Integrating Handheld Technology and Web-based Science Activities: New Educational Opportunities

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Abstract

We describe the integration handheld computer technology into an existing web-based educational platform, the Web-based Inquiry Science Environment (WISE) and the synergy it produces. This solution facilitated a research program that explores how handheld computers (a.k.a. PDAs) can expand the scope and functionality of inquiry activities in K-12 science and mathematics curriculum. We present the WISE software and curriculum and explain how combining it with handheld technology creates unique educational opportunities. We then describe the system we have developed and its future.

Introduction

This paper will present an innovative application of handheld technology for science education. For the past seven years, the Web-based Inquiry Science Environment (WISE) project, funded by the National Science Foundation, has explored the most effective designs for inquiry activities that draw upon the wealth of Web resources. We have designed an effective browser-based learning environment that scaffolds students as they work collaboratively on inquiry projects.

The designs of the WISE learning environment, inquiry curriculum and assessments are based on a pedagogical framework called Scaffolded Knowledge Integration. This framework, developed by Dr. Marcia Linn and her colleagues (Linn and Hsi, 2000), has been developed through twenty years of classroom research with technology and inquiry (Linn and Songer, 1982, Bell, Davis and Linn, 1995; Slotta and Linn, 2000).

Continuous improvement of the WISE technology has resulted in easy-to-use software that scaffolds students as they perform critique, design or debate projects. A growing library of such projects has been developed by "WISE Design Partnerships" that include scientists from agencies like NASA, NOAA, and The National Geographic Society. In the past several years, WISE has grown dramatically in the size of its curriculum library as well as the audience of teacher and student users. Thousands of teachers and many thousands of their students are now using WISE inquiry projects in conjunction with their science courses.

We have begun to research the challenges faced by science teachers as they adopt the innovative technology and inquiry methods entailed by WISE. This research has involved the formation of partnerships with two large school districts -- Denver Public Schools (Colorado), and Desert Sands Unified School District (California). Working closely with administrators within these districts, we have helped science teachers integrate WISE activities with their courses, and developed networks of WISE mentors within the districts to help offer support.

In conjunction with these school district partnerships, we were recently awarded a grant of 500 Palm IIIc handhelds from *The SRI Palm Education Partnership*, to research effective uses for handheld technology in education. We proposed to develop Palm activities that would complement our existing library of Web-based projects, benefiting from the scaffolding of the

WISE technology and curriculum. We sought to integrate the use of handheld computers with WISE curriculum, enabling both data collection activities like surveys and field observations and reflection activities in analyzing the collected data.

In this paper we present an overview of the WISE environment, detail the goals of our handheld technology initiative, describe it functionally. We then present our experiences in a pilot test and look toward the future.

WISE: The Web-based Inquiry Science Environment

WISE offers a powerful browser-based learning environment for middle and high school inquiry science projects. Students work collaboratively in these projects, actively using materials and software from the World Wide Web. In one project, students evaluate the health of a local creek, modeling the factors that contribute to pollution. In another, they compare two competing theories about why deformed frogs are appearing in American waterways. Figure 1 shows a screenshot of the WISE learning environment and Figure 2 shows the growth of our user base. An *inquiry map* on the left-hand side of the browser window coordinates all student activities, resulting in Web materials, pop-up notes or hints (shown in the Figure), or any of a variety of other tools and features, such as online discussions, journals, causal maps, data visualizations, and an argument editor. Throughout the project, students are scaffolded by the inquiry map as they work collaboratively to perform carefully designed inquiry projects.

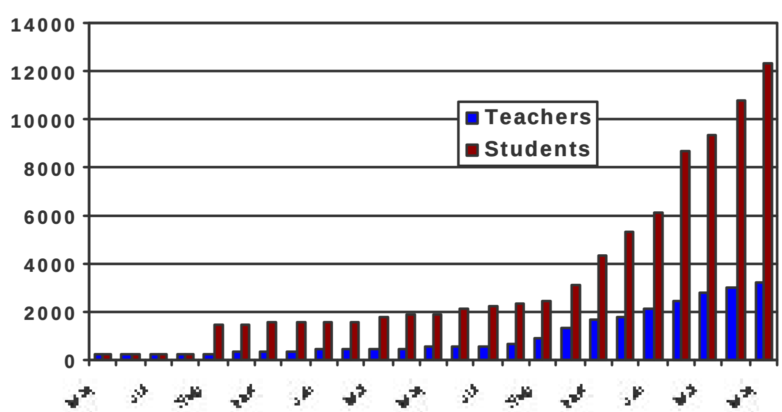


Figure 1 WISE user interface, notes, hints **Figure 2** WISE user signups in past 2 years

WISE projects are designed to offer teachers a means of adding inquiry and technology to their existing curriculum. Teachers choose from a library of projects, each accompanied by a lesson plan, assessments, scoring rubrics, connections to standards, and opportunities to customize the project to local issues and curriculum topics. Teachers can monitor and grade student work, provide formative feedback during a project run, and manage their student accounts. Reviewers of this proposal are invited to visit http://wise.berkeley.edu/) where they will find more than 30 different projects, in topics of physical, earth and life sciences at grade levels from 4 through 12.

We have researched the effectiveness of WISE activities for student understanding in a wide range of classroom studies, summarized in a recent book by Linn and Hsi (2000). All WISE activities are assessed by pre-post test items, as well as embedded assessments, which show that students develop a deep understanding of the science content, and gain important lifelong learning skills related to critique of evidence, debate of arguments, and design of personally relevant solutions. WISE research has demonstrated an impact on student understanding of science, fluency with technology, and literacy in the use of language and argumentation (Linn and Slotta, 2000).

Goal of project

We seek to leverage the strength of the WISE platform and curriculum to provide effective new applications for handheld technology. The key innovation that handheld technology affords is convenient and portable data entry. Within the scaffolding and instructional context of the WISE learning environment, this becomes a powerful pedagogical instrument.

For example, working in the *Genetically Modified Foods* project, students download a carefully designed survey into their handheld, and then interview their friends and family between classes or after school (e.g., collecting age, gender, dietary habits, and beliefs about GM Foods). Later, they put them in the syncing cradle and all their data is transferred to the WISE databases. This provides collaborative data for the students to draw upon as they continue to debate whether GM foods are dangerous.

By facilitating data collection, we can then provide useful tools for analysis. For example, in the *Healthy Creeks* project, students can collect data on-site using probeware or simply typing in their pH findings. In the classroom, they can analyze the variance among their class and how it relates to other classes. Using the data analysis tools, the students can explore the data. For example, comparing the average pH of the creek each month for the past 2 years. Such activities empower the handheld with the context of a broader curriculum.

System description

In the course of bringing our vision to handhelds, we have developed a versatile collaborative database that can be used to collect and analyze any sort of data in any context. To explain, we will describe a mock application from start to finish.

Remember that a WISE project consists of steps that the student navigates through using the inquiry map (far left of Fig 1). To bring collaborative data into a WISE project, the author adds a step from the Data Collection / Analysis family. We begin by selecting the "Form blank" step (Figure 3). A form blank is the empty form that is to be filled out.

Within the form blank authoring window, we author the form blanks for this project. A form blank is comprised of a sequence of form fields. A form field is comprised of a prompt and a data input definition. Data input types include text, numbers, radio buttons, checkboxes, pop-up menus, lists, etc. To define a form field, the author chooses the type and then sets the parameters of that type. For instance, if it is a checkbox field they will define the choices and optionally include an image to represent each choice.

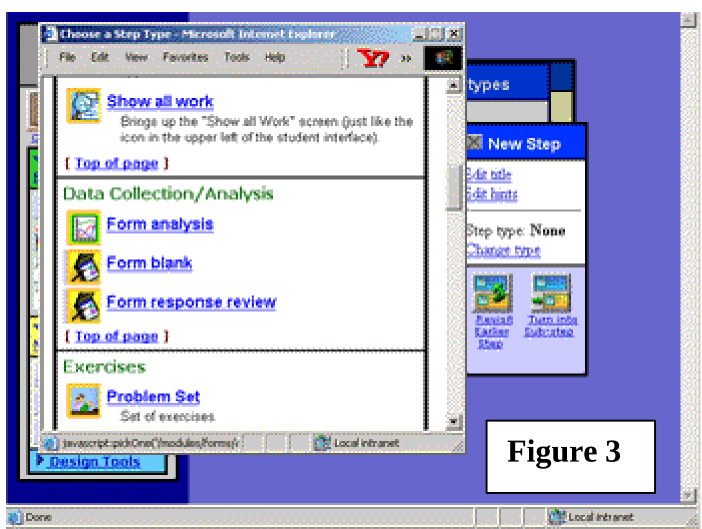


Figure 3

For the sake of explanation, let us author a form called "Fishies". It consists of three form fields. The first has a prompt of "Which tank did you watch?" and a pop-up menu to choose between Main, Tropical, and Arctic. The second, "Which fish did you watch?" lets the user choose images of a guppy, a tuna, and a shark. The third, "How many did you count?" lets the user input a number.

We also add a "Form analysis" step. Here we choose which fields to analyze. We also choose the scopes of data to include in the analysis: just the group's data, the whole class's data, data for all users of the project, data for all projects. (A form field, once defined, can be reused in any form blank even across different projects.) We also choose what types filters to provide the student to guide their reflection. Filters can omit or include responses that meet certain criteria, such as temporal range or response to a field.

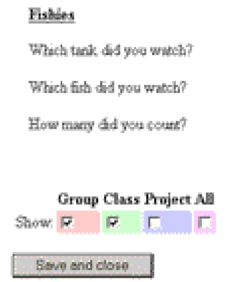


Figure 4

For our project, let us choose to analyze the fish count based on the tank and fish that the student watched (Figure 4).

Now we have our collaborative data collection and reflection working in the web browser (Figure 5). This is all well and good, but we want the students to have Figure 5 on their handhelds. To do this, we go to the handheld setup page of the authoring environment and defined channels to send to the handhelds. A channel is a selection of form blanks to fill out preceded by introductory text, much like a WISE project step. It is separate so that the author can differentiate the tasks to perform on the handheld from those to perform in the browser. (An in-class form may have the students make predictions and the on-site form collect the true data.)

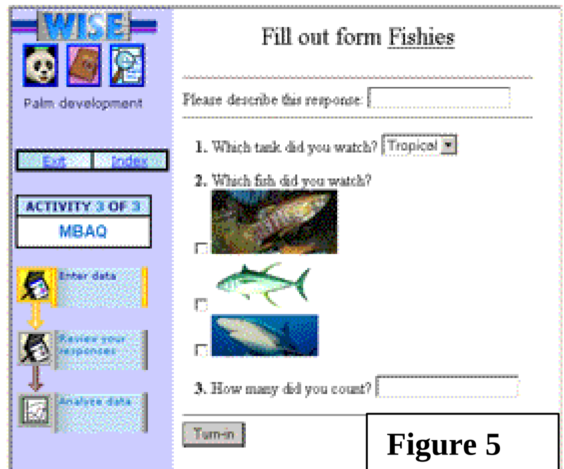


Figure 5

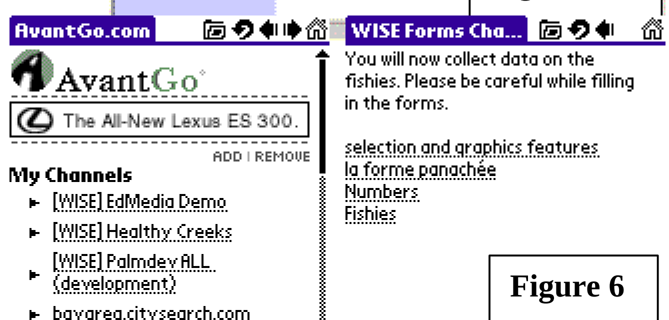


Figure 6

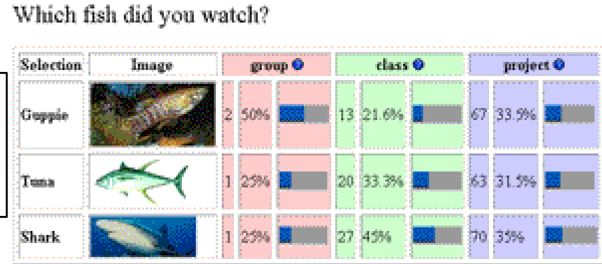
Once we have defined the channels, we click to subscribe the handhelds to them. We currently make use of a service called AvantGo to transfer the data. (AvantGo is a commercial service and may not suit us in the long term, but because we have built our system on open standards we can easily shift to other services or create our own.)

Figure 7

Once this is done, the students put their handhelds in the cradle and let them sync with the WISE servers. This downloads the channels and form blanks for them to fill out.

Each set of handhelds shares one AvantGo account. The account lists the channels that have been subscribed (left Figure 6). When the student picks up their handheld for a WISE project, they select its channel. In our example, "EdMedia Demo". They are then presented with the instructions and list of form blanks that the project author specified (Figure 6).

In our example, they select the “Fishies” form blank. Figure 7 shows how this form blank appears on an actual Palm IIIc, in contrast to the web browser in Figure 5.



Which fish did you watch?

Selection	Image	group			class			project		
Guppie		2	50%		13	21.6%		67	33.5%	
Tuna		1	25%		20	33.3%		63	31.5%	
Shark		1	25%		27	45%		70	35%	

The students then fill out the form wherever they may be. Since the handhelds are shared by the whole class, each student signs their form with their name in order to receive credit. (Any illegible or no-name work is sent to the teacher’s management window to reattribute.)

When they return to the classroom, the students drop their handhelds in the cradle to submit their responses to the WISE server.

They return to their web browsers to explore the data and reflect. The inquiry map guides them through this exploration. Within a Form analysis step they experiment with the parameters of the filters. The system them renders the data for the subset they have defined. (Figure 8) This is how the students mine the meaning out of their data.

Pilot Run: Aquarium Partnership

The system has been shown to succeed in a real classroom. In partnership with the Monterey Bay Aquarium, we developed an inquiry project to help "extend the visit.” Before the trip, the project moves students to ask themselves questions that help their investigations during the aquarium visit. During the trip the handheld forms prompt the student for data to collect. After the trip, the analysis steps help student explore the data and derive conclusions.

Educators from the aquarium wanted to help students focus on marine science concepts, including the factors relating to fisheries decline. We co-designed an activity where students explore the fish in Monterey Bay, reflecting on why some fish are placed on a "Seafood Watch List " while others are not. Students chose one fish for specialization, which they investigated at the aquarium. The forms prompted them to record observations about the fish and other features of the aquarium. We designed an observation form that would help students reflect on the habitat and adaptations of "their fish," as well as a checklist of aquarium activities that was beamed to students by aquarium docents. These observations provided a focus for student activities at the aquarium while enabling the collection of student data for use in later stages of the project.

An initial test of the project with students from an oceanography club at a local high school provided valuable experience on the use of our technology. Students embraced the handhelds even more quickly and easily than we expected. After a few minutes, they had no difficulties navigating the forms or inputting text using Graffiti. The pilot run also provided us with real-world data on the logistics of syncing a classroom worth of handhelds and we are factoring these observations into the future of our technology design.

Future

Our future research is to determine the pedagogical value of the technology we have developed. Based on the aquarium project observations, we are currently refining our designs for use by several classrooms which are scheduled to visit the aquarium after running the WISE project. We will contrast the activities of these students while at the museum with those of students who did not use the WISE handheld integration, to evaluate the impact of our scaffolding on students' experience of the aquarium visit.

Our next target for handheld integration is our longstanding Genetically Modified Foods Debate project. Currently, eighth-grade students engage in a two-week inquiry based curriculum on genetically modified foods. Students learn to weigh the tradeoffs involved in using one method of agriculture or another, as well as to support their position with appropriate evidence. Students are given many opportunities to express their ideas, and learn from each other while debating the controversy over whether GM foods are safe for human consumption. With handheld forms, students will be able to extend their own investigations beyond the classrooms and into their social networks. Back in the classroom, they can visualize the data and compare based on criteria they choose. Additionally, they can incorporate and compare responses from their teacher's other classes, or from classes in another district, state, or even country.

We also seek to understand the effects of bringing learning into a social context. In the process of surveying, students can learn to evaluate information sources, to develop syntheses and clarity on issues that are confounding to others, how to use data for knowledge development, interviewing skills, assessment practices, and self-monitoring opportunities. They develop a coherent understanding by first asking people what they know, talking about issues with them, then researching the relevant facts and concepts independently using WISE. How does our use of handheld technology improve students' general inquiry skills?

Another avenue of research that we would like to pursue is the data representation component itself. We plan to develop many different visualizations and comparison schemata for the data and evaluate their relative effectiveness. The challenge is to develop software that is 1) flexible, 2) intuitive, and 3) works well on the computers found in most classrooms.

Conclusion

The WISE learning environment and handheld computers are synergistic. The handheld provides the mobility necessary to collect real-world data and observations. WISE provides the scaffolding to give these data pedagogical value. By integrating them, we have created the exciting education opportunities described and certainly even more opportunities that we have not yet imagined.

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