phone book (Roland, 2003; Weiss, 2003). As these devices continue to evolve, their size and weight continue to decrease while their capabilities increase. Through third party handheld computer vendors, many PHHCs include scaled down versions of familiar computer software such as word processor or electronic spreadsheet.

Handheld computers can be useful classroom management tools because they allow the teacher to make notes on lessons and activities, record and student behavior, and track appointments. The data can be stored for later use and the information can be easily transferred into computerized grade books, lesson plans, and student files. Educators and administrators need ongoing access to information and having it available on a handheld tends to result in more effective instruction and classroom organizational management (Fleischman, 2002).

For teachers and students alike, Palm handheld computing can make note taking, using educational software, or using the Internet as easy and convenient as taking out a pen and pad. Using a handheld computer with wireless access means educators and students can have answers anytime. As this technology evolves, Palm handheld computers will become more powerful. Digital cameras, audio and video players, and even cell phones are integrated into handhelds (Brown & Brown, 2002). As prices decline, their accessibility will increase.

A number of studies over the past five years have focused on the advantages of the hand held computers and their impact on student learning (Crippen & Brooks, 2002). Similar student gains were found in studies of Palm handheld computer use among elementary and secondary students throughout our nation (Crippen & Brooks, 2002; Education at PalmOne, n.d; Roland, 2003).

Public School Using the Palm Handheld Computer

Yankton High School in South Dakota conducted a study that showed handheld computers could improve students' grades (Education at PalmOne, n.d.). Wanting to explore the benefits of one-to-one computing, the district provided Palm handhelds and keyboards to 75 randomly selected students and four teachers. Students signed up, as a group, for four classes: physical science, algebra, English/Speech, and Spanish 1. Teachers developed inquiry-based interdisciplinary units that infused the Palm handheld computer use.

Students began using the handhelds as organizers and quickly moved onto writing, graphing mathematical formulas, taking quizzes, mapping concepts, creating animations, and much more. Teachers and students discovered an array of software, including Documents to Go from Data Viz; GoKnow's Freewrite, Sketchy, PicoMap, and PAAM classroom synchronization manager. They experimented with Palm system software and equipment such as PowerOne Graph from Infinity Softworks; ImagiGraph, ImagiMath, and ImagiProbe from ImagiWorks; Vernier LabPro; Quizzler from Pocket Mobility; Thought Manager by Hands High Software and MathCard from Checkmate Software. The teachers used Margi's Presenter-to-Go for projecting PowerPoint presentations, and Discourse from ETS for getting instant feedback on student answers (Education at PalmOne, n.d.).

Surveys showed that students using the handhelds felt more comfortable trying new technology and were better prepared for classes. They had higher rates of attendance and showed more positive attitudes about completing and turning in work. A science and math teacher noted that the students learned the software programs quickly and developed patience and problem solving skills. In addition, the GPA of the students using handhelds was 3.08 – higher than the 2.79 GPA for students not using handhelds (Education at PalmOne, n.d.).

In recent years, researchers in Ohio conducted regional conferences and workshops in which pre-kindergarten through postsecondary level educators learned to use Palm handheld computers (PHHC). Teachers, especially teacher educators, must be comfortable with their own computer skills before they can effectively model handheld computer use with their students.

Will educators on a university campus embrace Palm handheld computers' use and demonstrate the features and resources to their pre-service teachers? Can the handheld computer be used as a tool to bridge the digital divide? With these foci in mind, a statewide initiative was launched to teach teacher educators to use Palm handheld computers.

Ohio Handheld Computer Initiative

Over a three year period, eighty-five faculty and staff from universities in southwest Ohio participated in Palm handheld computer (PHHC) training. The five rounds of PHHC workshops were part of a statewide Ohio Board of Regents (OBR) Technology initiative in which higher education staff and faculty members were taught to use the devices. The PHHC training consultant was interested in training the teacher educators to use the PHHC and in investigating:

1. To what extent will the participants benefit from Palm handheld computer training? More specifically, will they learn to use the handheld computers?
2. What are some of the creative ways they will use the Palm handheld computers?
3. Can handheld computers be used as tools to bridge the digital divide?
4. Did the participants view them as an equitable tool to bridge the digital divide?

The following sections describe the study's participants and materials, method of data collection and learning to use the PHHC. Implications, troubleshooting, future directions for the Palm handheld computer's use, and bridging the digital divide are also discussed.

Participants and Materials

An invitation was extended to faculty and staff from the training consultant's home institution and five neighboring universities to participate in the OBR Palm handheld computer study. Over a three year period, eighty five university teacher educators participated in a study in which they were taught to use the Palm handheld computer. The participants completed surveys that gauged their computer literacy skills and PHHC knowledge and Memo of Understanding forms in which they agreed to complete all paperwork and attend three 3-hour workshop sessions which culminated in the creation and demonstration of a PHHC project.

The PHHC workshop sessions were held every two weeks with the first, third and fifth round of participants being trained over three summer terms from 2003 until 2005. The second round was held during the fall quarter 2003 while the fourth was held during winter quarter 2005. There were 20 workshop participants in the first round of training, 20 in the second, 17 in the third, 7 in the fourth and 21 in the fifth. All participants provided information about their backgrounds and their history with the project:

- Approximately 40% were in the first training cohort, 20% in the second, and 20% in the third while 20% did not identify their cohort;
- Sixty-eight percent were faculty members and 32% were administrators;
- Almost 90% were from state universities, almost 10% from private colleges or universities;
- Approximately two-thirds were affiliated with the college or department of education at their campuses and one-third was affiliated with other areas.

Data Collection

A qualitative approach was used in which data were collected and triangulated through multiple measures that included the PHHC surveys, the PHHC training consultant's observations of and discussions with the participants, and the video recordings of each workshop session. Although all participants completed surveys, 12 were selected for interviews based on their performance during the training period and follow-up interactions between trainer and participants. The video recording of each of the third workshop sessions showcased the participants demonstrating how they will use the Palm computer.

The two graduate assistants used a modified version of an interview instrument that was developed by Wexford Incorporated. The interviewers were selected based on their overall capabilities for organizing and conducting interviews, and for their background in instructional technologies. They interviewed the participants over a three month period for approximately 30 to 45 minutes in person or by phone.

Open-ended responses were sorted into two groups utilizing the participants perceived level of technology use. Respondents were coded as "Advanced Technology Users" and "Basic Technology Users" based on a triangulation of their participant responses to survey question 5 (Before you participated in the PHHC Project, how would you rate your use of computers and peripheral devices?) and to open-ended survey questions related to training and implementation. Figure 1 lists the percentages of participants' technology use before participating in the study.

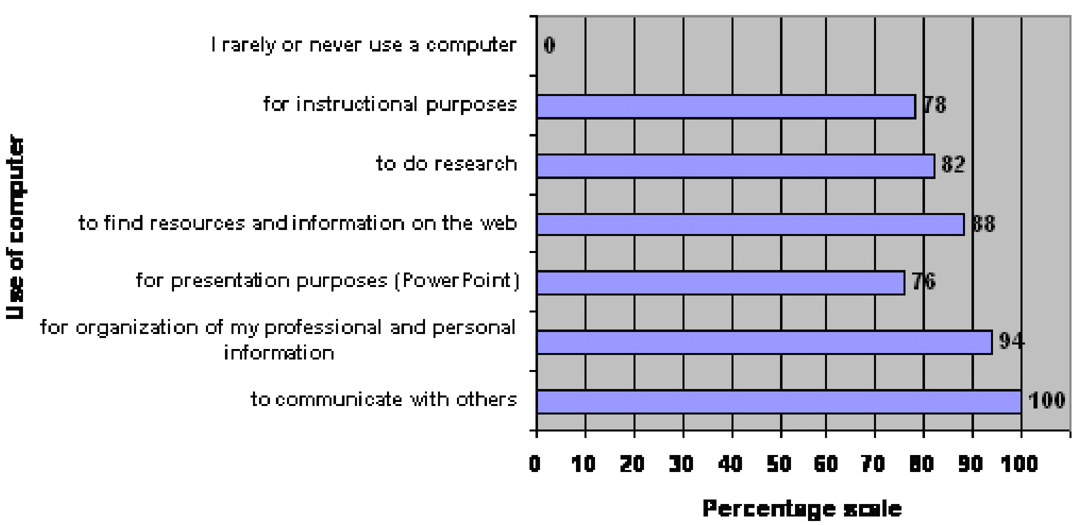


Figure 1: Percentage of Participants' Technology Use prior to the PHHC Study (N = 85)

Data Analysis

Advanced Technology Users

Participants with the following characteristics were considered to be Advanced Technology Users (ATUs):

Use of technology for personal and professional use --

- Participants use of a variety of technology tools (computers, PHHCs, probes, digital cameras and video) and reported using a variety of specific software for personal use, classroom management, data management, etc.

Use of technology for instructional purposes --

- Participants use a variety of technology tools for instruction and project-based learning.
- Participants use technology beyond the simple use of PowerPoint/LCD projectors for lesson presentation.
- Participants require students to use technology to learn content or skills and develop multi-media products/projects.

Technology Background/Experience --

- Participants had an extensive technology background due to their educational background in computer science or educational technology.
- Participants had experience instructing teachers on how to use technology in the classroom or had experience coordinating technology grants or programs.

Basic Technology Users

Participants with the following characteristics were considered to be Basic Technology Users (BTUs):

Use of technology for personal and professional use --

- Participants use technology was limited to word processing, simple spreadsheets, use of PHHCs for personal organization (calendar, to-do lists), basic Internet searches, and discussion boards on WebCT.

Use of technology for instructional purposes --

- Participants use computers, overhead and LCD projectors for PowerPoint presentations in class.

Survey Findings

The following section provides survey information from the participant-respondents about their experiences and benefits from the Project.

Question 1: Have you participated in other technology or PHHC training?

Advanced Technology Users. Twenty-eight of 37 respondents stated they have received other technology or PHHC training. Other technology training included:

- Software applications - Dreamweaver, Inspiration, PowerPoint
- Online course management software – WebCT
- Other internet training – software and website development
- Workshops/Training on how to use technology for instruction

Five respondents had extensive technology backgrounds due to the nature of their educational background or their work experience. Three respondents stated they had not participated in other technology or PHHC training.

Basic Technology Users. Thirty-two had participated in other technology training, including use of software applications (EXCEL, PowerPoint); online course management software (WebCT), web-based tools (TaskStream), and other digital media devices (digital cameras, scanners). About one-third had not had any previous PHHC or other technology training.

Question A3: Who conducted it or provided it?

Advanced Technology Users. Most participants were provided training through*:*

- Technology Vendors: Apple or IBM
- National Professional Organizations
- Computer Technology Conferences
- University or community college sponsored training through WebCT or face-to-face workshops

Others received training through programs at their specific universities:

- Wright State University's Center for Teaching & Learning
- Cedarville College
- University of Dayton
- Miami University
- Walsh University

Question A5G: Before you participated in the PHHC Project, how would you rate your use of computers and peripheral devices?

Both Advanced and Basic Technology Users reported using computers and peripheral devices (before the PHHC project) for instruction and for presentations or demonstrations.

Most Advanced Technology Users had extensive experience using technology for instruction. They teach their students how to use computers and other peripherals (digital cameras, scanners, digital video cameras, and digital microscopes), use a variety of software applications (Word, EXCEL, PowerPoint, FrontPage) and have other technology related skills (video editing, creation of DVDs, website development). They also conduct online courses via WebCT and Blackboard.

One participant stated,

> "…technology allows one to compress the teaching-learning process within a Constructivist pedagogical environment."

Only one Basic Technology User indicated how he/she used technology for teaching and learning in the classroom.

> "I engage in CBL (Calculator-Based Learning) activities. I plug in light probes, sound probes and students identify patterns. …students use EXCEL to record all data from experiments in biology content courses. Students produce PowerPoint presentations in both content and methods classes."

Advanced Technology Users. Participants also indicated extensive use of technology for teacher- and student-led presentations. Through the use of the LCD projectors, participants stated that they:

- Conducted lessons and formal presentations using PowerPoint
- Shared Internet websites and resources with students
- Demonstrated use of WebCT

Basic Technology Users. Almost all Basic technology respondents stated using LCD projectors and overhead projectors in the classroom for presentations and demonstrations. (Although they use PowerPoint/LCD projectors to deliver instruction, the participants did not state how their students were using the technology for learning).

Question A6: Since you participated in the PHHC Project, how have you used the PHHC? If you have NOT been using the PHHC, please explain what the barriers have been to its use.

Both Advanced and Basic Technology Users reported using the PHHC as a personal and professional organizer and as a data collection tool for use in the classroom by the instructor and students.

Advanced Technology Users. Fourteen participants use their PHHCs in the classroom or developed assignments/projects in which students use PHHCs. These included:

- Use of software useful in science education (Pico Map, Cooties and Sketchy) and use of probes for demonstrations in science classes and science courses for teachers

- "All students had PHHCs. The software is the mini version of the diagnostic manual, so students can use the system to talk to their clients and very quickly be able to work through the decisions with the PHHCs."

At least seven respondents use the PHHC to observe student teachers in the field. They developed their own forms for observations or used other standardized forms downloaded to their PHHCs via Documents to Go.

> "I have used the PHHC to do my field visits for observation of teacher candidates. I use the keyboard and Palm to take my notes, the camera to record the classroom and school and then sync with Word to produce the final observation sheet."

Basic Technology Users. Most respondents also use the PHHC in their classrooms. The most common use for classroom management of student grades, attendance, and participation). The PHHC were also used:

- In presentations: "I learned to use the Margi with the PHHC and presented at a state conference. I showed others how to use the technology…"
- For note-taking during meetings (used along with the portable keyboard)
- As a data collection tool (classroom management, classroom observations)

In relation to obstacles encountered while using the PHHC, Advanced Technology Users reported having difficulty hot syncing the Veo camera software with the m130 PHHC, having difficulty using the PHHC with the Mac platform and connecting the PHHC to the Internet. At least two respondents had issues while using probes with the PHHC.

One participant stated that the PHHC would be helpful for note taking but not for replacing the TI calculators used in the math classroom. Other barriers to using the PHHC included PHHC probe maintenance and reliability; poor focus and resolution of detachable PHHC digital camera. The high learning curve related to the new technology was also a barrier:

> “You have to do special writing on the writing area of the screen called graffiti; all the letters aren’t exactly the letters we write the way we write them in the alphabet. …It was easier for me to take out my paper and pencil calendars. Instead of making less work, for me, it seemed to be making more work.”

Question A7: Since you participated in the PHHC Project, are you interested in using emerging technologies (or upgrading the PHHC and software)? Please describe.

Advanced Technology Users. All respondents were interested in using emerging technologies. The following is a list of their technology interests:

- Upgrade existing PHHC (from m130 to Zire or Treo)
- Additional software for the PHHC: GPS/mapping, Directions to Go, FileMaker Mobile, Bluetooth, e-Books, dictionary and thesaurus
- Digital Cameras
- Margi presenter
- Upgrade existing software: Documents to Go
- Ability to use Internet to access email via the PHHC
- More information on freeware
- Voice-recognition technology
- Electronic portfolios and how they can posted on the WWW
- iPod
- Digital Imaging
- Probes for the PHHC
- Use of PHHC for data collection and information management

Basic Technology Users. All respondents were interested in using emerging technologies. The following is a list of their technological interests:

- Upgrading existing PHHC (from m130 to Zire, PHHC with wireless internet connection)
- New software for PHHC: FileMaker Pro
- Online courses, how to use WebCT
- Science Probes and their use with PHHCs
- Visualization and simulation software for PHHC
- Use Vernier Software and use the PHHC camera and video to collect data
- How to use Documents to Go PHHC software in the classroom
- Vernier data logger and how it can be used for data collection

Question B1: How did you learn about the Ohio PHHC Project?

Advanced and Basic Technology Users. There were three different notification methods identified; word of mouth, notification through faculty-based communication and conferences, and notification by e-mail targeted to specific individuals.

Just over half of all the participants heard about the PHHC training by word-of-mouth communication. When divided into groups, all respondents from the technical group and the non-technical group had learned about the PHHC training directly from the trainer or colleagues who new about it.

Question B2: Why did you want to get involved in the PHHC Project?

Both respondent groups had two themes in common. The majority of the combined respondent groups were interested in new technology with a subset of both groups whose primary incentive was obtaining the free PHHC. Beyond the interest in new technology and a free PHHC, the themes for each group differ in that the reasons for non-technical group were more personal and the reasons for the technical group included extending their knowledge to their students.

The largest group respondents from the Advanced Technology User group was interested in learning new technology with a small subset interested in getting the free PHHC. Another group was interested in increasing their technology skills and a fourth group got involved so that they could have an impact in improving student learning.

The majority of the Basic Technology Users were interested in getting involved in the PHHC Project due to their interest in making their skills more current and becoming better organized, personally and professionally. A small subset of that group was interested in the PHHC Project primarily because they would receive a free PHHC. There were two small groups that got involved due to encouragement from colleagues and/or family or because of their personal knowledge of the trainer.

Advanced Technology Users

- Interested in new technology (21 of 37)
- Interested in learning new technology and wanted the free PHHC (8 of 37)
- Interested in increasing PHHC skills and knowledge (4 of 37)
- Interested in new technology to improve student learning (4 of 37)

Basic Technology Users

- Interest in new PHHC technology, be better organized, and perform better: (23 of 48)

  “The idea of finding new technology to use and it sounded like they had some great things I could do, it would be neat to learn how to do them…and it worked very well with where I was going” [in her work and research].

- Interested in learning new technology and wanted the free PHHC (9 of 45)
- Encouraged by colleagues and/or family (2 of 47)

- Personal knowledge of the trainer and interest in new technology (14 of 48)

Question C1: Please describe the training you received?

Advanced Technology Users. Most participants described the sessions as three, three-hour sessions that built one upon the other. The first session was a demonstration of the PHHC and its functions. A step-by-step introduction of the PHHC and how to do the basic functions of operation was given. This included beaming documents and resetting the PHHC. The second training session involved presenting real-life examples. The third session was “show and tell” presentations. Participants explained what projects they were planning to do or projects they had actually done.

Several participants mentioned that it was very motivating as each technology tool was introduced and passed out and they were shown how to use them. Each day felt productive and useful because so much was covered with time to explore and internalize what was learned.

Some participants thought that the training was like an overview but felt the training was very helpful and informative, organized, and covered a lot of information in a short amount of time.

Basic Technology Users. During the first session of each of the five rounds, participants learned about the features and personal uses of the PHHCs. The second rounds focused on the educational usages of the PHHC, the Margi Presenter-to-Go adapter and the Vernier scientific probes' usage. The third session allowed the participants to demonstrate how they would use the PHHC in their personal and professional lives. All workshop sessions were video recorded by a graduate assistant. As an incentive for completing the three required workshop training sessions, the participants were allowed to keep the PHHC, the camera, and the portable keyboard. In general, the activities were basic but moving into more complex tasks.

> "The training covered the basics…this is what it is, this is what it does, and here are the limitations."

Other recurring comments were about the structure and delivery of the presentation. Participants thought the presentation were well organized and that the trainer communicated and shared the content effectively and efficiently.

> "I think the trainer did a very good job telling us how to use it and how to set it up. Within the first day they helped us to set up documents…"

Participants thought the interactive aspect of the sessions gave them the time and opportunity to experiment and work at their own pace.

- "There was plenty of open time to give participants time to experiment before going to the next level, which allowed participants to work at their own pace."
- "One thing that I really liked about it is that I felt like everybody in the room was just like me. We were all people in academia who didn't know a lot about computers."

Question C2: Did the number of pacing of the training sessions meet your needs?

Advanced Technology Users. Most believed the pacing of the sessions was just right and these sessions met their needs. The sessions covered a lot of ground in a short time but it wasn't too much. There was also time allotted between each session, which helped to contribute to the internalization of the skills learned through the sessions.

> "There was a good balance and there were not too many details, it was enough for people who want to know and who are curious to learn."

A few participants, however, felt more training would have been helpful. One participant wanted to have more advanced training as an additional session.

Only two of the participants thought the pacing was too slow. These were participants who had prior knowledge of PHHCs and because others were not as technologically advanced, they thought the pacing was necessary and couldn't be changed. None of the participants thought the pacing was too fast.

Other recurring comments:

- Pacing good but more support needed

  "The only thing was only having one instructor and there was nobody else to help out and deal with people who weren't clear about the instruction. That is the only thing."

- Distractions

  "Training would have been just right if faculty participants had been more respectful. A lot of distractions/misbehaviors interfered – participants going off on own, talking about unrelated things. The instructor's pacing and planning were just right."

Basic Technology Users. Most participants reported that the number and pacing of sessions met their needs. They liked the pacing of the sessions because it allowed them to experiment and play and then move to the next level at their own pace. The time of exploration and experimentation gave them an opportunity to learn the process and application of the tools. Participants also commented on the "good training techniques" used by the presenter to effectively communicate the content so that it was clear to them.

> "The workshop situation seemed to work well. There were not a lot of different levels of users and it didn't turn into the knowledgeable vs. the new users. The pacing was good and they were creating/doing things during the process that helped them proceed to the next level."

Three of the participants commented on the presenter's delivery of the content.

Participants commented that the presenter always remained calm and patient as she answered questions and provided assistance. They also liked working in small groups, which allowed the trainer to closely monitor their progress and give them more attention and support. This helped to create a very comfortable environment for learning.

Question C3: What were the most positive aspects of the training?

Advanced Technology Users. The expertise of the trainer was cited as the most positive aspect of the training. Many believed the trainer was knowledgeable and skilled in communicating effectively how and what to do with the technology tools presented. The presentations were comprehensive, fun, and engaging. The training sessions included lectures and time for "hands-on" activities – a very effective aspect of the training. One participant found the initial instruction so helpful that she was able to learn more complex applications before the second session. Participants also mentioned the accessibility of the consultant as an important part of the training. During each session there was frequent checking for understanding and monitoring progress.

Some participants believed that just learning the technology was the most positive aspect for them. They enjoyed learning various strategies and techniques for utilizing the technology to its fullest potential. Participants enjoyed the step-by- step instruction and time to explore and learn on your own.

Additionally, the workshops provided time for the participants to share ideas and skills learned through the sessions. Interacting with colleagues – hearing what other people were thinking and how they were considering using the PHHC – was enjoyable for many of the participants.

And finally, receiving a free Palm was the most positive aspect of the training for several participants.

Basic Technology Users. These participants commented that the trainer maintained an upbeat, informal, and relaxed atmosphere, which created a feeling of camaraderie and an eagerness to learn. They also felt the trainer's knowledge, skills, and experience gave her a lot of credibility with the group and enabled her to assist everyone no matter what level they were own. The process for teaching the content consisted of instruction, followed by a demonstration, and then the opportunity to apply what was taught and demonstrated. The process enabled participants to start at a basic level and move to more complex tasks. The incorporation of a "hands-on" approach with time to experiment with the technology tools and share ideas and information with other colleagues was also effective. Most participants enjoyed mastering skills, like being able to input personal data, and then use graffiti to write directly on the PHHC. They also enjoyed beaming these items to others.

- "The hands-on approach was the most positive aspect of the training. "
- "…learning some of the tricks, accessing information or using the PHHC to store information---or even to spread information."
- "I think that the idea that I got to try something new and I got to see how it works."

The participants also commented on the trainer's good use of time and the value they held for the teacher's time. Other comments included, "No time was wasted and a lot was accomplished. This was due in large part to the sessions being so well organized."

Question C4: What aspects could have been improved?

Advanced Technology Users

- Smaller groups: Some participants thought a smaller group would have been more helpful to the learning process although the large group was divided into subgroups.
- Handouts: Many ideas were verbally shared but few or no handouts were given to participants to review what was presented.
- Too many different computer skill levels: Participant suggested that different levels of training could be provided to the people at different levels of expertise.
- Other Issues – Participants shared other aspects of PHHC use they had difficulty with:

  "It seems really handy for student teacher supervision, but if I'm trying to use it in an instructor mode, the students all with Palms – 15 to 20 Palms – is problematic. …you can't quickly charge or hot sync all the units at one time - the technology's just not there, yet.

Basic Technology Users. Most participants felt that the sessions could be improved. Twenty-six made suggestions which were grouped in the following categories:

- Orientation Session: Use this session to determine the learning level of the participants rather than waiting until the first session.
- Specific Software: Some participants had specific interest and wished they could have had more time exploring what most interested them.
- Manuals: It was difficult to keep up with instructions. A reference manual would have been useful.
- Time: Participants felt they needed more training time
- Technology Glitches: When things go wrong, how to troubleshoot the problem or have a plan B so that your presentation can proceed.

Two participants thought the training was too fast, but for different reasons. One thought the training was too fast for novice users while the other wanted to have more time learn and talk about products. The remaining participants saw no need for improvement.

Question C5: Did you consult with your trainer outside the scope of the prescribed training sessions?

Advanced Technology Users. Most participants consulted the trainer outside the scope of the training sessions. Often it involved specific questions related to technology tool they were working on. Some of the reasons given for consulting the trainer were to fix a problem with the PHHC, or obtain software to use the PHHC in the classroom or to get a software upgrade. Some emailed or phoned the trainer about questions or problems with using the PHHC.

A few of the participants never contacted the trainer for help. The reasons given was they were either able to sort things out themselves, had other resource people to help them, or there was just no need.

Basic Technology Users. The majority of participants did consult with the trainer outside the scope of the prescribed training sessions. The purpose of the consultations ranged from asking the trainer for resources for the palm to resolving technical problems related to the technology tools the participant was using. These consultations usually took place face to face. The trainer was contacted many times.

- "The participant consulted the trainer numerous times outside the scope of the training sessions. The participant had initial problems with synching the PHHC with the computer and had to ask the trainer for help. Every time the participant had a question he/she asked the trainer."
- "Yes… the trainer is always there if I have questions."

Four of the participants contacted the trainer via email. This was usually done to get an answer to a specific question. Eleven of the participants never contacted the trainer. They did not feel a need to contact the trainer or there was a time issue with their own schedule. One participant felt that the trainer was busy and didn't want to disturb her. She tried to resolve her own problems or challenges. However, all participants agreed that the trainer was readily available to assist them. None of the participants had trouble getting assistance if they needed it or requested it.

Question D1: How have you used the skills/ tools you developed as a result of the training?

Advanced and Basic Technology Users. A majority of all respondents indicated developing skills and tools on the PHHC for personal organization, professional use and instructional/educational. Of those identified as Basic Technology Users, three respondents had used the skills and tools since taking the PHHC training. Almost half of all respondents report using their PHHCs for more than one of the following skills/areas:

- Personal organization

  Use it to organize personal information: calendar, addresses, phone numbers, to-do lists, etc

  "Personal planning/calendar/organization skills have improved as a result of having everything in one place…"

- Professional use

  Use it to organize work-related information: contact information, appointments, take notes during meetings, organize account information and passwords, financial records, phone call logs, etc.

  "Use the camera regularly to take pictures at conferences and meetings; use the addresses and calendar feature to schedule meetings; take notes on Microsoft Word"

- Instructional/Educational use

  Respondents used the PHHC to collect and manage student teacher field observation data; design professional development experiences for teachers; for grading purposes using EXCEL, to take pictures to enhance lecture notes and presentations; to conduct PowerPoint Presentations; and to use with probes in science classes.

  "I use the Palm daily and it has become a vital part of my field observations. I also use the photos to create a file of the schools I visit for others to use when they have to visit the same school. I record the teaching of the teacher candidates with the camera and my observations with the keyboard."

"I've used the camera for creating documents about various art processes. Students took the pictures and I imported them into a word-processing document. I added text explaining the processes and students use the collections as a reference tool…"

"Instructional enhancement as previously described (experimentation with/use of scientific probes in methods classes, notes log on all classes)."

Question D2: Are there any artifacts or examples of your work with the PHHC that you can share with us?

Advanced Users and Basic Technology Users. Seventy-seven of the respondents had examples that they could share as an example while eight did not.

Question D3: How do you plan to use PHHC technology in the future? What new strategies or software related to the PHHC do you think you might use? Please describe.

Both Advanced and Basic Technology Users described plans for future PHHC use in four major areas:

- Personal organization
- Professional use – (presentations, spreadsheets, note taking)
- Educational purposes – instruction
- Education purposes – field observations, classroom management
- Upgrade or acquire new software/hardware

More than half of all respondents cited having more than one strategy or plan for their use of PHHC technology in the future. For their professional use, respondents indicated that they

- "Will continue using PHHC to take notes at meetings, use calendar. Wants to learn how to use Margi for PowerPoint presentation, use PHHC in place of laptop."
- "Would like to be able to present at conferences and other events using PHHC."
- "Wants to use the Internet on PHHC for research purposes to and lectures."

Educational Purposes – Instruction

- "…hope to use the probes to instruct my Science and Math courses…"
- "…interested in expanded student use of the Zire 71 in the classroom. Students could use the camera feature to enhance their projects…"
- "Introduce PHHC (to teachers) as a data collection and information management device…"

Educational Purposes – field observations, classroom management

- "I will probably use it to keep track of student grades and homework assignments…"
- "…will use a grade book program available for Palm to make observations during class discussions…"

Upgrade or Acquire New Software/Hardware

- "Interested in Bluetooth technology – wireless login to the network through PHHC."

- "…would also like the following software: File Maker Pro, creating student handbooks into e-books and wireless capabilities."
- "Different memory cards to increase memory and Internet access..."

E1. What factors have helped you in using the PHHC?

Advanced Technology Users. The following factors helped Advanced and Basic Technology Users to use the PHHC:

- Training support and guidance - Participants stated that the training and the free PHHC propelled them to start using the PHHC.
- Informal support networks - Several respondents formed informal support networks that helped them troubleshoot technical issues and share tips and tricks. These networks helped some participants become more comfortable with using the PHHC.
- Previous experience with PHHCs
- High level of comfort with technology
- Portability – The PHHCs compact size made it easy for participants to use it for a variety of purposes and in a variety of settings.
- Ease of use – Participants stated having an easy time transitioning to the PHHC from paper-pencil tasks.

Basic Technology Users. These users cited the training they received as one the major factors that helped them to use the PHHC. Participants indicated several key characteristics of the training they found most helpful:

- High level of support from Trainer and other Project participants
- Carefully designed initial training program
- Pacing of the training and extensive guided practice
- Trainer's use of motivation and encouragement
- PHHC experience of other participants – Their ability to demonstrate the potential of the PHHC for classroom applications.

Question E2: What factors have hindered your use of the PHHC?

Advanced Technology Users. The following factors related to hardware or software hindered participants from using the PHHC:

- Hardware limitations with older PHHC models – older m130 has limited capabilities and it's difficult to find software, camera attachments are difficult to use.
- Battery life/recharging issues – PHHC has only one charger. A portable charger would be helpful. Newer PHHC models have flash memory that help alleviate the problem of losing data when batteries run low.
- Issues with Mac platform and the lack of support – third party programs have to be purchased to fully use additional software.
- Inability to "sync" to multiple computers
- Insufficient number of PHHCs for students to use in classrooms at one time
- Instability of communication between probes and the PHHC

Several respondents identified time as a hindrance to using the PHHC. The participants would like more time to find more ways of using the PHHC. Also, some participants stated they spend a lot of time troubleshooting technical issues.

Some participants also had difficulty using the stylus and were troubled by the size of the PHHC screen.

Basic Technology Users. Technical issues were a major hindrance. Many lacked the technical expertise to troubleshoot problems. The following factors hindered participants from using the PHHC (many of these are similar to the Advanced Technology Users group):

- Battery life is too short.
- PHHC screen is too small and resolution is poor.
- Older PHHC models - limited capacity (memory and speed)
- PHHC compatibility with Mac platform and university portals
- Synchronization – Perhaps due to participants limited technology skills, synchronizing the PHHC to a computer was a major issue.
- Difficulty with peripherals and software: keyboard malfunctioned often, software kept crashing, computer continued to freeze during syncing.

Several respondents stated that they were unsure whether they will use the PHHCs with students or for instruction. And a few others cited a lack of time as hindrance as well.

Question E3: Would you have started to use a PHHC without participating in this project?

Advanced Technology Users. Twenty-three out of 37 respondents would have started to use a PHHC without participating in this project for the following reasons:

- Had previous PHHC training
- Owned a PHHC before the project
- Had an interest in PHHCs and the opportunity to be trained pushed them to use it.

Fourteen of the 37 respondents would not have started to use a PHHC without participating in this project.

Basic Technology Users. A majority of respondents would not have started using the PHHC had it not been for the training and support they received. Many indicated that they needed an extra incentive to get them started using something new, the free PHHC and training pushed to start using the PHHC.

The participant's technology knowledge and skills also was a factor. A few respondents reported not having sufficient technology skills or time to learn a new technology.

- "I'm not into technology, so I don't know the latest and newest things. …until something is actually brought to my attention and demonstrated for me—show me how it can be used in my world, and what the benefits to me are…"
- "Would I be doing what I'm doing on the PHHC without the project, no—I don't think so. I think that part of it is hearing what's available and once you start hearing some of the things that people were doing, it sparked other ideas for what I could use it for."

Eight respondents had already been using a PHHC or had previous experience using PHHCs.

Question F1: What benefits have you experienced from the PHHC project?

Advanced Technology Users. A large majority (30 of 37) of the participants benefited from the training with only 8 of 30 reporting that the benefit was limited to their personal productivity. Two participants indicated they did not benefit from the PHHC training. Participants underlined that "being in the project made things, like taking notes, more convenient, but it has not increased her personal and professional activity."

Basic Technology Users. A large majority (29 of 48) of participants indicated that they had experienced a benefited from the training, with only four of those limiting it to either increased personal or professional use. Three respondents indicated they did not benefit from the training.

> "Just more awareness of the broadness of use. I don't think it increases my personally and professional productivity."

The following are benefits both groups have experienced as a result of their participation in the PHHC study.

- Time efficiency: scheduling appointments and keeping track of contacts is easier using the PHHC.
- PHHC project at some extent decreased her fear of technology.
- Organization: Easy to organize and track information for meetings, classes, students, etc.
- Notes taken during meetings can be shared quickly with others
- Portability and ease of use for student teacher field observations, research, data collection

Question F2: What benefits have your students experienced from your being in the PHHC Project?

Advanced Technology Users. Twenty-three of the participants indicated that the students benefited from their participation in the PHHC project.

> "My students have benefited from my participation…They get their field notes in a readable form and more timely. They have also begun using Palms in classes and, in some cases, have bought their own, because they use them to take notes, and beam assignments..."

Thirteen participants were unsure or did not indicate whether the students benefited from their participation in the PHHC project. Only one Advanced Technology Users indicated that the students did not benefit from his/her participation in the PHHC project.

> "Participant declared that his students did not have PHHCs, therefore it was not beneficial to his students."

Basic Technology Users. Seventeen of the participants indicated that the students benefited from their participation in the PHHC project.

> "Both methods and content students have been exposed to and used the PHHC for data collection purposes. Students also benefit from participant's increased level of organization as their professor."

The remaining participants were unsure or did not indicate whether the students benefited from their participation in the PHHC project. The following are benefits listed as experienced from both user groups.

- Students are familiar with the basic functions of the PHHC as a result of the participant sharing their knowledge with students in class
- Personal organization for classes (grades, participation) has helped participant provide timely information to students
- Student receive instant feedback from participant
- Students see the potential of using hand-held technology to enhance learning
- Students see the portability and ease of use of PHHC as a data collection tool

> "It helps students to ask questions and design their own experiments because they can see instantaneous results. They collect the data, and then can conduct the experiment multiple times…"

- Immediate access and sharing of class/course resources (via beaming)
- Modeling the use of PHHC for presentations (using Margi and PowerPoint)

Question F3: What benefits have others (such as colleagues) experienced from your being in the PHHC Project?

Advanced Technology Users. Fifteen indicated colleagues/others benefited from their participation in the PHHC project

Basic Technology Users. Seventeen indicated that colleagues/others had benefited from their participation in the PHHC project.

The following are benefits others have experienced as a result of both user groups' participation in the PHHC study.

- Generated interest in the use of PHHCs by discussing PHHC applications with colleagues

> "We have gotten some others interested about the use of PHHCs…in a math classroom…some have looked at it and started to think about the use of it for their personal use…"

- Participant has helped colleagues use/troubleshoot the PHHC

> "I help other faculty in using the PHHC and by answering their questions about the PHHC."

- Participant and colleagues can quickly share information, dictations and meetings notes with each other

> "His colleague benefited from the forms [student-teacher observation] he developed by using the PHHC."

- Discussed other uses of PHHCs with colleagues

Question F4: Has your institution benefited from your participation?

Advanced Technology Users. Half of the respondents felt that their institution had benefited from their participation.

Basic Technology Users. Almost half of respondents felt that their institution had benefited from their participation. Overall, a majority of respondents felt that their institutions benefited from their personal and professional increases in productivity. The following are examples:

- Quick access to and distribution of information to students

> "I think it has been a big benefit to my students because having that instant feedback, as opposed to waiting three days for me to find the time to write it up."

- Quick access to and sharing of information with colleagues;

- Increased productivity by decreasing the amount of time it takes to plan and organize lessons, observations and meetings; better organization and retrieval of information

  "Being in the project expanded the range of things that I would do. I've been able to extend things that I would typically be limited to doing in a laboratory setting to field settings."

  "The primary benefit has been in personal productivity. Instead of writing out my field observations by hand and then retyping them into word or writing them on the department field forms…I merely sync the Palm with my computer and use Documents to Go."

- Calendar and reminder features have assisted with schedules and priorities.

Question G3. Have you purchased any accessories for your PHHC?

Advanced Technology Users. Thirty-six have purchased additional hardware, software, and other accessory purchases with personal funds.

Basic Technology Users. Almost half of respondents felt that their institution had benefited from their participation. Ten respondents also purchased additional hardware, and software purchases with personal funds. Their institution has been supportive in purchasing additional software (expansion cards, Margi presenters, keyboards, PHHCs for other faculty or department-wide use). A total of 5 respondents reported that professional development or department money was used for these purchases.

Question H1: Can the handheld computer be used as an effective tool to bridge the digital divide? (This question category was available for the fifth cohort group.)

The respondents agreed that the PHHC is a powerful tool that can bridge the digital divide and make technology accessible to all students.

Question H2: Do you think the PHHC could assist pre-kindergarten through 12 grade classroom teachers?

The faculty and staff agreed that the PHHC can assist pre-kindergarten students in mastering concepts and facilitating learning.

Question H3: Did the participants view the handheld computers as an equitable tool to bridge the digital divide?

Citing the free educational software and comparing the cost of the PHHC's as a major factor in making computer technology available to low income school, the participants viewed the handheld computer as an equitable tool to bridging the digital divide.

Question H4: Do you view the handheld computers as an equitable tool to bridge the digital divide?

The participants viewed the handheld as an equitable tool to bridge the digital divide and warned that classroom teachers will experience similar learning experiences as PHHC participants.

Discussion

The survey questions focused on investigating and discovering (a) who benefited from the faculty and staff learning to use the PHHC, (b) factors that helped or hindered their PHHC use, (c) overall skill levels and handheld and computer technology and peripherals usage, and (d) future directions.

Learning to use the PHHC

The trainer was interested in discovering to what extent will the participants benefit from Palm handheld computer training, and more specifically, will the participants learn to use the handheld computers? All of the teacher educators learned to use the PHHC at varying rates; some quickly becoming advanced users while others used the PHHC primarily for its calendar and contact applications. A majority of the faculty and staff said participation in the PHHC workshops assisted them in learning, gaining and refining their computer skills, and in becoming more organized. The graduate student interviewers reported similar results. All participants say they were the primary beneficiaries of the training and seven used the Palm handheld computers and Margi Presenter-to-Go adapters at conferences to present their PowerPoint slides.

University Personnel Embraces the Palm Computer

Over approximately three years, eighty five university teacher educators participated in an OBR PHHC study in which they were taught to use the Palm handheld computer. They were taught the practical, personal, professional and educational uses of the Palm m130, Zire 71 or Zire 72 computer. Participants in the first and second workshop cohort received a Palm m130 handheld computer, the *Palm handheld computer: A complete resource for classroom teacher* book by the International Society for Technology Education (ISTE), a portable keyboard and Veo camera as incentives for participating in the study. The third cohort received the Zire 71 handheld computer with built-in cameras while the fourth and fifth cohort groups received the Zire 72 with peripherals.

The Palm handheld participants attended three 3-hour workshops in which they learned and demonstrated the basic and educational uses/operations of the Palm computer. First and second workshop participants were required to read Part I of the *Palm handheld computers: A complete resource for classroom teachers* book before the first session and Part II before the second session. By the time the third training round began, the PHHC technology had improved and the changes in hardware and software made the resource book obsolete and necessitated changes in the training. The rapid evolution of the PHHC technology was a primary factor in making changes to the training throughout the almost 3 years of the project.

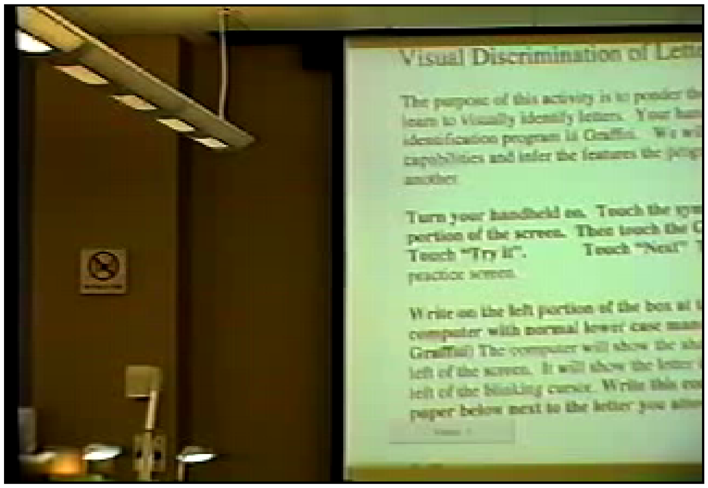
During the first session, participants learned about the features of the Palm and desktop software. The second was a trouble shooting session in which participants learned how to use educational software applications, freeware games, scientific probes, and accessories available for the PHHC. The third session provided a forum to discuss and/or demonstrated how the participants will use Palm handheld computer, software and technology in their professional lives. Participants were amazed at the vast amount of educational and curricular resources in the “palms of their hands.”

Most participants enthusiastically learned to use the basic Palm applications and created a mirror image of their Palm applications through hot syncing or transferring their Palms to the desktop software. The sessions were interactive and fun. Some participants “were caught” beaming notes to each other during the lunch break. The participants appeared to enjoy learning to use the Graffiti, the notepad and contact applications more than some of the other applications. The fact that they could import addresses into their contact application was a timesaver. The participants also enjoyed taking pictures with the camera.

Implications for Handheld Computer Use

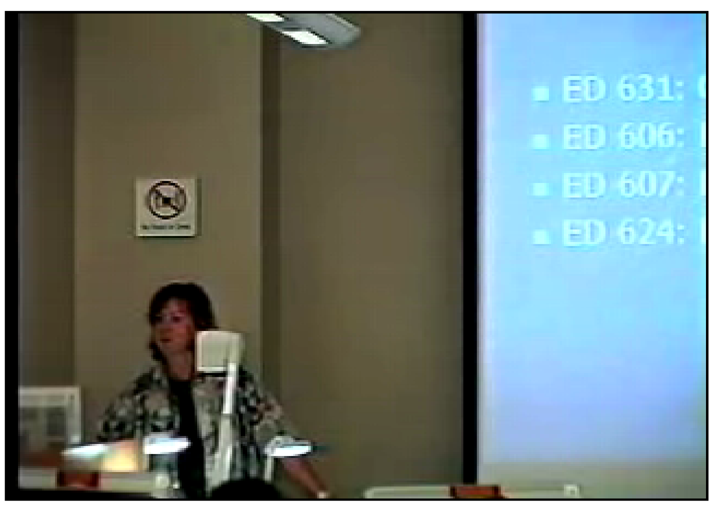
The teacher educators demonstrated creative ways to use the PHHCs during the show and tell presentations. Most explored using the PHHC with their students whether teaching, supervising or observing students at their field placement sites while some demonstrated using Dataviz’s Document to Go to manage their students’ grades and attendance. Ten of the cohort one and two participants demonstrated how they would use the educational software applications from HICE or GoKnow that were included in *Palm Handheld Computers: A Complete Resource for Classroom Teachers* with their classes while other participants created templates for evaluating their students.

The participants created a template or activity that will be used either in the classroom with pre-service teachers or to assist in the delivery of service to the student. A literary professor demonstrated the use of the handheld computer for visual discrimination of letters. The professor asked the participants to go to the graffiti icon and touch "try it." Next, they wrote on the left portion of the box at the bottom of their handheld computers with normal lowercase manuscript letters. They were to answer the question, “What letter does the lower case ‘a’ make? An ‘e’ or what letter did you get? a = e b = _____.” This leads to a discussion of how students learn literacy skills (Video 1).



Video 1: Handheld Use for Visual Discrimination of Letters (4:26; 19.3 MB)

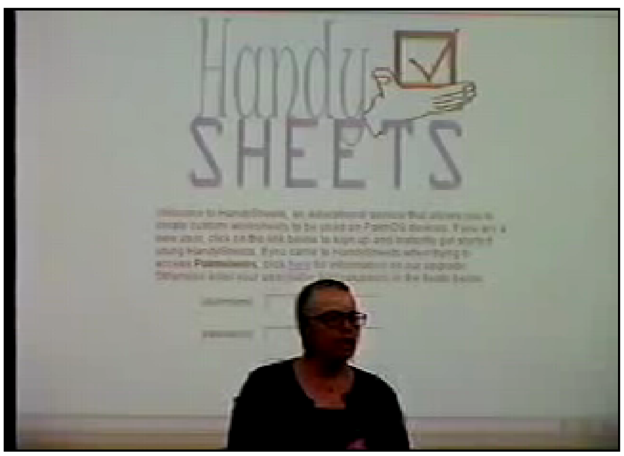
Another literary faculty member showed “The Many Uses of a Palm Hand-Held Computer (PHHC)” for her pre-service reading teachers. **(Insert the O’Connor QuickTime movie here)** In this activity elementary students guess the meaning of unknown word by using or not using context clues. After displaying their answers on the PHHC, the teacher tabulates scores quickly and posts them on the Elmo projector. The students then use Bubble Blasters to reinforce grammar concepts.



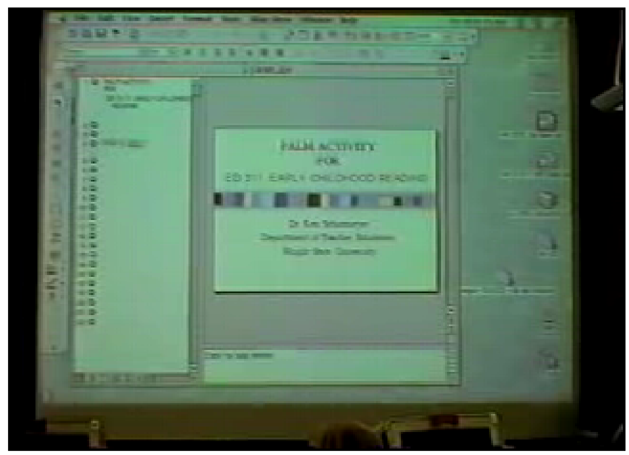
Video 2: Handheld Uses for Pre-Service Reading Teachers (2:01; 9.0 MB)

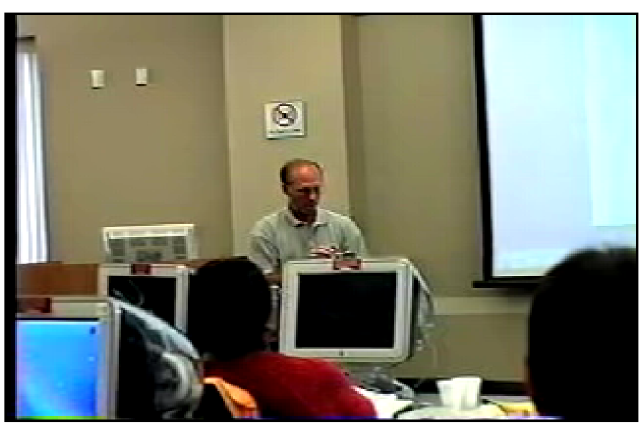
An educational leadership faculty member from cohort 4 demonstrated Palm Converter software, which converts angles, area, clothing, fuel consumption length, numbers, shoes, speed, temperature, time volume and weight. He told the Palm participants that a value is placed in the blank and the software converts this number to short or full value. The participants followed along during the demonstration. Some resources developed and demonstrated by the university's faculty and staff included

- Developing a supervision template based upon the 19 Pathwise criteria to observe student teachers;
- Using the handheld computer for visual discrimination of letters. This activity was designed to have participants ponder the ways in which children might learn to visually identify letters and learn to read;
- Playing vocabulary games by using Pico Map;
- Using Dictionary to go to reinforce grammar concepts;
- Writing Predictions using Freewrite;
- Using the keyboard to practice summarizing skills;
- Learning propaganda techniques and culturally responsive teaching techniques by using Handy Sheets (Video 3);
- Creating Spreadsheets and PowerPoint Slides by using Dataviz's Sheets To Go and Slideshow to Go (Video 4);
- Using MVal and Learner's Profile to evaluate students and preservice teachers;
- Using the tape recorder for note taking;
- Using the still camera and video camera to evaluate preservice teachers;
- Using the handheld for recordkeeping (Video 5).



Video 3: Propaganda Techniques (1:31; 6.0 MB)


Video 4: Spreadsheets & PowerPoint (1:31; 6.1 MB)


Video 5: Recordkeeping (2:33; 11.2 MB)

Troubleshooting

The International Society for Technology Education's (ISTE) *Palm handheld computers: A complete resource for classroom teacher* book was found to be an invaluable resource during the first two series of workshops. Since the PHHC technology has developed at a rapid pace, the software included in the book was incompatible with the Palm Zire 71 and 72 and should no longer be included with the book. The Palm educational software and Vernier's software and technology were great tools for demonstrating and linking the real world to the academy, but incompatible with the Palm Zire 71 and 72. Other problems were encountered and resolved included

1. Making sure the computers' security software is completely disabled. When using the College of Education's computer lab, the administrative and security software became engaged upon restarting the computers after installing the Palm Desktop software. Laptop computers are the better choice for demonstrating desktop software installations.
2. Checking the PalmOne website under the software application's frequently asked questions (FAQs) link and reading through the questions to discover possible problems or conflicts with the software before – installing to the Palm handheld. Some participants created questions, worksheets, activities and spent time searching websites, have products that are useless because incompatible programs cannot be hot synced to the Palm handheld.
3. Installing desktop software on the participant's home or office computer before the second session. When participants have different operating systems, the time needed to install various applications will vary. In some cases, the software was installed in minutes; in other cases, hours were spent installing software on the various computers.

Although these challenges occurred, the majority of the participants remained optimistic and proud of their creations and newly developed handheld computer skills.

Future Directions

The participants learned about the features, personal, professional and educational usages of the PHHC, the Margi Presenter-to-Go adapter, the Vernier scientific probes' usage and demonstrated how they'd use the PHHC with their pre-service and in-service teachers. Continuous and ongoing professional development in handheld computer technology can yield high results as educators become lifelong learners by gaining successful and lasting skills. Future directions and projected PHHC uses include

1. Participants' continuing use of the Palm handheld computers in their personal and professional lives and with students in their classes.
2. Participants' planning to assist in-service teachers in using the handheld at the university's local partnership schools.
3. Consultant's training of articulation agreement pre-service teachers to use the PHHC.

Since the PHHC's is relatively inexpensive, many participants say upgrading their PHHC is more likely to occur. In comparing the PHHC's advantages and replacement cost to the desktop computer, the PHHC is portable and the cost is minimal (Education at PalmOne, n.d.). As the participants become more comfortable with using the PHHC, they will discover more innovative uses for the Palm computer in and outside of their classrooms.

Bridging the Digital Divide

Can the handheld computer be used as an effective tool to bridge the digital divide? Did the participants view the handheld computers as an equitable tool to bridge the digital divide? The participants agreed that the PHHC is a powerful tool that can bridge the digital divide and make technology accessible to all students. Since access to technology should be about the effective use and careful integration of technology into the curriculum, the PHHC is an equitable, cost effective choice.

In comparing the PHHC's advantages and replacement cost to the desktop computer, the PHHC is portable and the cost is minimal (Education at PalmOne, n.d.). The participants said they are planning to continue using the Palm Handheld computers in their personal and professional lives and with students in their classes. The participants will continue to assist the college's pre-service and in-service teachers in using the handheld at our local pre-kindergarten through twelfth grade partnership schools.

Conclusions

All students, especially those living in low-income neighborhoods, must be afforded the opportunity to gain the computer skills that will be needed to participate fully in local and national economies (Bitter & Pierson, 2002; Costello & Stone, 2001; McBride-Stetson, 2004). Students should have an opportunity to use computer and information technology to add value to their lives and to achieve their goals. Educators must become skilled and proficient computer and information technology users who advocate and provide occasions for all students to develop high level cognitive skills.

Gender and multicultural education research consistently report that there are inequities relating to technology resources available to members of these groups (Costello & Stone, 2001; McBride-Stetson, 2004; Parkins, 2004). Initially male students tend to be more involved with and exhibit high level of confidence while using computers; however, these tendencies can be ameliorated by involving females, minority and low income student groups with computers at an early age and maintaining that involvement throughout the school curriculum at each grade level. Teachers, as reflective practitioners, must examine themselves for possible biases and encourage all students to participate fully in their classrooms.

Using different sections of the NCLB law – Title I, Title II and Title V – teachers can bridge the digital divide by purchasing and using handheld computers with their students. As demonstrated in the Ohio Palm Handheld computer study, educators must forge ahead and become those reflective practitioners that gain appropriate computer technology skills. The study clearly illustrates that learning to use the Palm handheld computer can lead to successful and continued use.

As educators become more confident of their computer skills, they must plan their curricula so that all students have equitable access and equal opportunities to be involved with instructional technology, whether desktop, laptop or handheld computers throughout their schooling (Forcier & Descy, 2002). When faced with the dilemma of having to choose versatile, yet cost effective technology for classrooms, consideration must be given to using school funds wisely for technology purchases such as the pocket computer and handheld computer. Continuous and ongoing professional development in information and computer technology can yield high results as educators become lifelong learners by successfully gaining computer literacy and handheld computer skills. Educators must ensure that all students have access to computer technology regardless of gender, ethnicity, socioeconomic background, and disability as NCLB makes this success possible.

Acknowledgements

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Dynamic Virtual Instruction: Enhancing Online Courses and Connection

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Abstract: The content of statistics is often a challenge for graduate education students in not only an online environment but also the face-to-face (F2F) setting. This paper presents the pilot results of an online graduate statistics course that utilizes virtual lectures as the primary source of instruction. Survey results indicate that students reported high levels of satisfaction with the course videos, packet, and structure. Students also indicated that student interaction with both instructor and students needed to increase.

Introduction

The impetus for offering an increasing array of online courses at the post-secondary level has been growing at a remarkable rate (Presby, 2001; Simonson, Smaldino, Albright, & Zvacek, 2003). While there is considerable debate about whether the primary reason for such a drive is economic, rather than pedagogical, researchers are engaged in exploring how learning outcomes are achieved in e-learning environments (Stacey & Rice, 2002). This particular study presents evidence of positive learning outcomes achieved in an online graduate course, and delineates relationships between student achievement and course design. Taking a design-based research approach (Baumgartner et al., 2003; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003), this study explores pedagogical issues related to an online graduate course pilot in statistics and the effects of integrating virtual lectures on student learning and satisfaction. Data collected and analyzed for this unique critique include survey data regarding learning behaviors, course behaviors and preferences; archival records of course online chats; instructor reflective journals; conversational interviews; and course grades.

Context

To serve the instructional demands of nearly all the graduate programs in the College of Education at Bowling Green State University, six to seven sections of Introduction to Statistics in Education are offered each session, with approximately thirty students in each section. Of these sections, about three are for off-campus programs. Finding qualified instructors for these off-campus sections has continued to be a challenge. One such solution has been to teach Statistics in an online environment. One of our best Statistics instructors developed such a course and piloted it with an off-campus cohort. This initial pilot utilized the textbook as the primary source of instruction and information. Student support was provided via the telephone, in which the instructor spent hours tutoring students on the phone. In the end, students reported great frustration with the course. The majority felt that they needed more direct instruction on the concepts. Students were often unable to delineate the important aspects of the content. While students were appreciative of the telephone support the instructor provided, the verbal explanations lacked visuals to reinforce the concepts. Their recommendation was that Statistics should not be offered in an online environment.

While the authors understood the reasons for this online failure, we believed that the course could be offered online if certain instructional and affective needs of the students were addressed in the course design. Research has found that when students are highly anxious about the content such as statistics and have low ability, a highly structured environment provides the support students need to be successful (Leonard, 2002). Research on student achievement in online courses has shown that learning behaviors such as self-regulation and motivation are important (Miller, Rainer, & Corley, 2003) as well as student interaction with instructor and fellow students (Kearsley, 1998). DeBourgh (1998) found that an effective instructor is the most important predictor of student satisfaction in online courses. Student interaction has also been found to predict student satisfaction of online instruction (Boverie, et.al, 1998). This research and instructional experience guided the course development process.

Course Development

In the author's face-to-face (F2F) courses of Statistics, students had repeatedly told the instructor that her explanations, support, examples, and activities coupled with the course packet really helped them understand statistics. The utilization of digital video was identified as a means of continuing the implementation of these successful instructional methods. Besides conveying key concepts, the virtual lectures were used as a way to build connections and community within the course, helping students get to know the instructor more fully, by hearing her voice and inflections during explanations of course material. Online students frequently relate a sense of detachment experienced in online courses (AAUW, 2000; Kramarae, 2001), as well as a need to better understand the perspective of their online instructor in interpreting material (Presby, 2001; Simonson et al., 2003) and providing virtual lectures of high quality in substance and delivery would address these concerns. Adding multimedia elements to online courses have shown promising results (Berz, Erdelyi, & Hoefkens, 1999; Eskicioglu & Kopec, 2003; Kwon & Kim, 2002), so proceeding with the choice to incorporate virtual lectures into the course seemed prudent.

Media Challenge and Development

Initially, the format of the virtual lecture seemed obvious. Videotaping the instructor teaching the F2F class, and then uploading these lectures in streaming video format from the online course shell would give the online learners access to the material and contact with the instructor that was desired. However, several problems existed with this model. Firstly, practice videos revealed that taping an existing F2F class was distracting for the viewer as the taped students often added background noise as well as dead air time which in turn added unnecessary length. Therefore, videos were created specifically for the online course, so that students would feel that the instructor was teaching them as they viewed. Another problem in the video process was the need to combine shots of the instructor, document camera, and computer screen for a cohesive and clear video. While multiple cameras were utilized, the virtual lectures were taped live to reduce the amount of editing. Finally, lighting and microphone placement were critical in capturing high quality footage. Even after these elements were addressed, exporting the product resulted in a virtual lecture that required significant bandwidth and hardware to handle effectively. Unfortunately, many online students had very slow Internet connection speeds and older computers that prevented them from receiving these lectures completely intact. Audio and video file types were also an issue. Virtually troubleshooting the plethora of student issues in accessing the streaming video lectures became very time-consuming and frustrating for both the instructor and the students. This frustration began to erode the foundation of community-building that was a focus of the course.

For these reasons, an alternative media format for the virtual lectures was sought. Attention was given to selecting a venue that would still offer students additional media input (visual and auditory), access to the instructor's inflections and explanations in an audio format, and would be more easily distributed. Lectures were placed on DVD's and distributed to students at the beginning of the semester (Figure 1). Students received a set of 4 DVD's containing a total of 12 video lectures. These lectures were substantive and contained more than the "talking head" of the instructor as they presented material in a lecture format (Video 1), facilitated learning activities and example problems (Video 2), and demonstrated computer applications using StatCrunch (Video 3). Videos are aligned with a course packet, so that students can follow the lecture, graphics, and computer demonstrations and complete activities and problems while they are viewing. The course was facilitated in BlackBoard, where all course documents and assessments were available as well as the course Discussion Board.

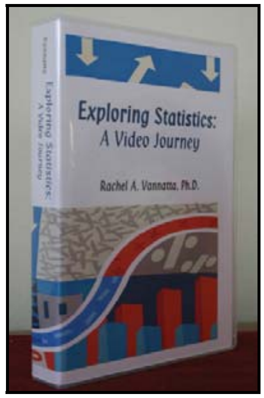
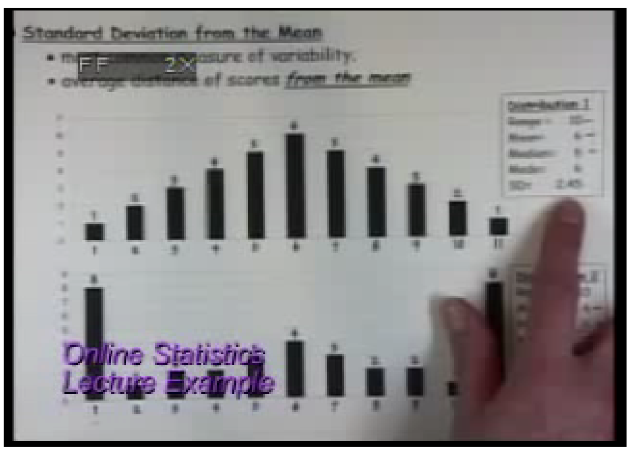
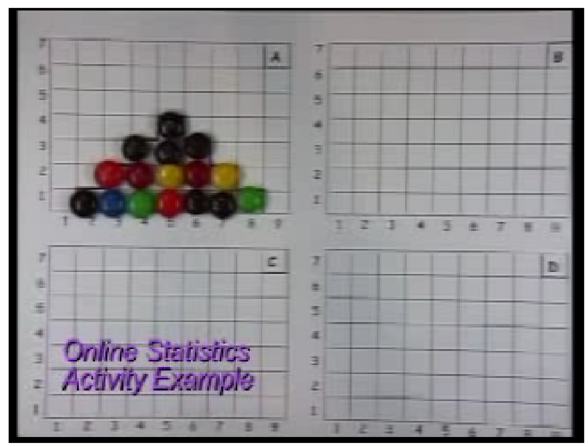


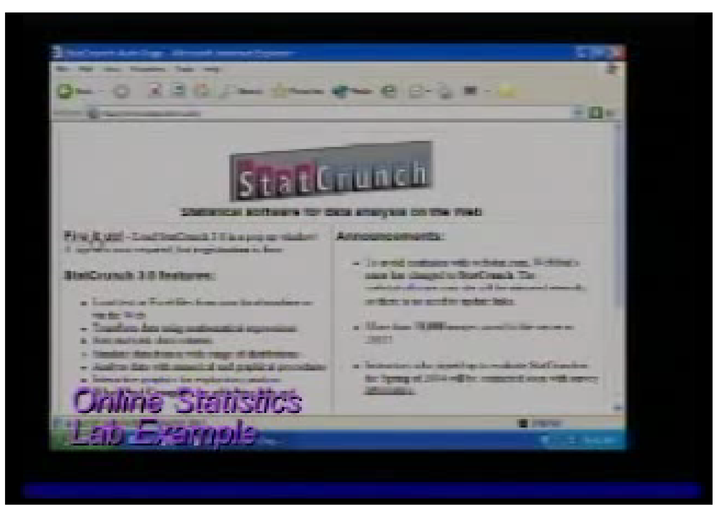
Figure 1: DVD Set of Virtual Instruction



Video 1: Lecture (0:52; 3.6 MB)



Video 2: Activity (1:44; 7.5 MB)



Video 3: Lab (1:42; 6.6 MB)

The instructor spent a great deal of time planning the content and how it would be presented within the videos. She also talked to many other instructors who had experience teaching online courses—they shared suggestions and frustrations, much of which surrounded student/instructor interaction. As a result, the instructor limited most class interaction to the discussion board, where students could voluntarily post questions about course process and content. Another aspect that received much reflection was the course calendar and structure. While much research has shown that students value the flexibility of online instruction, they also need some structure to be successful (Leonard, 2002). Consequently, an optional weekly schedule was created that assists students in meeting course expectations and deadlines. However, only five due dates were assigned through out the semester. All due dates were scheduled for Tuesdays at 5 p.m. in order to provide consistency.

Pilot

The course was piloted the Fall of 2004 with 32 students (n=27). The majority were female and pursuing a master's degree in teaching and learning. Most were taking an online course for the first time and were also enrolled in three or more course. Data collection consisted of a pre-survey (Appendix A) that was administered during a F2F session. The pre-survey consisted of 24 items that were derived from the Motivated Strategies Learning Questionnaire (Pintrich et al., 1991) and 8 demographic items. A post survey (Appendix B) was completed online at the end of the course. This instrument measured course behaviors and preferences with 26 items that utilized a five-point Likert scale.

Results

Pre-survey results revealed that students reported relatively high levels of learning behaviors with internal motivation (4.02) and self-regulation (3.80) showing the highest means for the sample (See Table 1). Students reported a mean of 3.6 for technology use and comfort.

A review of post-survey results with regard to course behaviors and preferences indicate that the course packet and videos were most instrumental in facilitating one's learning (See Table 2). Students reported that the course schedule assisted them in meeting course deadlines and that it provided an adequate amount of structure and flexibility. The majority of students viewed the videos through the DVDs provided rather than through BlackBoard, which required a high speed Internet access. Students also indicated that they missed discussion time with the instructor and that they weren't always comfortable submitting questions to the Discussion Board.

Table 1: Means and Standard Deviations for Learning Behaviors

Learning Behaviors	***M***	***SD***
Internal Motivation	4.02	.66
Self-Regulation	3.80	.65
Technology Use & Comfort	3.60	1.15
Meta-Cognition	3.51	.65
External Motivation	3.48	.64
Help-Seeking	3.07	.68

Table 2: Means and Standard Deviations for Course Behaviors and Preferences

Course Behaviors and Preferences	M	SD
Course Packet Facilitate Video Viewing	4.79	.51
Assignment Directions East to Follow	4.75	.53
Course More Difficult w/o Videos	4.71	.75
Like to Take More Online Video Courses	4.70	.66
Helpfulness of Video Lectures	4.67	.64
Course Schedule Assisted Me	4.58	.66
Missed Discussion Time w/Instructor	4.53	1.62
Helpfulness of Video Computer Demos	4.45	1.06
Completion of Activities & Problems	4.46	.98
Viewed Videos through DVDs	4.45	1.22
Highly Recommend Course to Friend	4.42	1.10
Practice Tests Helped in Exam Preparation	4.38	1.06
Comfort in Contacting Instructor	4.08	.88
Used Course Schedule to Follow Routine	3.88	1.30
Assignment Feedback Timely & Detailed	3.87	1.10
Helpfulness of Video Activities	3.75	1.11
Comfort Submitting to Discussion Board	3.41	1.14
Checked Discussion Board Regularly	3.25	1.15
Prefer More Structured Schedule	2.04	1.08
Regularly Experienced Technical Problems	2.00	1.18
Textbook was Helpful	1.96	1.00
Prefer More Flexible Schedule	1.88	1.11

T tests of independent samples were conducted to examine group differences in course achievement with respect to: gender, first time online students versus repeaters, and high and low levels in internal motivation, external motivation, self-regulation, metacognition, help-seeking, and technology use and comfort. Interestingly, results indicate no significant group differences in achievement for gender; first time online students versus repeaters; and high and low levels in external motivation, self-regulation, metacognition, help-seeking, and technology use and comfort. The only significant group difference (high versus low) in achievement was in internal motivation; $t(26) = 2.45$, $p < .05$, two-tailed.

Open-ended survey questions revealed that the most liked aspect of the course was the use of the videos and course packet. Nearly every student commented on how these two materials facilitated their learning. Interestingly, every student referred to these two materials together, never separate. One student stated, “I loved the course packet matched with the videos. Being able to pause, rewind, etc. to understand concepts was extremely helpful.” Several indicated that they liked the ability to view the videos several times to review content. Other “Liked Best” aspects of the course included the flexibility of working at one’s own pace, practice quizzes and exams, clear explanations, and instructor was energetic and easy to listen to. Students also indicated that they appreciated the encouraging comments and emotional support that the instructor expressed within the videos.

When asked about what course aspects they liked the least, the majority of students expressed displeasure with the textbook in that it was not an essential component of the course. Most indicated that the course packet and videos provided all the instruction they needed. Another negative aspect of the course that most students mentioned was the lack of interaction with the instructor and fellow students. Students mentioned that they missed being able to receive an immediate response from the instructor when posing a question. Discussion Board posting frequency (course procedures, n = 37; course content, n = 31) indicate that students were not very comfortable posting questions. Most questions were directed to the instructor not other students and were posted by the same few students. Finally, the only other negative aspect of the course that students cited was the experienced of technical problems with the videos.

When asked to provide recommendations for improving this particular online course, students focused on the aspect of interaction. Numerous students expressed the need to increase teacher/student interaction by having one or more F2F meetings or holding monthly live chats. Students also felt that student/student interactions were important and that possibly creating student groups or partners would provide an opportunity for student communication and support.

Conclusions

Virtual lectures can be an incredible instructional resource for online courses. Additionally, the corresponding packet seems to serve as an excellent companion as it provides a clear map for navigating the videos and its lectures, activities, demonstrations, assignments, and the course as a whole. Students repeatedly reported that the videos and course packet best facilitated their understanding of course concepts. Students cited the instructors clear explanations, humor, and activities as strengths of the videos. In addition, they also indicated that the technology itself provided many benefits: rewind, pause, multiple viewings, etc. Student also commented on the emotional support that was communicated in the videos by the instructor. The level of structure (suggested weekly schedule) and flexibility (only 5 due dates) provided in the course seems to be an appropriate level.

These elements within this online course environment combined to foster positive learning outcomes. Previous research on online courses has indicated that student learning and satisfaction is often enhanced when multimedia is integrated (Berz, Erdelyi, & Hoefkens, 1999; Eskicioglu & Kopec, 2003; Kwon & Kim, 2002); a clear, warm, and effective instructor facilitates the course (Boverie, et.al, 1998; DeBourgh,1998); and a balance of structure and flexibility guides the course schedule (Leonard, 2002). The only negative aspect cited by the students was a lack of interaction with the instructor and fellow students—a course component that has also been found in the research to enhance learning and satisfaction (AAUW, 2000; Kearsley, 1998; Kramarae, 2001). As a result, future courses will not rely on voluntary postings on the discussion board but rather require discussion board postings and chats at certain points in the semester.

An interesting finding was the significant difference in course achievement with respect to internal motivation. This suggests that those with high internal motivation are likely to achieve higher course grades in online courses. Consequently, internal motivation may be a predictor of academic success in online courses.

In conclusion, while designing such online courses required significant instructor investment, the dividends of student achievement that resulted were well worth the effort. The utilization of virtual lectures with the corresponding packet was the most preferred instructional method for online students as it provided: opportunities for multiple viewings, hand-on activities and demonstrations, and a caring instructor with clear explanations and a little bit of humor!

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Book Review

The Future of Higher Education: Rhetoric, Reality, and the Risks of the Market
Frank Newman, Lara Couturier, Jamie Scurry
San Francisco: Jossey-Bass, 2004

reviewed by
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Kent State University

A recent headline in the Chronicle of Higher Education states "Today's Colleges Must be Market Smart and Mission Centered." The major theme of the article is that "there will be no return to a simpler era when market forces played a less dominant role in American higher education." That is a nutshell is also the major theme of the book under review: The Future of Higher Education: Rhetoric, Reality, and the Risks of the Market, by Frank Newman, Lara Couturier and Jamie Scurry. The results of an extensive four-year investigation conducted by the Futures Project at Brown University, this books looks at the major influences impacting higher education, focusing on the competitive nature of every aspect of university life: attracting students and faculty, obtaining research grants, winning athletic titles, generating revenue, and acquiring rankings and prestige. A major caveat frames the discussion: "if not skillfully structured by thoughtful and strategic interventions of government, the market and growing competition will distort the purposes of higher education and further widen the gap between rhetoric and reality" (p. 1).

Newman describes the two historical purposes of higher education: 1) safeguarding societal needs, "most notably the search for truth;" and 2) "creating a skilled and educated workforce." The book addresses both the opportunity and risk for those in higher education in responding to these two basic goals as they face what he characterizes as "the grip of transforming change." Changes highlighted include increasing competition among traditional institutions; rapid expansion of new for-profit and virtual institutions; technological approaches to teaching; globalization of colleges and universities; and the shift toward viewing higher education as a market, rather than a regulated public sector.

While the reader is led to believe that these transformations are causing unique new conflicts as those in higher education determine purposes and effectiveness of their institutions, the litany of changes and challenges presented caused me to look at a 1964 book Anti-Intellectualism in American Life, for which Richard Hofstadter won the Pulitzer Prize. Its focus is to say something about the historical conflict between the life of the mind in a society dominated by the ideal of practical success. He suggests that in America there has always been conflict between those who supported humanistic learning and those for whom contemplation was only useful if it could be transformed into practical intelligence. He quoted an orator at Yale, who in 1844 cheerfully proclaimed the end of humanistic learning for its own sake:

> The age of philosophy has passed, and left few memorials of its existence. That of glory has vanished, and nothing but a painful tradition of human suffering remains. That of utility has commenced, and it requires little warmth of imagination to anticipate for it a reign lasting as time, and radiant with the wonders of unveiled nature.

Hofstadter shows that by the 1920's, the interest in linking higher education with utilitarian needs led to a shift in the nature of curriculum to develop more and more courses which "might interest and attract the young." The increasingly vocational character of American higher education was the result. This was supported by an abiding faith in technological progress as the way to develop industry and to cultivate "the money making faculty."

We can look at Newman's book through Hofstadter's eyes. While some of the causes of the tension between values and mission and the marketplace may be unique to our time, the current debate over the purposes and nature of higher education as described in Newman's book are part of a historical pattern.

Two other recent publications, released in 2005, compliment Newman's book. The first, a book, entitled Remaking the American University, by Robert Zemsky, Gregory R. Wegner and William F. Massey, looks specifically at competition for students, referring to recruiting activities as an "admissions arms race," It examines the purpose of higher education through the eyes of various groups of prospective students, focusing on the "fastest-growing group of purchasers in the higher education market"… who view colleges and universities "principally as providers of spot courses and skills." The second is a report entitled Online Distance Education Market Update: A Nascent Market Matures, by Eduventures, an independent research firm. For that group of students who do purchase education one course at the time, distance education is a growing and significant option. Enrollment is expected to exceed 1 million students in 2005, representing a market of more than $6 billion. Eduventures shows that what is driving this demand is the need for "easy access to quality higher-education programs" as well as a growing acceptance of technology to deliver "just-in-time, in-the-right place" educational opportunities.

Newman suggests that competitive circumstances such as those described in the above publications, are forcing higher education leaders to face three demanding tasks: 1) to respond to a worldwide higher education marketplace, driven by a growing virtual and for-profit higher education sector; by 2) constructing a "workable higher education system;" and 3) ensuring that the result for both the system and their institution is serving public purposes. The book suggests that university "gridlock" in the name of governance can mitigate against making the types of dramatic changes necessary to be responsive in the market driven environment.

Yet, the book ends on an optimistic note, stating that it is indeed possible to rebuild the compact between higher education and the public. Newman concludes that 'there was never a period in which the opportunity for contributing to society has been as great as it is now." He and his colleagues call on leaders of colleges and universities to clarify and enhance the public purposes of higher education, stating that this is not the time to stand on the sidelines to see how things turn out. Taking the responsibility for focusing on mission by making appropriate changes in response to market forces as well as by providing social benefits, is identified as the major task facing higher education leaders in the 21st century.

> And they see technology as having a major role to play in creating strategies for the new era : "Technology will open new possibilities for extending the university's reach and improving the capacity to teach and research." The book ends with this observation :

> …technology is no respecter of tradition as to how organizations are organized. New forms of pedagogy are emerging. We will no doubt have to face the possibility of fundamental changes in what a university or college looks like.

This book provides a thoughtful look at those forces impacting higher education today. It is recommended reading for all those working toward creating an effective balance between being market driven and serving the public need.

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