THE GATHERING AND USE OF INFORMATION BY FIFTH GRADE STUDENTS WITH ACCESS TO PALM HANDHELDS

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Handheld computers may hold the possibility for a one-to-one computer: student ratio. The impact of the use of Palm® (Palm, Inc.) handhelds on information acquisition and use by 5th grade students in a North Texas school during a class research project was investigated. Five research questions were examined using observation, interviews, surveys, and document analysis. Are there differences in information gathering and use with the Palm between gifted, dyslexic, and regular learners? What relevance criteria do students use to evaluate a web site to determine whether to download the site to the Palm and afterwards whether to use the downloaded site's information in the report? How do the Palms affect the writing process? Do the animations and concept maps produced on the Palm demonstrate understanding of the intended concepts? Are there significant differences in results (i.e., final products grade) between Palm users and non-Palm users?

Three groups of learners in the class, gifted, dyslexic, and regular learners, participated in the study. The regular and dyslexic students reported using Web sites that had not been downloaded to the Palm. Students reported several factors used to decide whether to download Web sites, but the predominant deciding factor was the amount of information. The students used a combination of writing on paper and the Palm in the preparation of the report. Many students flipped between two programs, FreeWrite and Fling-It, finding

information and then writing the facts into the report. The peer review process was more difficult with the Palm. Most students had more grammatical errors in this research report than in previous research projects. By creating animated drawings on the Palm handheld, the students demonstrated their understanding of the invention though sometimes the media or the student's drawing skills limited the quality of the final product. Creating the animations was motivational and addressed different learning styles than a written report alone. No statistically significant difference was found in the scores of the three 6+1 Traits categories, however the Palm users didn't meet the page-length requirement for the research project but the majority of the control class did.

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CHAPTER 1

INTRODUCTION

The primary focus of this study is the impact of the use of Palm® (Palm, Inc.) handhelds on information acquisition and use by 5th grade students. The study investigates the different ways in which the students used the Palm handhelds and how it affected the information gathering and use during a research project about inventors. "Learning with hypermedia is essentially an information usage activity," (Yang, 1997, p. 72) which places this research firmly within the field of information use studies.

One of the latest evolutions in computing, whether in the classroom or not, originates in the decrease in physical size and increase in the computing power and the size of the memory in the devices (Pownell & Bailey, 2000). Powerful computers that fit into a pocket are being used for many information gathering and management tasks. Whether called PDAs (Personal Digital Assistants), Palmtop computers, or handheld computers, these devices have the ability to put computing power in the individual student's hands.

Computers in the Classroom

The presence of computers in the classrooms has grown rapidly in the last 10 years. In 2000, the average public school contained 110 computers (Snyder & Hoffman, 2002). A government report found by the fall of 2000, 98 percent of the public schools in the United States had access to the Internet, but only 77 percent of the instructional rooms were connected (National Center for Education Statistics, 2001). Computers are

usually distributed in small numbers to the classrooms or aggregated into computer labs. Soloway, Becker, Norris, and Topp (2000) surveyed educators in Nebraska, Florida, and New York during the time period of 1999-2000. They found 60% of the 6,000 educators surveyed reported they had less than two computers in their classroom. Restricted access to computers may be a problem leading to the reported lack of use. Without access to computers in the classroom, the amount of time each student gets to use computers is restricted to a small fraction of the instructional week. The lack of several computers in the classroom also means the use of computers is often isolated from the more traditional learning activities, and not integrated into the learning of other subjects.

Becker (1999) observed frequent use of computer is closely associated with having computers accessible in the teacher's classroom. Soloway et al. (2000) also found 50% of the teachers report their students use a computer less than 15 minutes a week. Similarly, Becker (2000) in his nationwide survey reports 70% of the teachers have their students use computers less than three times a week.

Handhelds as a Solution

Handheld computers are one way to reach a one-to-one ratio of students to computers. "By combining much of the computing power of a desktop system with the portability of a graphing calculator, handhelds could become the first truly personal computer used by students both in and out of school." (Bannasch, 2000, para. 1) They provide the potential to integrate computer technology into the learning day. The major participants in this study were elementary school students, who were novices in regard to using the Palm handheld for educational purposes. In this study, there was a 1:1 ratio

of handhelds to students. Each student had access to the handheld at home and school. Despite the limitations of handhelds, such as battery life and screen size, they offer numerous possibilities.

- Handhelds support the gathering and use of information. Web sites can be downloaded, notes can be taken, and drafts written on the handheld.
- Handhelds allow for the portability of information. Once the information has been gathered, it can be used anytime, anywhere. It allows the information to be used where the students' activities and learning occur.
- The Palm is instantly accessible for learning with its instant-on feature. Students don’t have to wait through a long boot-up cycle common to desktop computers to start their work. This is particularly important when integrating technology into a limited school day.
- The handheld also supports the creation and editing of documents.
- Handhelds offer several input techniques. The handheld can be connected to an external keyboard; a keyboard screen can be accessed on the handheld to enter text; or a student can print in Graffiti, a single stroke printing method to input text, numbers, and other characters.
- Handhelds offer various means to transfer data between devices to support collaboration. For example, infrared beaming from handheld to handheld supports peer review. The infrared beam sends and receives information from device to device allowing the sharing and editing of documents.

The Palm IIIc used in this study has some severe limitations also. The small screen leads to several problems that limit use. Only one program can be open at a time. This problem with the current Palm operating system limits the student's access to multiple programs simultaneously. For example, because only one program can be open at a time, a student can't have a Web site and a word processing document open at the same time. To go from one program to another requires 3 taps. Fortunately, the programs start up immediately, allowing students to rapidly go from one program to another. Another problem caused by the size of the screen is the fact that one can only see approximately eleven lines of text containing about seven to nine words at a time so it is hard to get an overview of what one is doing. Some of the pictures downloaded from the web extend past the sides of the screen. Of course, there are technical glitches that occur in the everyday operation of the Palm that slow down the use of the Palm or entirely stop the day's work for that person. Technical glitches will be discussed in the Results section.

As more and more schools move towards seeking solutions to the problem of universal access to technology, they have begun to examine handhelds as a possible solution. This will make systematic research on the use of handheld computers essential. The purpose of this study was to find out how students gather and use information when they have access to a Palm handheld on a continuous basis. The handhelds in the study were used for word processing, creating concept-maps, storing web resources, and for drawing and animation. The Palms in this study were self contained units without direct access to the Internet. Web resources were found using a desktop computer and then downloaded into the Palms. At a later time, the students

read the Web sites and used them as reference sources instead of taking notes directly from the Web sites on the computers. The students never took notes from the desktop computers even though during past research projects that was the method that they used. For the past projects, the students took notes from the desktop screen on note cards. Even though there were many times when the desktop computers were available, note taking from the desktop computers was never observed.

Several educational software packages, produced by the Center for Highly Interactive Computing in Education (HI-CE) at the University of Michigan (http://www.handheld.hice-dev.org) were used for this study. HI-CE worked closely with this study, offering advice throughout the project. Their help was invaluable to troubleshoot problems during the study.

Definitions

Concept Map: A graphical representation of a central concept and its relationship to facts and factors related to it. Usually a concept map has a central node with the name of the central concept within the node and annotated lines leading from the central node to auxiliary nodes labeled with the name of the sub-concepts.

Fling-It: A program used to download Web sites from a desktop computer created by HI-CE for the Palm operating system.

Flinging: Downloading a Web site from a desktop computer to a handheld.

FreeWrite: A word-processing program created by HI-CE

Giraffe: A typing program that comes as part of the software package for the Palm IIIc. Giraffe is used to practice Graffiti (see below).

Graffiti: A simple handwriting recognition system that utilizes specific strokes for each alphanumeric character, often similar to capitalized letters or standard numbers. Most characters are entered with a single stroke of the stylus. Letters are formed on the left of the Graffiti writing area, numbers on the right.

Handheld computer: A small, mobile device that provides computing and information storage and retrieval. In this study, the Palm IIIc was used. This version has a color screen and runs the Palm operating system. It weighs 6.8 ounces and is 5.06" x 3.17" x .67"

Happy Hacker® Cradle (PFU America, Inc): A device in which the handheld is inserted which allows data to be transferred between a keyboard and a handheld computer.

Hot Sync (or sync): Short for synchronization, to hot sync a device means to transfer documents or programs from the Palm to or from traditional desktop computers. Conversely, documents or programs can also be transferred by the same method from desktop computers to the Palm.

Information gathering: Activities associated with accessing, choosing, and using information.

Inventors project: A three-week research project about inventors. The products from the project are a two and one half-page paper, a concept map, and an animated drawing of the invention. (see Appendix C for the assignment)

Infrared (IR) beaming: Transferring data between two devices, such as two Palms or between a Palm and a printer, without cables.

Palm Artifact Management program (PAM) – A program on the desktop computer that during synchronization uploads documents created in some of the programs created by HI-CE.

Peer Review: Editing another student's document for a numbers of problems such as incorrect sentence structure and words misspelled or used incorrectly.

PicoMap: A program used to create concept maps produced by HI-CE for the Palm operating system.

Reset: There are two types of reset. A soft reset only loses the work that has been done since the current program was opened. A hard reset loses all the settings and created documents. To restore the Palm after a hard reset, the Palm is hot synced to the desktop computer, which restores it to the status at the time of the last hot sync. Some program settings are lost during a hard reset. The student is required to reset these programs or settings. After any reset, Rubberneck (see below) needed to be restarted to log the Palm operations. Additionally the number of minutes before the Palm became inactive from nonuse needed to be reset.

Rubberneck: Rubberneck is a program created by HI-CE to create a log of the time and date when each program is started and stopped.

Sketchy: A graphics animation program created by HI-CE for the Palm operating system.

Stylus: A pencil-like implement with a blunt end used to navigate and input data on the touch-sensitive handheld screen.

Synchronization cradles: A device in which the handheld is inserted which allows data to be transferred between a desktop and handheld computer.

Research Questions

An extensive body of formal research is lacking concerning how students use the handheld computer in the classroom and how this use might affect the gathering and use of information. This study was designed to investigate the following research questions:

- Are there differences in information gathering and use with the Palm between gifted, dyslexic, and regular learners?
- What relevance criteria do students use to evaluate a web site to determine whether to download the site to the Palm and afterwards whether to use the downloaded site's information in the report?
- How do the Palms affect the writing process?
- Do the animations and concept maps produced on the Palm demonstrate understanding of the intended concepts?
- Are there significant differences in results (i.e., final products grade) between Palm users and non-Palm users?

These questions were explored in a contained classroom over a three week period. Observations of each phase of the research project included the information gathering phase, the writing and editing phase, the supplemental activity phase, and the final presentation phase. The initial phase looked at the effect of the handheld computer on information gathering. In this study, information was narrowly defined as facts and figures about the inventors and inventions assigned to the students. Information gathering was explored at one point, the choice of whether to download a Web site into the handheld after the site had been located on a desktop computer. The information

gathering in this situation was task driven. Students were attempting to find facts on certain topics of information about their chosen inventor. To answer research question 2, the researcher observes and questioned students on how they decided to download Web sites to their handheld.

During the writing and editing phase of the project, explorations focused on the use of paper versus the handheld, how the peer review process proceeded, and how the class formatted their papers on the desktop computer. After the papers were written, they were compared to papers from a class that didn't use handhelds to writing their reports.

Finally, students were observed and questioned about the creation of products using two software programs. This study examined if the animations created on Sketchy and the concept maps created on PicoMap enhanced the learning situation.

Significance of the Study

Computer technology affects everyone's life in the United States. It is a reality that schools are finding it difficult to implement and maintain a comprehensive and modern technological environment for their students. One possibility is to supplement more expensive desktop computers with handheld computers. A recent report on the Palm Education Pioneer program found handhelds can be used effectively in grades 2-12 (Crawford, Vahey, Lewis, & Toyama, 2002). In that study, teachers felt handheld computers were an effective instructional tool. Handheld computers are portable so they can be used in and out of the classroom for a variety of purposes. The teachers in the Palm Education Pioneer program indicated "handheld technology confers a range of benefits on instruction, including improving the quality of instructional activities,

promoting students' autonomous learning, enhancing students' communication and collaboration, improving students' organizational skills, and enhancing students' motivation."(Crawford et al., 2002, p. 40)

Schools are looking for a ready solution to the problem of technology access. Systematic investigation of how students are using handheld computers in an educational setting will allow school officials to make research-based decisions. Understanding the complex interactions and behaviors of information gathering and use with handheld computers may inform the design of better systems.

This study looked at a diverse population of fifth grade students using handheld computers for a class assignment. Direct quotes, observation reports, and analysis of survey questions create a rich, thick description of how different learners used the handheld. The literature base is lacking in valid research looking at handhelds in the classroom. Most of the reports describe classroom situations using the handheld, without addressing any of the issues addressed in this research study. This study explores issues that have not been extensively studied, such as differences between gifted, dyslexic, and regular learners and how handheld computers affect the writing process.

Limitations of the Study

There are several limitations to this study. The project ended a week before school was out for the year. It may have been hard for the students to focus on the project when their hearts and heads had already moved on to middle school. Behavior problems are rampant at this time of year and it is sometimes difficult to motivate the students to concentrate on their school work.

Additionally, the students had been given the Palm just two weeks before the study began. If the students had had more time to adjust to the Palms, their behavior might have been different. One might expect novice users to exhibit different behavior and attitudes than an experienced user. The duration of the project could create other limitations. The project about inventors only lasted three weeks and from the onset of Palm usage to the final presentation was only five weeks. In Robertson, Calder, and Fung's study (Roberston, Calder, & Fung, 1997), the frequency of use was reported at the end of five weeks and at the end of the school year. All students except one were using a handheld computer either very frequently or frequently at the end of the first five weeks. However by the end of the project there was a drop in the use of the handheld for school-related activities. The novelty effect of new "toys" was still very much in evidence throughout this study.

It was hard to build rapport with some of the students in that amount of time. Some of the students quickly adapted to the presence of the researcher, but others were still hesitant to answer questions or volunteer information. The project also moved very quickly from one aspect of the project to the next. The students progressed from choosing an inventor, to writing a thesis statement, to rough draft to final copy, to presentation within a three-week time period, making it difficult to follow each student's progress through the research project. It was especially difficult in this situation where several students were in the computer lab, several in the library, and others remaining in the classroom during several of the research periods.

The Hawthorne effect also could also come into play. The Hawthorne effect refers to a study at the Hawthorne plant of the Western Electric Company in Chicago

Illinois (Mayo, 1933). The study found the presence of the researchers affected the behavior of the workers being studied. The term now refers to any impact of the research on the subject of study. The students were always aware of being observed. The amount of intense observation and note taking was minimized by reliance on the log analysis of Palm usage to determine which programs the students were using and when the programs were being used.

The literature review that follows explores how limited and exploratory the research base on handheld computer has been. The findings of this literature review will then justify the direction of a narrower and more formal research project to uncover the effect of handhelds on the gathering and use of information. Data are needed to determine the effectiveness of using the handheld in the classroom. As a consequence of these findings in the literature review, a need for more research in this field exists before continuing to spend time, money, and other resources in purchasing computers for schools. This research project will generate data that will help us understand the ability of handheld technology to be an effective tool for teaching and learning.

CHAPTER 2

LITERATURE REVIEW

The computer is predicted to become a "powerful educational tool that can be used to facilitate, stimulate, and consolidate learning" (Fung, Hennessy, & O'Shea, 1998, pg. 109). Even though the presence of computers in schools has grown tremendously over the last ten years, the impact on teaching and learning has been minimal (Inkpen, 1999). One factor that might limit the impact on teaching and learning is limited access to computers in schools. According to the study by the Software & Information Industry Association (Meeker, Kellogg, Politoski, & Schneiderman, 2002), 94% of all schools have access to Internet and 93% of students use the Internet, however these data don't reflect the actual access and use of the computers and the Internet. Even though these data demonstrate almost all the schools are connected to the Internet, student access to the Internet and even non-networked computers is still limited. Market Data Retrieval's study (2002) reports a 3.8 to 1 ratio of students per instructional computer and only a 4.9 to 1 ratio for networked computers. On average, almost five students share every computer connected to the Internet and six students share every multimedia computer.

Computers in schools are typically either distributed throughout the classrooms or placed in a central location such as a computer lab. When the computers are placed in the classroom, it often means there are only one or two computers per classroom.

Norris, Sullivan, and Soloway (2002) found 60% of teachers have less than two computers in their classrooms. In the computer lab setup, larger numbers of computers are available, but this still does not guarantee a computer for every child. Additionally, 65% of teachers have limited access to a computer lab. Limited access is defined as once a week or less. The amount of time each child actually gets to use the computer is quite small. In this same survey of 10,000 teachers, 42% of the teachers report their students use computers less than 15 minutes per week and 65% of the teachers report their students use the Internet less than 15 minutes per week.

Differences between Handheld and Desktop Computers

One method of increasing access to computing devices is to provide students with cheaper devices such as handheld computers. As early as 1998, Fung, Hennessy, and O'Shea (1998) predicted a growing shift away from conventional desktop computers to smaller more personal machines. While handhelds can't replace desktop computers at this time, they do supplement them and extend the use of desktop computers for other instructional uses. Robert F. Tinker, the director of the Concord Consortium, a nonprofit group in Massachusetts that studies and develops applications of new technologies for education, calls handheld computers the "equity computer, a computer that you can afford to give every child." (Trotter, 1999, para. 4)

According to Pownell and Bailey (2000), four characteristics, portability, accessibility, mobility, and adaptability, distinguish the handheld computer from the desktop computer. Portability is based on the physical characteristic of size. Handhelds are easy to carry around. Students can take handhelds wherever learning takes place, whether in the classroom, in the field, or at home. "Getting the Palms® (Palm, Inc.) to

complement classroom computers makes a lot of sense to me, if you take advantage of the portability," said Christopher J. Dede, a professor of education and information technology at George Mason University in Fairfax, Va. "It doesn't make any sense to substitute Palms for laptops or desktops" (Trotter, 1999, Complementary Uses, para. 4).

Accessibility is another area of comparison between laptops and handhelds. Handhelds are considerably less expensive to purchase and maintain than laptops (Belanger, 2000; D'Orio, 2000; Staudt, 2000). D'Orio (2000), as well as numerous others (Ray, McFadden, Patterson, & Wright, 2001; Soloway et al., 2001; Vahey & Crawford, 2002), believes handhelds are one solution to providing access to growing student populations. Handhelds don't require expensive modification of the school's electrical system or cabling when classrooms add their use to the current infrastructure.

Mobility refers to the ability of the user to access the handheld wherever they are and not be tied to the desktop. Information can be accessed and retrieved anywhere, anytime, including outside, whether at school or on fieldtrips (Hsi & Manus, not dated; Soloway, 2000). The possibility of data collection, analysis, and reporting in the field is an important feature for teaching and learning.

The final characteristic is adaptability, the ability to change behavior because of the technology. The handheld has the ability to extend the person's information environment. Collaboration and sharing of information and software is enhanced by handhelds. According to Soloway, Becker, Norris, and Topps (2000), this sharing and commenting on other's work leads to an increase in the quality of finished products, such as reports and presentations.

The differences in desktop and handheld computers make them complementary. Some things are difficult to do on the handheld, so access to desktop computers is important. For example, handhelds have limited value for large word-processing or multimedia projects. Inputting and formatting large projects are time consuming and difficult with handhelds. Some believe attempting to use a handheld as the primary computing tool could result in frustration and inefficiency in both time and effort (Rainger, 2002). In order for a handheld to be used to its full potential, the user must have access to a desktop or laptop computer.

One-to-one Ratio

Even though access to a desktop or laptop computer is necessary, one of the most important benefits of handhelds is their ability to provide a one-to-one computer-student ratio. This ratio is believed by many to be necessary for true technological innovation in education (Brown, 2001). Computer labs or a limited number of computers in the classroom offer limited access to students; handhelds can improve access. According to Darrell Walery, Director of Technology for Consolidated High School District 230 in Orland Park, Illinois, "In education, we're wrestling with the student-to-computer ratio. We expect students to use computers only when they sit in a computer lab. This is not a very real experience ... whereas, the Palm gives the students the ability to use the computer any time an idea pops into their heads." (Batista, 2001, p2, para. 11)

Staudt's study (1999) indicated how important a one-to-one ratio is. In his study, pairs of second-grade students shared one handheld computer. By the second lesson, the team member who was not holding the handheld showed signs of boredom and

some even wandered away until it was their time to hold the Palm. The researcher postulated each student needed their own handheld to be engaged and to have a sense of ownership. To test this theory, Staudt gave each student a handheld and it appeared the students were more actively engaged when they had access to their individual handheld.

Handhelds in the Classroom

Teachers find handhelds beneficial for classroom management and believe handhelds can be integral to instruction (Ray et al., 2001). In one handheld project, 95.6% of the teachers indicated they believed handheld computers were effective instructional tools for teachers and 93% stated the use of handheld computers contributed positively to the quality of the learning activities their students completed during the project (Crawford et al., 2002).

The pilot study by the National Council for Educational Technology (NCET), "Portable Computers in Schools", is a large-scale research project of portable devices in the classroom (Hennessy, Fung, & Scanlon, 1999). In that study, over 6,000 machines including handheld computers and graphing calculators were distributed in 250 schools. Collectively, the research indicated the main benefits of portables are: increased pupil motivation, improved attitudes, greater productivity and better quality of work produced by pupils, and more time and opportunities for independent, investigative learning across the curriculum. Hennessy, Fung, and Scanlon predicted the increasing use of portable computing could create an opportunity for an exciting new learning culture.

Handhelds are being used for many purposes in classrooms. In suburban Chicago, 3,000 students studied fitness and nutrition, science, and language arts with

the help of handhelds (Patterson, 2001). In another part of Illinois, high school students used handhelds with thermometers and probe attachments for collecting data for science classes. (Batista, 2001)

Some handheld projects are used for authentic problem solving. In Maine, middle school students collected water pollution data for the community to use in making water use decisions (Wood, 2002). Using Palm handhelds equipped with GPS locators and temperature gauges, the students gathered real-time water-temperature data from precise locations around the city. Ruth MacLean, the students' teacher, said "We're the first to get the city data from these stream sites, and the kids are thrilled that our data will be part of a real decision-making process. (para. 3)" This project allowed the students to learn how to solve real problems using available technology and the city got the needed data at no cost.

One math teacher used handhelds for formative assessments throughout the semester. The quizzes were instantly graded, the students got instant feedback, and the teacher could see how individual students and the class as a whole scored. She said the quizzes were being done before, but with the handheld devices, the students got instant feedback and were motivated to do better and improve their scores, just like in a video game (Hudgins, 2002).

Teachers are even using handheld devices to teach musical literacy (Bogue, 2002). In Bogue report, students composed simple melodies using Palms, tone modules, software, and MIDI adapters.

One study in the United Kingdom looked at the influence of handheld computers on reading course materials (Waycott, 2002). They found the use of handheld

computers had a number of impacts. The small screen size made skimming more difficult and required greater concentration. Strategies for highlighting text had to be modified. Being able to access learning resources any time anywhere influenced reading behavior. They found data input methods were slow and awkward. Navigating through the documents was difficult. Waycott concluded using the handhelds did influence the activity of reading course materials due to the portability of the information, the ability to cut and paste the electronic material, and the difficulty in skimming.

Teachers are also using handhelds for their professional work. In a study in southeastern United States, six middle school teachers were asked how handhelds enhanced teaching and assessment (Ray et al., 2001). These teachers reported they benefited from instant access to records and other information such as parent contact information.

Benefits of Ubiquitous Access

Several studies have explored the benefits of providing students with ubiquitous access through the use of portable computers, either laptop or handheld. Benefits range from increased motivation to student achievement (Rockman et al, 2000a; Stager, 1995). The laptop program sponsored by Microsoft and Toshiba, Anytime Anywhere Learning, reported better access to technology could have a positive impact on learning and teaching styles (Rockman et al, 2000a). Each student in the program had access to a laptop computer at home and at school and their teachers received training on how to integrate technology into the classroom. The teachers reported access to laptop improved student writing. In support of that finding, the laptop students outscored their non-laptop peers in independently scored writing assessment tests.

Other studies have also demonstrated increased student achievement in various disciplines when students have ubiquitous access to computers. Lowther, Ross, and Morrison (2001) reported students using laptops (Hennessy, 1999) appeared much more fluent than other students when using current technology for learning, research, and production. Writing achievement seemed to be positively affected by access to laptops. Students using laptops to write a prompted essay were compared with a control group on several dimensions, such as organization, idea, style, and conventions. On each dimension, performance by the students using laptops was higher than the control group. For the students using laptops in this study, the researchers reported computers were fully integrated with and a natural part of the students' educational experiences both at school and at home. Additionally, the teachers felt use of the laptops had resulted in students having greater research skills, improved writing skills, increased interest in school, and greater self-confidence.

Findings in a study with secondary students indicated students learned more in a high school anatomy and physiology class when they had access to laptop computers, were exposed to multimedia software, and created projects with presentation software. The research demonstrated laptop computers with accompanying software had a favorable effect on students' achievement scores (Siegle & Foster, 2000).

In addition to increasing their skills, access to handheld or laptop computers can increase motivation and improve attitudes. Several studies have found the use of handhelds motivational for students (Vincent, 2002; Staudt, 1999). Hennessy, Fung, and Scanlon's (1999) research indicated students were enthusiastic about handheld computers. One study, looking at the use of the Palm with second grade students,

reported the students were immediately engaged with the applications available on the Palm (Staudt, 1999).

Students using laptops were more active, autonomous, and collaborative in their classroom behaviors in a study by Lowther, Ross, and Morrison (2001). For example, cooperative learning was observed “frequently” or “extensively” in 35% of the laptop classes, but only 11% of the control classes. Students frequently or extensively engaged in projects in 55% of the laptop classes compared to only 17% of the control classes. Teachers whose students used laptops confirmed these impressions by describing their students as more independent, active, and engaged. The teachers were impressed with students’ abilities and interests in using computers to enhance learning.

Overall the students with laptops expressed better attitudes towards computers. Students reported using computers increased pride in their work and motivated them to work longer and harder (Rockman et al, 2000a). They believed computers "helped them improve the quality of their schoolwork, made their schoolwork easier to do, made it more fun and/or interesting, and helped them understand their classes better" (Rockman et al, 2000b). Rockman et al reported there was only one attitudinal question on which the students who didn't use the laptops scored higher. The comparison group enjoyed playing games on the computer more than the students with laptops did. However, Fung (1998) found using handhelds caused little change in the belief computers were enjoyable or exciting to use.

Another study looked closely at the change in attitudes of users before and after using handheld computers (Fung et al., 1998). The greatest change in attitude was the decrease in the belief computers were difficult to use. This supports other studies

reporting using handhelds in the classroom can increase confidence in using technology (Hennessy, Fung, & Scanlon, 2001; Lowther et al., 2001).

Benefits of Handhelds

As mentioned previously, handhelds are an effective way to give students ubiquitous access. There are several reasons handhelds are beneficial for use in schools. The teachers in the Palm Education Pioneers Programs (Crawford et al., 2002) cited portability and ease of access, the integration of computing into a wide variety of educational activities, promoting autonomous learning and student organization, promoting student motivation, promoting student collaboration and communication (using infrared beaming), and supporting inquiry-based instructional activities as the most important benefits of handhelds.

The students in Hennessy's study (1999) ranked the perceived benefits of handheld computers to facilitate learning in the following order:

- Flexibility and use outside classroom
- Personal ownership
- Prefer typing to handwriting
- No domination of machines
- Independent working
- Greater computer access
- More interesting than desktop machines

In Fung, Hennessy, and O'Shea pilot study (1998), the students commented on several advantages of the handhelds. They thought the handhelds provided a motivational stimulus, making it easier to produce improved written work. They liked the advantages

of ease of storage and portability and being readily available at all times. They felt the handhelds had increased their knowledge of computers and the handhelds offered a range of useful functions.

Cooperation

Several studies indicate improved cooperation among students when using handhelds. Vincent (2002) observed students who had similar technical problems often collaborated to solve the problem. Hennessy, Fung, and Scanlon (2001) observed the natural tendency of students using handheld devices to cooperate with each other stimulated productive discussion.

When Staudt (1999) compared second and fifth graders' cooperation when using handheld computers, she found the second graders moved out of their pairs to cooperate with the larger group at the beginning. Second grade students spontaneously shared with others their methods of getting from one application to the next. However, the fifth graders in the same study only shared their discoveries with their team members at the beginning of the experiment, not sharing with the larger group. As the experiment progressed, the teams shared data to come to a group understanding.

Cost and Power

Handheld computers are becoming more powerful and less expensive. Handheld computers are quickly evolving to do more at even less cost. The handhelds in 2000 were similar in computing power to a Mac from 1988 and run on a few AAA batteries (Bannasch, 2000). But unlike calculators, which are limited to very specific functions, handheld computers are adaptable to many applications. Handhelds allow a much wider

distribution of computing resources using limited funds, allowing more students and teachers to be equipped with their own computing tools. As Norris and Soloway point out, any limit to the computing power of the handheld will be minimized by the support of the school network (Norris & Soloway, 2002).

Size and Portability

Because handheld computers are small, lightweight, and can run on batteries, they can be used anywhere inside or outside the school. Additionally, they consume little desk space on pupils' desks. Whether in a classroom or a computer lab, the wires and cables force desktop computers into a more or less permanent configuration. Handhelds, like other portable devices such as wireless laptops, allow groups of students to face each other, form a semicircle, or to create any other seating arrangement as needed. This simple portability gives students and teachers many more options in when, where, and how they do their work.

As part of the research of the Center for Innovative Learning Technologies Ubiquitous Computing Project, several studies have examined the grade-appropriate use of handheld computers with K-6 students. A pilot study in 1999 examined the use of Palm handhelds with second and fifth graders in Massachusetts (Staudt, 1999). The second graders in the study used handheld computers with an attached temperature probe. They worked in pairs to develop questions and design procedures to gather data on the Palm. The handheld's probe allowed real time measurement of temperature as it changed, a procedure also possible with a desktop computer. However, due to the size and portability of the handheld, the student scientists secured their real time measurements in the field creating a more authentic environment for the experiments.

The handhelds allowed the students to connect questions and theories to the data while in the field. The handheld computers allowed the second graders to "engage in active, creative and reflective investigation of the environment" (Staudt, 1999, Student investigations, para. 1).

Ease of Use

Research indicates handhelds are easy to use. Hennessy's (1999) research indicates students learn to use handhelds quickly and easily with minimal instruction. One fifth grade class quickly became "experts" and even created small movies to demonstrate different applications (Vincent, 2002).

Handhelds take seconds to boot up (instant on), and save any work upon exiting a program or turning off the handheld. They even continue where students left off the next time they are switched on. They have a very long battery life, extending to a full school day of use, and they can then be charged up during the night. Files can be easily shared between handhelds for peer review and printing using the infrared ports (British Educational Communications and Technology Agency, 2001).

Limitation of Handhelds

Handheld computers have great potential for helping students gather and use information. However, like all technologies, there are limitations. These concerns range from technical problems to cheating. The teachers in the Palm Education Pioneers Programs (Crawford et al., 2002) cited damage to the handheld devices (especially the screen), problems with synchronization, and some inappropriate use (such as game playing and off-task beaming) as the most troublesome of problems.

Problems can occur when teachers use the handhelds for professional work or when they attempt to integrate them into teaching and learning. Pownell and Bailey (2000) suggest the main limitations of the handhelds for adults are small screen size and inefficient data input methods when they are being used. The main barrier to the use of handhelds for professional work by teachers in Ray, McFadden, Patterson, and Wright's study (2001) was limited time to learn how to merge the use of the handheld with the desktop computer, including, but not limited to, syncing the handheld.

Cost

Even though the cost of handhelds is much less than laptops or desktops, the expense of purchasing hardware, software, and training may still limit the use of handhelds in an educational setting. Purchasing issues include cost for hardware and software, durability, replacement cycle, and warranties. The initial cost of handhelds is substantially cheaper than desktops or laptops, but cost is an issue when attempting to put a handheld in every student's hand. Because handhelds are not replacements for desktop computers, but must be supported by desktops, there will be the recurring expense for purchasing and maintaining desktop computers (Pownell & Bailey, 2000). Additionally, there are peripherals, such as keyboards, which make the handheld more expensive, but also makes the device more useable. Software is another expense that must be considered. Some educational software is available free of charge such as the suite of programs available from HI-CE (Center for Highly Interactive Computing in Education), but other programs have fees and licenses.

The cost of replacement batteries is another concern for educational users. While the batteries have long life and can be recharged, costs for replacement may be prohibitively high.

There is a compatibility problem resulting from the lack of an industry standard for handheld operating systems. Applications are usually written to either be compatible with a Windows or Macintosh desktop system.

Damage and Loss

Loss and damage to the equipment is often sited as potential problems in implementing a handheld project. Because handhelds are so small, administrators fear they will be easy to lose. Even in laptop programs, there is general concern about keeping track of the laptop (Lowther et al., 2001). In Orland Park, Illinois, 2,200 Palm IIIxe handhelds were used in three high schools and less than 10 were stolen or lost (Batista, 2001).

Durability is an important concern for educational users. Handhelds were designed for adult use and may not be sturdy enough for student use. Several studies report breakage during projects (Ray et al., 2001). In the Illinois project mentioned above, most of the damage was attributed to the glass screen, which has been replaced with plastic in newer models (Batista, 2001). Other projects report very little breakage.

Inappropriate Use

Inappropriate behavior, such as cheating, is another concern. Answers can easily be beamed from student to student. Off-task behavior is another problem. Because the

handhelds are an attractive nuisance, it is a temptation to "play" with the handheld, instead of working.

One school banned handheld computers completely because a student was caught controlling the TV in the back of the room (Batista, 2001). In fact International Communication Research found 23 percent of teenagers say they are forbidden to bring handhelds to school (Batista, 2001).

However, many students don't think the games on current handhelds are very interesting. One student in Michigan reports, "I sort of think playing a game on a Palm is kind of a waste of time. They don't have good graphics, and they're not really exciting games. If you are playing a game in class you must really be bored and want to try something new" (Batista, 2001, p. 2, last para.)

Dyslexia

The word 'dyslexia' comes from the Greek and means 'difficulty with words.' In 1968 the World Federation of Neurologists referred to dyslexia as “a disorder in children who, despite conventional classroom experience, fail to attain the language skills of reading, writing, and spelling commensurate with their intellectual abilities (Price, 1994, p. 4).” The Texas Education Agency (TEA) (1998) defines dyslexia as “a disorder of constitutional origin manifested by a difficulty in learning to read, write, or spell, despite conventional instruction, adequate intelligence, and sociocultural opportunity.” Dyslexia is the most common type of learning disabilities with 5-10 percent of the population affected (Roongpraiwan, Ruangdaraganon, Visudhiphan, & Santikul, 2002). Dyslexia causes difficulties in learning to read, write and spell. Other skills, such as short-term memory, mathematics, concentration, and sequencing may also be affected. Dyslexia

varies in degree and from person to person. Dyslexic people often have distinctive talents as well as typical clusters of difficulties.

TEA (1998) lists the following characteristics associated with dyslexia:

- Difficulty with the development of phonological awareness and phonological processing skills;
- Difficulty accurately decoding nonsense or unfamiliar words;
- Difficulty reading single words in isolation;
- Inaccurate and labored oral reading;
- Lack of reading fluency;
- Variable degrees of difficulty with reading comprehension;
- Variable degrees of difficulty learning the names of letters and their associated sounds;
- Difficulty with learning to spell;
- Difficulty in word finding and rapid naming;
- Variable difficulty with aspects of written composition;
- Difficulty with learning and reproducing the alphabet in correct sequence; and
- Family history of similar problems.

Brain imaging techniques show that dyslexic people process language-based information differently. Dyslexic readers don't use the same area of the brain that is normally used in language processing, but rather use areas for visuospatial processing (Backes et al., 2002).

Bennett and Sally Shaywitz (1995) report an equal number of boys and girls are dyslexic however, the Mayo Clinic study (Katusic, Colligan, Barbaresi, Schaid, & Jacobsen, 2001) refuted their evidence and suggested a much larger percentage of boys are dyslexic. In the Mayo Clinic study, boys were 2 to 3 times more likely to be affected by dyslexia than girls. Functional MRI scanning has shown girls use two areas for phonological processing, whereas boys only use one area in the left hemisphere (Shaywitz, 1996). Brooks (1997) hypothesized that girls have a greater chance to compensate for damage in one area because the other area's back up function. In this study, there were 4 females and 2 males who had been diagnosed with dyslexia.

There is evidence that instructional intervention can minimize the effects of dyslexia (Mathes & Denton, 2002). TEA (1998) requires the school district to provide students diagnosed with dyslexia an appropriate instructional program in a remedial class setting on the student's campus. The instructional strategies of the program must utilize "individualized, intensive, multi-sensory methods contain[ing] writing and spelling components (p. 15)." TEA allows students to use a computer to take the written section of the TAAS/TAKS test, but they may not use the computer's spell check feature or save the document.

There is some evidence supporting the use of technology to ameliorate the effects of dyslexia. In Price's study (1994) evaluating the effectiveness of portable computers with students having dyslexia, the students improved substantially in their note taking skills, attitudes toward work, attitudes toward spelling, writing skills, and keyboarding skills. Using features of word processors, i.e. cut and paste, enabled the dyslexic students to concentrate on concepts instead of the mechanical process of

writing. Editing on the computer was much simpler. When the dyslexic students copied a draft by hand, the second copy might have more spelling and grammatical errors than the original. However the computer facilitates the editing process allowing time for the student to consider structure and vocabulary. Word processing allows the student to pay attention to editing and higher order skills, allowing the students to compete with their peers on a more equal basis.

Oakland, Black, Stanford, Nussbaum, and Balise (1998) and Broughton (1994) suggest multi-sensory presentations for teaching students with dyslexia. Using nonlanguage mental representations, such as the images produced on the Sketchy, may help students learn verbal information. Another way computers could assist students with dyslexia is by teaching kinetically. In Price's study (1994) the students reported remembering how it felt to type a word. This kinesthetic knowledge allowed the students to type the letters in the right order. Multi-sensory presentations applied across the curriculum can benefit the whole class, not just the dyslexic students (Townend, Not dated).

Handhelds and Dyslexia

There are several aspects of the handheld computers that might make them difficult to use for student with dyslexia. Rainger (2002) listed several features that might hinder accessibility. The first problem was the screen. High-resolution screens which only have a few background and font choices available caused problems for students with dyslexia. Monochrome backgrounds providing insufficient contrast made it hard to read the screen. The physical layout of the handheld may also have caused problems. Layout of hardware buttons and fixed onscreen buttons that are not intuitive may make

handhelds harder to use for students with dyslexia. Not only the layout, but also symbols and icons that are difficult to interpret create hardship for the students using the handhelds. Simple graphical navigational aids with clear menu structures would increase usability for these students.

Graffiti can also be difficult for those students with dyslexia. One example that might lead to problems is the letter T, which is drawn like an upside-down L. Other letters are only distinguished by a tail, for example G and C. In one case study of a college student with dyslexia, the student preferred keyboard input. He found graffiti very hard (Rainger, 2002).

Other Issues

Russell and Plati (2002) investigated whether the medium students used to compose test-like passages made a difference. They compared passages written on paper, an AlphaSmart (a portable word processing device), and a computer on five categories, topic development, English standards, total score, passage length, and words per minute. None of the differences between composing on paper and AlphaSmarts were statistically significant. However, when the mid-term grades were controlled for the differences in topic development, total scores between composing on paper and computer were statistically significant. Even though the students working on computers had access to a spell-check program, their English standards score were not significantly higher.

CHAPTER 3

RESEARCH DESIGN AND METHODS

Chapter 3 describes the research design and methods used in this study, followed by an elucidation of the population selection and methods of data collection and analysis. Efforts to ensure trustworthiness are then discussed.

Rationale for the Method

Accurately describing the nature of the student's use of handhelds is problematic due to the complex nature of the phenomenon. A valid description and interpretation of information-usage activity of fifth grade students using handheld computers as part of their normal educational experience was the desired end product of this study contributing to an understanding of this activity. Several researchers and authors have suggested using constructive, phenomenological, and naturalistic investigations to provide the rich, context-specific information necessary to understanding the effectiveness of these devices (Bednar, Cunningham, Duffy, & Perry, 1991; Boland & Holland., 1985; Neuman, 1989). In order to provide a fine-grained analysis of the students' information gathering and use behaviors, a mixed method study was chosen to generate rich, descriptive data lending support and context to the quantitative data provided by surveys and log analysis.

The goal of this research was the exploration and characterization of fifth grade students' use of Palm® (Palm, Inc.) handhelds during information gathering and use. The selection of data collection methods was based on the nature of the problem. The

exploratory, descriptive nature of this study lent itself to field research. Babbie (1997) claimed that one of the key strengths of field research is the comprehensiveness of perspective it provides. During the research project, the students were observed and interviewed, and they reported on their actions at the end of the day. In addition, the documents they created for the project were analyzed. The documents examined were the thesis statement, rough draft, and final paper. Also, journal entries assigned to the class on the use of the Palm during the project were examined. A Palm program called Rubberneck recorded the use of the Palm and time and date when applications were opened. The triangulation of multiple data sources and data collection techniques strengthened the transferability of the findings (Marshall & Rossman, 1989).

The research was exploratory and inductive in nature. Little previous research exists on the use of the handheld computers for information gathering. The inductive process was used to build theoretical constructs instead of testing theory.

Analysis occurred throughout all phases of the research using the constant comparative method originally developed by Glaser and Strauss (1967).

Selection of the Respondents

The overall goal of the research to explore information use while using handheld computers guided the selection of the population. Data were obtained from one class using the Palm handheld in a research project. The single class created a bounded unit.

Several prerequisites directed the selection of the population to be studied. One prerequisite for the study was a group of students engaged in a learning assignment employing the gathering and use of information while using the Palm handheld computer. Each of the stakeholders would have to agree to the research. The school

principal, teacher, and students would have to accept the researcher's presence in the classroom for extended periods during the study. The teacher and students must agree to participate in ongoing interviews and complete daily questionnaires during their work and after the project was completed.

The class was selected for the study using purposeful sampling. Purposeful sampling is the technique of choosing informants or cases that yield the most data for the purpose of the study. Patton (1990) argues that "the logic and power of purposeful sampling lies in selecting *information-rich cases* for study in depth. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the research, thus the term *purposeful* sampling" (p. 169, emphasis in original). The criteria used for selecting the respondents should directly reflect the purpose of the study and guide the identification of information rich cases (Merriam, 1998). The population under study was a single class. Mrs. V's fifth grade class included 24 students (10-12 years old) in their last year of elementary school. The class that was chosen was a particularly rich source of information due to the diversity of the students. In qualitative studies, the sample size is typically small.

The goal in purposeful sampling is to select cases that are information-rich with respect to the study. The class under study was mixed gender, with 14 boys and 10 girls. There was ethnic diversity in the class, 13 white, 6 Asian/Pacific Islander, 2 Hispanic, and 3 African Americans. Also, there were several levels of learning ability. There were 4 gifted students (TAG), 14 regular students, and 6 students diagnosed with dyslexia. Mrs. V. was certified to teach students with special needs, so students with dyslexia in the fifth grade at this school were clustered in her classroom. There was one

student with juvenile arthritis, who had problems with extended use of writing implements.

The University of North Texas Institutional Review Board granted permission to conduct this study. See Appendix A for a copy of the approved consent letter that was signed by all parents and the assent letter signed by all students. The steps to assure confidentiality was maintained were explained to parents, students, and the teacher. Pseudonyms are used for the purpose of confidentiality.

Procedure

The study took place between April 9 and May 17, 2002. The following timeline shows the progression of the study:

April 9, 2002 - Parent Meeting

April 10, 2002 - Student meeting and distribution of the Palms to the students

April 10-April 25 - Students practiced with the Palms

April 24 - Pre-survey administered

April 25, 2002 - The assignment for the research project about inventors was given to the students

May 1, 2002 - Thesis statement due

May 10, 2002 - Rough draft due

May 15, 2002 - Final copy due

May 17, 2002 - Presentations

Gaining Entry

Mrs. V. was contacted to ascertain her interest in participating in a research study using Palm handhelds in her fifth grade classroom. Mrs. V. and her class were

identified as a possible population for the study due to a previous acquaintance with the researcher's advisor. When the project was explained to her, Mrs. V. expressed a high level of enthusiasm and willingness to participate in the project. Mrs. V. established initial approval with the school principal, who wrote a letter approving the project and expressing her support for the research.

Initial Contact with Parents and Students

Mrs. V. assisted in contacting her class parents to arrange a meeting to inform them of the study. The parents were contacted by a letter sent home with the students inviting them to participate in an informational meeting about the research study (Appendix B). At the meeting, the methods and goals of the study were explained and questions were answered. Each parent was given a copy of the consent form (Appendix A) and a sheet explaining each of the Palm software programs that would be used in the study. The teacher gave a short demonstration of each Palm program. The principal of the school and the teacher of the class were present to answer any questions about approval of the study and to demonstrate their support for the study. Nine parents came to the meeting and all of them agreed their child could participate in the research study and signed the letter of consent. A second letter (Appendix B) fully outlining the intent and method of the study was sent home to the other parents. Each parent agreed to allow their child to participate in the study.

A student meeting was held during the school day to explain the research project to the students. The goals and methods of the projects were explained along with their right to drop out of the study at any time or to refuse to answer any question without any

repercussions. All of the 25 students assented to participate in the study by signing the assent form. An example of the assent form is in Appendix A.

The Study

The inventors project took place over 14 sessions of 2 hours each, over a period of three weeks. The aim of the study was to observe the use of the Palm in gathering and use of information during the student's research project. The students worked individually on each aspect of the project except for some collaboration during the peer editing process. For the study, each student was given a Palm IIIc handheld for his or her personal use. During the initial phase of the project while the students were becoming accustomed to the Palm, the students could not take them home. However, during the inventors research project, the Palms and full size keyboards could be taken home at the students' discretion. Each student was given a padded envelope, which they decorated according to their own taste, to protect the Palm. Each student had access to a full-sized keyboard, which the could use. The keyboard was connected to the Palm by a Happy Hacker® cradle. Both the cradle and the keyboard could be used in school and at home.

The students had access to another type of cradle. The synchronization cradle connected the Palm handheld to the desktop computer. That cradle could be used to upload documents to the desktop computer, including the Rubberneck report that tracks the use of the Palm and its programs. Students were not allowed to take the synchronization cradles home. This resulted in the inability to download other software including games or web sites from desktop computers onto the Palm at home. Also the student could not use the Palm to transport the work in progress home and then use a

desktop computer to work on the report. The available synchronization cradles were distributed between Mrs. V's classroom and the computer lab. Software was loaded onto the Palms before they were distributed to the students. A description of the software loaded onto the Palms is given later in this paper.

This research project focused on the use of Palms during the final research report of the year. The students had been introduced to the writing of research papers during the same school year. Three previous research papers had been completed during the year. The Palm was integrated into the regular end of the year curriculum. Besides the research project on inventors, the class used the Palm for spelling assignments, reading the final novel of the year on the Palm, and the completion of math worksheets. The assignment about inventors, shown in Appendix C, required the students to produce a 2 1/2-page paper with a bibliography. The project required five sources, including at least two print sources. Other papers written during the year had required two print sources, so the teacher and the researcher agreed the final paper would also have that requirement. The students could use books brought into the classroom by Mrs. V. or found in the library, they could take notes from Web sites on the desktop computer, or they could use the Web sites downloaded into their Palm. Students were encouraged to use the Palms, but were allowed to use paper whenever they wanted.

In addition to the paper, a concept map and an animated drawing of the invention, both created on the Palm, were required. Concept maps represent the conceptual structure of a topic showing meaningful relationships between concepts in the form of propositions. Propositions are two concept nodes linked by labeled lines

which provide information on relationships or describing connections between concepts. The type of concept maps created for this project, PicoMaps, are limited to concepts describable with a limited number of letters or numbers. The requirement for the PicoMap in this project was a minimum of ten nodes.

At the end of the research project, each student gave an oral presentation with a demonstration of their animation to the class.

At the beginning of the project, April 25, 2002, the students were presented with a list of inventors (shown in Appendix C) from the period the class had been studying in Social Studies. Many of the inventors on the list were relatively unknown, but the students had overnight to choose which inventor they wanted to study, allowing enough to time to find out what each inventor accomplished. The next day they brought back the list of inventors with their three top choices indicated. Most of the students were assigned one of their favorites. One boy decided he wanted to choose an inventor who was not on list and wasn't from the time period, Leonardo Da Vinci, and the teacher approved his choice. After a few days of research, another boy wanted to change inventors because he couldn't find enough information on the inventor assigned to him. His original inventor was Clarence Crane, the inventor of the candy, Life Saver® (Life Savers, Inc.). After attempting to assist the boy in locating additional information, the teacher allowed him to switch inventors. His new inventor was Frank Epperson, the inventor of the Popsicle® (Lipton Investments, Inc).

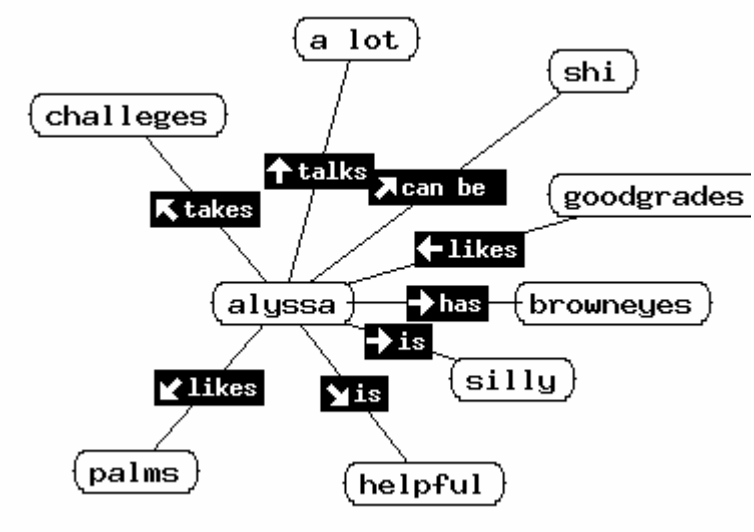
The research project was worked on daily from 1 p.m. to 3 p.m., from immediately after lunch to when the school day was over. The students could work in the library, the computer lab, or in the classroom. The classroom had three Pentium III

computers with Internet access the students could use. Additionally, a few books had been brought from the school library. The computer lab had computers with Internet access. Some of the computers in the computer lab had synchronization cradles attached to them so the students could download sites to their Palms. The whole class could not go to the computer lab to do the research because the lab was scheduled for other classes, but there were always a few computers not being used. When other classes were in the lab, teachers could send a few students at a time to do research there. If the other class needed all the computers, the students coming do to research were required to leave the lab. The students could also go to the library to work on their research project. The computers in the library were only used for the online public access catalog to find books. Even though the librarian had lent Mrs. V's class several books on inventors, there were some books she felt couldn't leave the library so there were some reference books still there. The teacher remained in the classroom to help students. The computer lab specialist was in the lab, but was usually teaching classes and not available to help with searches.

Several handheld applications were used for the research project. The first program was a word processing program called FreeWrite. It allowed the students to take notes from their sources, write and edit their papers, and send their completed work to the teacher's computer. FreeWrite documents could be beamed to other students for peer editing. The program had spell-checking capabilities and auto-capitalization, but did not have all the features of a desktop word processing program such as MSWord. Final formatting and editing for this project was done in MSWord on a desktop computer.

The second program, PicoMap, allowed the student to create concept maps. Figure 1 is a concept map produced by one of the students while she was practicing using PicoMap. Concept maps were introduced in fifth grade in the school. The concept maps created by the students were used to demonstrate their knowledge of their research subject by graphically representing the concepts and the relationship between the concepts. Drawing a circle created a central node, in which the student typed a label indicating the central concept of the map. Additional circles were created and then labeled with related concepts. The label on the line between the nodes indicated the relationship between the concepts. The nodes must be spread out on the screen so all the labels could be read. The whole concept map are too large to be seen on one screen, so a set of navigation arrows allowed the user to scroll around the map.

FIGURE 1 Example of a PicoMap



By using a program called Fling-it, Web sites could be downloaded to the Palm for use at other times. Fling-it compressed Web sites to fit on the Palm for use at home or when the student didn't have access to the school computers. Fling-it warned the

user whenever the user attempted to download a site with frames the site might not display properly. Fling-it could also download electronic encyclopedia articles available online. One feature in Fling-it was the inability to cut and paste text from downloaded sites to other programs.

Another program the students used was Sketchy, a graphics animation program with the ability to duplicate, insert and delete frames. Students drew a series of pictures and animated a presentation. Each student was required to create a Sketchy animation to show the class during the oral presentation.

Data were gathered using two other HI-CE programs. The Palm Artifact Management program (PAM) downloaded documents created in PicoMap and FreeWrite to the desktop computer. The other program, Rubberneck, logged how long the Palm was on, what programs were being run, and when a document was created or modified. It did not record the details of the modifications to any documents. Rubberneck did not automatically restart after a soft reset so the possibility of not tracking all use was eminent. Students were also able to turn Rubberneck off, so they could operate the Palm and the details of their actions would not be recorded.

Data Collection

The researcher functioned as one of the primary data collection instruments, using formal and informal interviews and observation throughout the project. To ensure reliability and validity, a combination of data collection methods and multiple data sources was used. Five strategies were used to collect data during the project: (1) informal and formal interviews, (2) observation, (3) daily surveys, (4) document review of products, i.e., the animations, concept maps, and final reports, and (5) Rubberneck

logs. Methodological triangulation used dissimilar methods to complement the strengths and weaknesses of each method. "The effectiveness of triangulation rests on the premise that the weaknesses in each single method will be compensated by the counter-balancing strengths of another" (Jick, 1983, p. 138)

Gall, Borg, and Gall (1996, p. 773) defined triangulation as the "use of multiple data-collection methods, data sources, analyses, or theories as corroborative evidence for the validity of qualitative research findings." Both methodological and data triangulation were used in this study.

Interviews

Two main types of interviews were used, informal conversational interviews (Patton, 1980) and in-depth interviews. Informal conversational interviews occurred during the observation period. In informal interviews, the questions are not pre-planned but are in response to the observations. As a particular activity was observed, questions were asked and answered. The informal conversational interview was usually short and only addressed the actions being taken at the time. It interfered with the flow of work to some extent, but the students would resume their work after the researcher moved on.

The other type of interview conducted was a semi-structured interview. A semi-structured interview involves asking a series of preplanned questions and then probing to obtain additional information (Gall et al., 1996). This interview technique offers a standard format for each interview, but has the added flexibility of the opportunity for further clarification and explanation. The semi-structured interviews were conducted at the end of the research project and built on observation of the research process. Each student was asked a series of questions from the interview protocol, and then additional

responses were elicited during the interview. Some examples of the interview protocol questions were: 1) Tell me about your thoughts about the Palm; 2) How did you use paper with the Palm when you were writing your paper; 3) Why did you fling the Web sites you did? The teacher was also interviewed at the end of the project. All formal interviews were taped. The recordings were transcribed verbatim by a paid transcriptionist. A copy of the transcribed interview was provided to the teacher as a form of member check. She was encouraged to review the transcript to verify for accuracy and intent. She reported the transcript accurately reflected her comments and didn't suggest changing the wording.

Interviewing students allowed the researcher to probe students' actions and obtain reasons for their actions. Merriam (Merriam, 1991) suggested using interviews when one can't observe behavior, feelings, or how people interpret the world around them. Interviewing was essential because the interviewer could ask follow-up questions to student's initial responses. Interviewing students allowed a glimpse into why students carried out specific information gathering and using behaviors.

Observation

In addition to interviews, observational data were collected in the classroom and the computer lab. The inclusion of observational data provided a more complete description of phenomena than would have been possible by just interviews. Observational data may yield more accurate data than self-report data (Gall et al., 1996). The data can be collected in the natural setting; however the observer has the possibility of changing the behavior of the participants by his or her own presence.

The research questions determined the focus of the observations. The basic observation categories included: 1) type of tool being used: paper, Palm, or desktop; 2) activity: writing report, flinging sites, looking at Web sites, reading book, taking notes, creating Sketchy, creating PicoMap, peer editing; 3) engagement: on task, talking to neighbor, working in other subjects, thinking. The focus of the observations was much wider than just duration or interval recording. Observation in qualitative research has a much broader focus than observation in quantitative research. In qualitative research, behaviors and environmental setting are observed from a holistic perspective (Gall et al., 1996).

During the observations, the researcher took a participant-observer role. According to Gall, Borg, and Gall (1996, p. 345), the participant-observer "observes and interacts closely enough with individuals to establish a meaningful identity within their group; however, the researcher does not engage in activities that are at the core of the group's identity." Merriam reports that participant observation maximizes the advantages of using people as a data collection instrument (Merriam, 1991). Students would ask the researcher about their research problems or Palm technical questions and she would answer to the best of her ability. Being able to approach the researcher with questions helped build rapport with the researcher.

Observation was conducted throughout the students' research project. Data were collected during the initial assignment phase, data collection, writing both rough and final drafts, and formatting and presenting the final products. Observational data collection was completed when the student project was complete.

Written field notes were taken during all observations and informal interviews. Field notes containing date, participants, activities, and observer comments, were compiled during observation. At the end of each day, notes were transcribed and made more complete after leaving the classroom, allowing a fuller description of the observations.

Surveys

Students completed questionnaires before, after, and during the project. Initially the students filled out a survey about computer and Gameboys® (Nintendo Co., Ltd) usage. This survey obtained information about basic levels of comfort and use of other technologies. Each day the students answered a questionnaire about the days' work. The questionnaires are in Appendix D-G. Most of the questionnaires were multiple choice, but some of the questions were open-ended. Some of the questions remained the same with questions added or modified as the research progressed. Other questionnaires were unique for the day's activities. The questionnaires allowed data gathering from the whole class every day. They confirmed the observations for the day and added additional information from the students' point of view.

Document review of products

Documents can refer to a wide range of written and physical materials (Merriam, 1991). In this study, document review was used to examine the artifacts produced for the project, including the report, with its rough draft and thesis statement, the Sketchy animation of the invention, and the concept map created in PicoMap. Each student’s Palm was examined to determine the Web sites downloaded with FlingIt.

Further data about the students' perceptions of the Palm was gathered from journal entries, a morning activity where students write about an assigned topic.

Documents were collected in several ways. Artifacts created in FreeWrite and PicoMap were downloaded to the Palm Artifact Management program (PAM). Animations created in Sketchy were beamed individually to the researcher's Palm. Additionally, documents produced by and about the school under study, including the school Web site and promotional brochures, were examined.

Valuable data was collected through document review. Documents about the school allowed the researcher insight into both the demographics of the school and also school administration values. Student products provided evidence of student use of the Palm and comprehension of topic under research. Review of Rubberneck logs provided evidence of amount and types of Palm use.

One primary source of interpretation of the artifacts was the teacher's evaluation, the grade she gave to the projects. Other interpretations from the artifacts emerged as is standard in qualitative research (Gall et al., 1996).

Data Analysis and Interpretation

Data collection and analysis are simultaneous activities in qualitative research (Merriam, 1998). Merriam goes on to say "emerging insights, hunches, and tentative hypotheses direct the next phase of data collection (p.152)." As this study progressed, new questions appeared on the questionnaires, the focus of observations altered, and new ideas for the final interviews were composed. The constant comparative method of data analysis was developed by Glaser and Strauss (1967) as the means of developing

grounded theory. The constant comparative method is compatible with the inductive, concept-building orientation of qualitative research.

"Rigor in qualitative research derives from the researcher's presence, the nature of the interaction between researcher and participants, the triangulation of data, the interpretation of perceptions, and rich thick description" (Merriam, 1998, p152).

Summary of Methodology

The purpose of this study was to explore through observation, interviews, questionnaires, document analysis, and log analysis, the impact of the Palm handheld on the information gathering and use by fifth grade students involved in a short research project. Qualitative and quantitative methods were combined to give a fuller, richer, and more valid interpretation of the data.

The methods are summarized in the table below.

TABLE 1 Summary of Methodology

1. Are there differences in information gathering and use with the Palm between gifted, dyslexic, and regular learners?

How to determine usage pattern:

Palm usage during gathering information		
How many sites have they flung?	Examination of Palm at end of session	Count sites (ask whether they have deleted any sites)
	Questionnaire	Ask number of sites flung everyday and comparison to number of sites still on Palm at end of project.
Are they using mostly books or mostly Web sites? Why?	Observation	Did they begin with books or Web sites? Did they only use books at the end?

	Interview	Where did you get most of the information for your report - books or Web sites? Why? Was it easier to get information from flung Web sites or off the desktop computer? Was it easier to get information from books or Web sites? If Mrs. V. didn't tell you to use books would you have used them?
Palm usage during use of information		
Are students going back and forth between Fling-it and FreeWrite? (or are they writing notes or sentences down on paper and transcribing)	Rubberneck	Examine usage patterns of programs (are they going back and forth frequently or staying on one program for a long time)
	Observation	Watch students as they write their paper
	Interviews	Ask about usage patterns, frustrations. When you are writing your paper, do you write your sentences on paper before you type them in on the Palm? Do you take notes from flung Web sites on paper? When you are writing your paper, do you go back and forth between Fling-it and FreeWrite to write notes? When you are writing your paper, do you go back and forth between Fling-it and FreeWrite to write your report? What problems did you have writing your report on the Palm?
Are they writing directly from the source or are they taking notes from the sources?	Observation	Is there an indication of note taking? Are the notes on Palm or paper?
	Interview	Tell me how you used the Palm to write your paper.
General usage		
Are they using the Palm at home?	Rubberneck	Time of use
	Interview	Ask about use at home
Which programs are they using?	Rubberneck	Examine usage patterns of programs

	Observation	Note programs used during the day to confirm Rubberneck pattern
Do they like the Palm?	Interview	Would you use the Palm if you didn't have to? What are the best things about the Palm? What would you change about the Palm? What's the most annoying thing about the Palm? How did the Palm help you research your paper? How did the Palm help you write your paper?

2. How do students determine relevancy when flinging or using sites?

How do students determine relevancy when flinging? Which sources did you use in the paper and why?	Interviews/questionnaires	Possible questions: How do you decide which sites to fling? When they are flinging, ask why they flung that particular site. After writing the report, have them open Fling-it and explain why they did or didn't use the Web sites they previously flung.

3. How do the Palms affect the writing process?

Problems	Interviews/questionnaires	Possible questions: What problems did you encounter while writing the report?
Peer editing	Observation	How are the students using the Palm for peer editing? What instructions did Mrs. V. give them?
	Interview	Was peer editing easier or harder with the Palm? How did you mark errors on the other person's

		report? Was it easy to find and correct errors when you got your report back?
How did they use paper vs. Palm?	Observation	Were they just transcribing notes from paper or were they composing on the Palm?
Did they use spellcheck?	Observation	Observe use of spellcheck.
	Interview	Ask about use of spell check.

4. Do the animations and concept maps produced on the Palm demonstrate understanding of the intended concepts?

Evaluation of Sketchy	Examine animation	Does it demonstrate the main features of the invention?
Evaluation of PicoMap	Examine concept map	Number of nodes Holistic evaluation
	Interview	What problems did you have completing your concept map/animation? Did the map/animation help you understand your inventor or invention?

CHAPTER 4

RESULTS

The goal of this research is the exploration and characterization of fifth grade students' use of Palm® (Palm, Inc.) handhelds during information gathering and use.

Description of the Class

Mrs. V. was a 25-year-old with three years of classroom teaching experience. She held a Master of Science in Computer Education and Cognitive Systems. She reported attempting to incorporate technology in the classroom as much as possible. Mrs. V. explained her teaching philosophy as:

> My teaching philosophy concentrates on the fact that all students should be treated as individuals. All learners have the right to a safe and respectful learning environment. All students should have access to learning materials that allow them the opportunity to become responsible for their own learning. I feel that technology is essential in the classroom. It allows students a vehicle for gathering information and allowing the user to drive their learning.

Her previous experiences with technology in the classroom included PowerPoint presentations and learning modules, using the graphing functions of Excel, and working in MSWord. In the year following this research, Mrs. V. served as teacher technologist assisting other teachers in the district in the integration of technology into teaching and learning.

Her classroom had three computers, two reserved for the students and one shared by the teacher and students. Before this study, the only printer in the room was

a dot matrix printer. For final reports requiring a higher quality printer, the computers in the classroom were connected to the printer within the school. For the duration of the study, the class had access to a printer that allowed infrared (IR) beaming. The IR printer allowed the students to beam files to the printer without a wired connection. The class had a 30-45 minute computer lab time each week during the Technology Connections class.

Environment

The classroom was housed in one of many portable buildings due to the overcrowding in the school. The school was built in 1989 in an affluent, rapidly-growing northern suburb of a large metropolitan area in north Texas. It had approximately 850 students with average class sizes ranging from 18 to 22. Immediately after this study, the school underwent construction to relieve the overcrowding, but during the study it was extremely overcrowded, with eighteen portable buildings to house the extra students.

The Texas Education Agency (TEA) awarded exemplary status to the school under study as part of the annual performance rating of all Texas districts. TEA rated the performance of all school districts and their individual campuses as exemplary, recognized, acceptable, or low-performing. To get an exemplary rating, at least 90 percent of all students and 90 percent of each student group (Black, White, Hispanic and economically disadvantaged) must have passed each section (reading, writing, and mathematics) of the Texas Assessment of Academic Skills (TAAS). Additionally, the school must have had an annual dropout rate of 1 percent or lower overall and for each student group.

In the school under study, thirteen percent of the students were identified as economically disadvantaged and 20% of the students used English as a second language or were limited in the use of English. Five percent of the students participated in the gifted program. Schoolwide, a little over half of the students (53%) were white. Of the remaining students, 11% were black, 7% Hispanic, and 29% other.

Almost one third of the teachers had a Master's degree. Teachers had an average of twelve years of teaching experience with half that time within the school district under study. The principal appeared to be very supportive and understood the importance of technology in the classroom.

A brochure describing the school mentioned it was the only school in the district to offer a Technology Connections class. This class was designed to introduce students to computers beginning in the first grade and continuing until the student left the campus. Each class was assigned a specific 45 minutes period each week for time in the Technology Connections class. The curriculum for the class was written by the teachers and funding for the hardware and software was provided by the Parent Teacher Association. As a result of this class, students became familiar with creating PowerPoints and graphs, searching the Internet, and word-processing.

The class's double portable building was situated behind the school. The other side of the portable was occupied by another fifth grade class, so if an emergency called one of the teachers away, the other would cover both classes by standing in the connecting doorway. Noise was heard infrequently from the other classroom. The classroom had several high windows allowing light in, but they were too high for external activities to be distracting. The classroom was decorated with student work and

was visually appealing. The teacher changed the seating arrangements two times during the few weeks of the project, but the students were never seated in rows or small group clusters. The three computers and printer were in the back of the room beside the teacher's desk. On the other side of the computers were two bean bag chairs that were coveted places for working. When the class was working on their research project, they could move around the room to find a comfortable place to work. Once the beanbag chairs were occupied, students would either find a convenient empty spot on the floor or continue to work at their desks.

Each student was given a Palm IIIc to use during the project. Each Palm was named and programmed with the assigned students' name and had software and drivers downloaded before they were distributed. Undecorated stickers were placed on the back of the Palm with the student's name and class identification number. The Palms were distributed to the students seven weeks before the end of school, two weeks before the inventors project was assigned. Cases were prohibitively expensive, so each student was given a padded envelope to protect their Palm. Students used the envelopes when the Palms were stored between uses and when taking the Palms home. Each student knew they were expected to care for the Palm, but would not be financially responsible for loss or breakage. There was a full-sized keyboard and Happy Hacker® cradle for each student. The Happy Hacker cradle attached the Palm to the keyboard.

A docking station to charge the Palms was placed on one side of the room. The other side of the room had a table to store the keyboards and Happy Hacker cradles. Whenever the students wanted to use the keyboard they would take a keyboard from a

large stack. At the beginning of the project, the cardboard boxes in which the keyboards were stored made neat stacks. As time progressed the boxes lost their structural integrity which made it much more difficult to stack the boxes without the stack tipping over. Students would spend time neatly stacking the boxes so the strong side of the boxes alternated. A better option would have been to have a rack with slots for every keyboard or a keyboard suitable to keep at the student's desk. In order to keep the Palms safe, the teacher would gather them up after the students used them and would hide them in a bucket behind her desk.

At the front of the classroom, there was a small podium for the teacher to rest papers on when she was teaching, a white board, and a small TV. An Elmo enabling the transmission of an image from the Palm to the TV was available for large group instruction. During the two weeks the students were practicing with their Palm, the teacher demonstrated the programs on the Elmo and gave them time to practice their Graffiti skills and become accustomed to using the Palm. In addition to the work the class did on their inventors project, they also used the Palms in other subjects. For example, they read the Jungle Book in Language Arts, wrote their spelling words, and checked their math assignments. They also created and beamed math problems to each other to solve.

After two weeks of learning the programs on the Palm, the assignment shown in Appendix C was distributed. The requirements were presented orally and each student had to get a parent's signature on the assignment sheet. The students were to return the following day with their top three choices for the project from a list of inventors from the time period of the 1700's to 1920, the time period the class was studying in Social

Studies. The list of inventors, with the ones chosen marked with an asterisk, is in Appendix C. The list included only male inventors, though some of the girls specifically wanted to research a female. There was a wide range in the amount of information available on the inventors. Inventors such as Benjamin Franklin had more readily available information than less well known inventors, such as Frank Epperson, the inventor of the Popsicle. One boy asked to choose an inventor who was not on the list and was given permission to research Leonardo Da Vinci, even though he was not from the time period assigned. One boy started with Clarence Crane, the inventor of Life Savers, but when he could not find an adequate amount of information, was allowed to switch to Frank Epperson. Interestingly, when the researcher asked him what Clarence Crane had invented, he responded he thought Crane had invented the crane.

After a week of researching their inventor, the students were asked whether they were glad they chose their inventor. If they were unhappy with their inventor, it was usually because they couldn't find enough information about him. One girl thought she had chosen a female inventor and expressed disappointment he was a male. Several students were happy they had chosen their inventor because it was easy to find information about him, but the main reason they reported they were happy with their choice was because the inventor or invention was interesting.

During the study, the researcher and teacher worked in tandem in the classroom, both being available to answer questions and solve technical problems. Both the teacher and researcher addressed the class, although the teacher took the lead in pacing the work, instructing the students, and reviewing what had been done and what was required for future work.

The class worked on the inventors project from right after lunch until the school day was over, from 1p.m. to 3 p.m. During forty-five minutes of that time, the students who were diagnosed with dyslexia went to a different room for separate activities, limiting the time in class they could work on their projects. Also, because the project came at the end of the day, the members of the class were trying to finish other assignments due that day. Many days, at least some students spent time finishing their spelling or math assignments and didn't choose to work on their research project at all.

The project went through several phases. The first phase was information gathering and composing the thesis statement. The class had three days to produce a short thesis statement, summarizing the main idea of the research report. Ten calendar days after the project started, the students exchanged documents for peer review. The next day marked a transition to focusing on creating the Sketchy and PicoMap for the project, but also getting the rough draft finished to turn in the next day. Two weeks after the thesis statement was due, the final copy was due. The time for the research project that day was spent in the computer lab, so the students could format their paper in MSWord on desktop computers. Two days later the students gave their oral presentations.

The first day the teacher sent the students diagnosed with dyslexia to the computer lab to start their research before they left for their standard time out of class with the teacher who worked with them on special activities. The researcher observed in the computer lab during the first day. All the computers along one wall were fitted with synchronization cradles for flinging Web sites. Another class was using the lab so only five students from Mrs. V's class could be in the computer lab at a time. At the

beginning the students diagnosed with dyslexia took each of the stations, but other students from Mrs. V's class rotated in as the two hours progressed. Several of the students had forgotten the previous instructions on how to download Web sites with Fling-it, but once they were reminded about the dropdown on the Internet Explorer toolbar they quickly remembered the process. Several students opened Netscape by mistake and then realized Fling-it only worked in Internet Explorer, so opened a new browser window.

Most students started searching with Google. Some then went to Yahoo. Many searched for "Fast facts about 'inventor's name'." When asked why they were searching with that query, they replied that type of query had worked during their research about presidents. Searching seemed very unsystematic, sites seeming to have promise were ignored. Some students just picked random pages from the results to look at after the first page instead of looking at each page of results in order. Some students didn't fling a Web site when the warning about frames appeared; others went ahead. Most students flung sites as soon as they found a site about their inventor. Some students would fling a large page for just a paragraph about their inventor. One student thought flinging whole sites for just one paragraph was wasteful and tried to figure out a way to download just a paragraph. One student found a timeline about many different inventions. When he tried to download the site, the timeline was unreadable. There was only one date about his inventor, but he didn't write the date down either on paper or on the Palm after failing to download the site.

Even though the students were working independently on their projects, there was evidence of cooperation. One student found a site with descriptions of many

inventors. After downloading the whole page of inventors whose name started with 'B', she commented she could help other people. She asked the person sitting next to her if he wanted her to download the page with his inventor on it. When he agreed, she connected his Palm to the synchronization cradle at the computer she was working on and downloaded the site for him.

As the research project progressed, most of the students stayed in the classroom to work instead of going to the computer lab or library. When all the computers in the classroom were busy, some students went to the lab to download additional sites. In the early days of the research project, the three computers in the back of the room were being used constantly, however some of the students worked on their spelling assignments instead of the research project. Even the students working on their spelling used the Palm to complete their assignment. The students, who were working on spelling, were mostly either TAG students or regular students. Two of the TAG students started on the assigned Sketchy animation by the second day of the research project. Most of the students were engaged with what they are working on. There was not much talking, staring into space, or other off-task behavior. Conversations overheard were relevant to using the Palm or other assignments

The class had to turn in a thesis statement on the third day of research. One student had taken notes on paper from his downloaded sites the night before and wrote his thesis statement from the notes into FreeWrite. Other students used paper to compose a thesis statement in class then transcribed it to the Palm. There was observational evidence of students going back and forth between FreeWrite and Fling-it to compose the thesis statement. One student who was attempting to write his thesis

statement into FreeWrite from his downloaded sites, couldn't remember a particular date so wrote the date on a tiny piece of paper as a memory aid. A couple students worked from books to find information for their thesis statement. Two students completed their thesis statements during the second day and printed them out. Others finished the next day.

Some of the students mentioned problems while working with Fling-it. One student found it difficult to tell which downloaded site she was working on because the names of the sites were all the same on the Palm. Some students flung the same site multiple times because they didn't realize they had already downloaded it. Only a few people had trouble after the first day remembering how to download the sites.

Pre-Survey

Initially, the class was given the survey shown in Appendix B about their use of computers and Gameboys® (Nintendo Co., Ltd), electronic handheld toys with about the same size screen as a Palm handheld. Table 2 summarizes the results of the pre-survey. All but one of the students reported a favorable attitude toward computer usage. There might be a connection between this attitude and the prevalent use of computers to play games. All but one student played games on the computer, but over half of the students in the class also used computers for schoolwork and to surf the Web. Fewer students used the computer as a communication tool as demonstrated by the reported low usage levels of email and instant messenger; this may have been due to the age of the students. In addition to computer access in the school, most of the students had a computer at home. Only one student didn't have access to a computer at home, however he was not the same student who didn't like computers. Two thirds of the

students assessed their own computer skills as good or excellent. Only one student reported her computer skills as poor. Most students owned a Gameboy, however less than half the students played with it as much as once a week. The habitual use of a small handheld toy such as a Gameboy might influence attitudes toward similar electronic devices. Almost everyone who owned a Gameboy had had it for a year or more giving them adequate time to become accustomed to it.

TABLE 2 Frequency data from survey administered at beginning of inventors project

Question	Answer	Results
Do you like to use computers?	Yes No	23 1
Do you use a computer at home?	Yes No	23 1
How much do you use computers?	Almost every day Several times a week Weekly Only when I have schoolwork	10 7 7 0
What do you do on the computer?	Schoolwork Games Email Instant Messenger Surf the web	17 23 11 9 17
Do you have a Gameboy?	Yes No	21 3
How much do you play with your Gameboy?	Almost every day Once or twice a week Once or twice a month Hardly ever	2 7 4 9
How long have you had your Gameboy?	A month or less Since Christmas A year More than a year	2 0 3 16
How do you learn best?	Play with the	14

	program Have someone show me how Read the instructions	 9 8
How are your computer skills?	Poor Average Good Excellent	1 7 13 3
When you use a Web site for a project do you take notes from the screen or print it out?	Write notes Print the site out	13 18
When you use a book do you write the paper with the book in front of you or do you use notes?	Use the book Use notes	13 20

Some students chose more than one answer for the last two questions in the survey. When asked whether they took written notes from a Web site or printed it out, seventy-five percent reported printing the Web site out although that behavior was only occasionally evident in this study. Students didn't print Web sites at school, but two students brought in printouts from home. Over fifty percent of the students responded they wrote notes from Web sites; however there was no observation of students taking written notes from the desktop computers. This was a surprising observation because Mrs. V. reported that in previous research projects the students took notes from the Web sites on note cards and then used the cards to organize and write the paper. When students found information about their inventor on a site using a desktop computer, they would download the site to their Palm with Fling-it and many would use the downloaded site to write their paper directly.

The last question on the survey was about how the students actually used books as information sources. When asked whether they use the book directly when writing a paper or whether they use the intermediate step of note taking, almost all students

reported they used notes. This was not substantiated with observations. Most students when being observed in this situation either wrote their report on paper or on the Palm while referring to books or a downloaded site.

Journal Entries

On the day the class was given the Palms, each student was asked to make a journal entry on their Palm about how they felt about receiving the Palm. They wrote short entries, from 50 to 250 words, using the full size keyboard attached to the Palm through the Happy Hacker cradle. Already they had discovered if they used the Palm for a short time, the Palm and keyboard would shut down and would require a soft reset. The Palm didn't detect that it was being used, if the keyboard was being used, so would time-out. After using the Palms for only a few hours, these and other technical problems had already manifested themselves. If the students mentioned in their journal they had had a problem, they usually just dismissed it as a minor inconvenience. At the beginning, the students were required to bring the Palm to an adult to be reset, but by the end of the project, the students could troubleshoot small problems themselves.

Universally, they reported they were happy and excited about the opportunity to be able to use the Palm and were looking forward to the time when they would be allowed to take them home to show their friends and families. They were aware this was a unique opportunity given to their class and it made them feel special. Several were already expressing sadness they were not going to be able to keep the Palms and mentioned they were going to ask for a Palm as a gift. One student talked about how she was going to earn money to buy a Palm by selling her "doll stuff" and Gameboy. The adjective they used most to describe the Palm was "cool". As one student said, "My

Palm is the coolest thing in the world." They anticipated using the Palm in class would be fun and some students mentioned they expected their grades to improve given the ability to check their math homework with the Palm's calculator. Several students mentioned the learning and organizational opportunities afforded by the Palm. As one fifth grader, who had been identified as gifted, pointed out, she thought "they could help educators around the world teach many different kinds of people a whole bunch of new things." At this point, the students were anticipating learning to use Graffiti, the input method using one stroke printing, and the games, such as Giraffe, used to teach Graffiti. The similarity to the Gameboy might have increased their expectation of the games on the Palm. They were enjoying becoming familiar with the features of the Palm. One student said he liked typing on the Palm better than on a computer, but he could not articulate why when asked later.

The second journal entry, commenting on the best and worse aspects of the Palms, was done about a month after the Palms had been distributed. The answers reflect a deeper understanding of the faults of the Palms, but also still demonstrate an undimmed enthusiasm for the use of the Palm in the classroom. One student summed up her feelings by saying, "It is fun and you can do lots of stuff on it." Another student when talking about the worse thing about the Palms said, "My worst favorite thing on my Palm is …NOTHING!" but then went on to say he wanted better games. Most of the students still liked playing Giraffe, a typing program to teach Graffiti, and beating their own personal best score, but a growing segment was becoming disenchanted after a month with the available games and wanted more complex, graphical games. The students expressed appreciation for the variety of programs available such as Sketchy,

but still desired more capability, especially Internet access, email and chat functions, and a better spell checker. Even as fifth graders, they appreciated being able to type their work instead of writing it in longhand. Several students appreciated being able to take the Palms home and how easy they were to setup, but there were several complaints about the full sized keyboard being too large to transport easily.

One problem often mentioned was the size of the pages on the Palm. This was not the same problem as the small screen. The students were worried about knowing how the number of pages on the Palm translated to the number of pages in MSWord. Tiny pages made it hard to know how much the student had written. The goal of the inventors project was to write 2 1/2 pages for the report and the students had a hard time calibrating the Palm pages to the size of the MSWord pages. When they had reading assignments, it seemed like a huge assignment because of the sheer number of pages assigned when in fact it was the same amount of reading as before. One boy put it aptly, saying, "the worse thing about the Palms is that when we have to read it looks like a lot of pages to read."

Many of the students cited technical problems as their biggest complaint. The Happy Hacker cradle required turning off the Palm before removing it from the cradle, otherwise the Palm froze and required a soft reset, a requirement causing much frustration and many students to lose work. In addition to losing their current work, after a soft reset, the student had to reprogram the Palm, so that it turns off after the maximum amount of time instead of five minutes. This was required because when the Palm was being used in the Happy Hacker cradle, it didn't register being used. As one boy reports, the worse thing was, "while you are working it shuts off and then you or the

teacher will have to restart the Palm and all the information about the thing you are doing will be eraesed (sic) and you will have to type it all over again." Even though students expressed thankfulness their work could be recovered by syncing to the desktop computer, they complained about how long that operation took. As one student reported, "I hate it when your Palm shuts down then you have to do a lot of work to get all the stuff back." They also mentioned other smaller problems, such as the precision required to activate the proper functions, the battery's short life span, and how dirty the screen got when touched. They expressed the fear the Palm might be destroyed or damaged, losing their work.

The students realized to switch between two programs on a Palm required more work than a desktop computer. It took several clicks to move from the word processing program to a downloaded Web site and when one returned to the word processing document it returned to the top of the document, not where one was working. However, some of the students believed the Palm made research easier. They liked being able to download Web sites for later use.

They also realized the Palm was a tool not a toy. One boy summed it up, "the worst thing about the Palm is that their (sic) is not good games on the Palm and we have to do work on it and we have to work all the time on the Palm." Some of the students thought the inventors research project was extra work even though all the other fifth grade classes had already completed the research project.

Survey Questions

Each day during the project, the students were asked to complete a survey with multiple choice and open-ended questions. The results of the survey multiple choice

questions during the information-gathering phase of the inventors project are summarized in Table 3. When asked whether they used the Internet or books for their research, most students had some variety in their answers. Three students claimed they only used the Web for research at school and never used books. Eleven other students used the web exclusively for over half the days. Three of the four students identified as gifted and talented balanced their time between the Web and print material. The six students diagnosed with dyslexia mostly used the Web. Of the students diagnosed with dyslexia, four students used the web over half the time, one student used print material over half the time and one student balanced his time between the Web and print.

TABLE 3 Frequency data from daily surveys during the information gathering phase of the inventors project

Question	Available responses	Date of Survey						
		4-29	4-30	5-1	5-2	5-3	5-6	5-7
What kind of resources did you use today?	Books	0	0	0	2	2	10	6
	e sources	12	14	12	14	17	14	4
	Both	5	8	5	6	3	0	12
How many sites did you fling?	0	0	10	17	21	17	18	14
	1	2	1	1	1	1	2	3
	2	5	4	0	0	0	2	3
	3	3	3	1	0	2	0	1
	4	2	1	0	0	2	0	0
	> 4	5	3	0	1	0	0	1
Did you take notes from Web sites that you **didn't** fling? (If yes - did you take your notes on paper or on the Palm?)	Paper	0	2	1	6	3	3	3
	Palm	1	3	1	3	1	3	2
	No	16	17	16	15	18	18	16
Which resources were most helpful?	print	1	3	2	4	7	8	10
	electronic	12	17	14	19	18	14	17
Did you take notes on paper or on your Palm?	Neither	4	3	10	5	7	7	5
	Paper	3	7	3	10	6	10	12
	Palm	6	3	3	1	2	2	4
	Both	4	9	3	7	7	3	1
How much information did you find about your inventor?	None	0	0	6	3	4		
	Some	5	5	4	6	10		
	Lots	12	16	9	14	8		
Did you have any problems with Fling-it today?	Yes		1	0	0	0		
	No		21	19	23	22		
Did you write sentences on paper before you typed in into the Palm?	Yes						12	
	No						10	

Do you like writing your paper on the Palm?	Yes No						20 2	
Did you work over the weekend on your paper?	Yes No						16 6	
Do you like being able to fling sites?	Yes No		22 0	19 0				
Did you use information in your rough draft that you didn't fling?	Yes No							14 7
Did you write your first draft on Palm or Paper?	Paper Palm							4 17
Note: Data are reported for each survey question appeared on the specific survey for that day.								

Two thirds of the downloaded sites were downloaded during the first two days of the project. These two days were times of intense computer use. Students left the classroom to use the computers in the computer labs and accessed the Web on the three computers in the classroom. The number of Web sites downloaded fell during the third and fourth day, as the students read over what they had downloaded, wrote their thesis statement, and started to organize their papers. The number of downloads increased again as the students realized they didn't have enough information to complete their papers.

The perceived helpfulness of the each data source also changed during the project. Frequency of data source reported as most helpful as the research project progressed is shown in Figure 2. The majority of students felt electronic resources were most helpful, but there was a steady increase in the number of students who felt print resources were most helpful. The students were required to include two print resources in the bibliography, so they had to refer at some point to print resources.

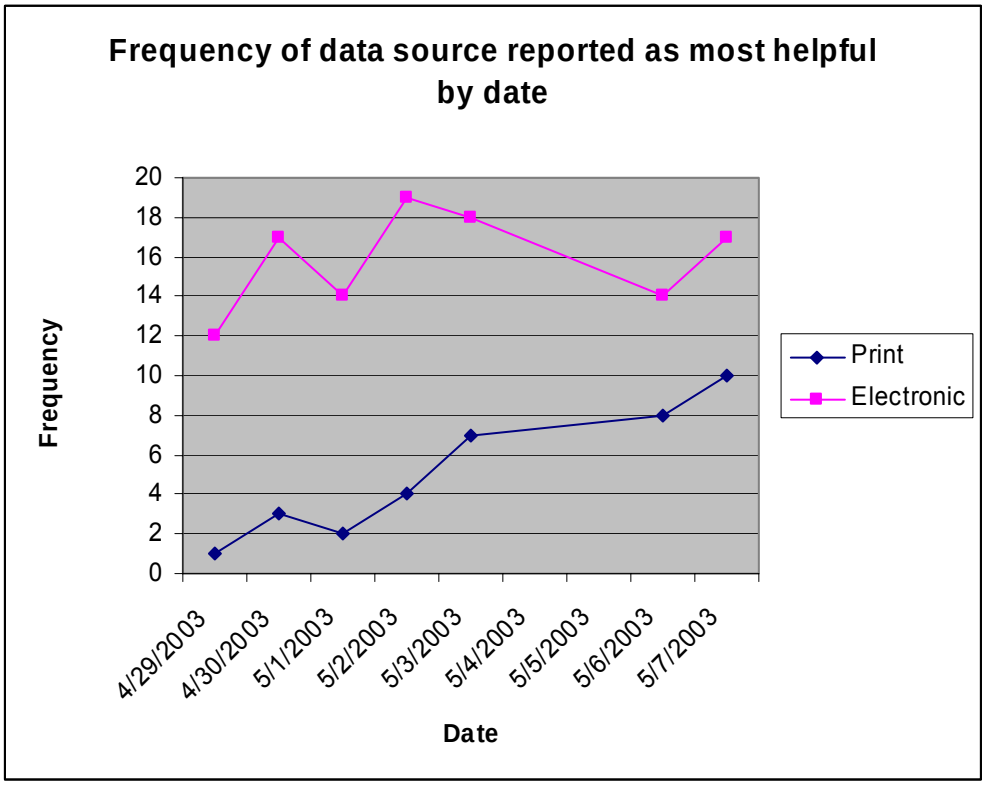


FIGURE 2: Frequency of data source reported as most helpful as the research project progressed

The question, “Did you take notes on paper or on your Palm?" received some interesting answers. Many students claimed to take notes on the Palm, but only one student's Palm had a document of notes. One of the gifted and talented students had a list of facts about her inventor on the Palm. Other students when they reported taking notes from the Palm were writing directly into their rough draft either on paper or on the Palm. Four of the students, three diagnosed with dyslexia and one regular student, reported writing their rough draft on paper. Seventeen other students reported writing their rough draft on the Palm.

Most of the students reported liking to be able to download sites to their Palms. They only reported one problem with downloading to their Palms. They also reported liking to write their paper on the Palm. When asked on the second day of the project

how their research was going, almost all said either good or great. Only three students reported their research was going pretty well or okay. One student mentioned they were finding valuable information by downloading Web sites. One student, who switched inventors the next day, complained he couldn't find enough information about his inventor. There were several inventors chosen with very little information available on them.

At the end of the second day of information gathering, the students were asked how they decided what sites to download. Most mentioned they skimmed the site even though they switched pages so quickly they only had time for the most cursory of examinations. Almost half of the students cited how much information was on the page about their inventor as the primary characteristic to determine if they would fling the site or not. One girl's answer sums up this attitude, "I decided by how much info they have." Some students mentioned they decide if the information was "needed" or "helpful". Only a few mentioned the information had to be "good" or "important." Only one person looked for specific information, such as the date the inventor was born. A few students remembered Fling-it has a tendency not to display sites with frames correctly, so they mentioned a prime characteristic to look for is a site without frames.

After one week of research, the students were asked what they would change about the Palm. The answers ranged from “nothing” to "start writing on paper." Two students wanted to be able to access the Internet from the Palm. Two students mentioned they wanted the ability to minimize and maximize windows so it wouldn't take so long to open and close things. Almost half mentioned they would like more and better games on the Palm.

The next class day, the students were asked about any problems they were having writing their research paper on the Palm. At this point, it was two days before they were going to do peer review. Some of the students had almost finished their rough drafts and some had barely started writing. Almost half claimed they weren't having any problems with the Palm, but some complained about technical problems such as the Palm freezing when removed from the Happy Hacker cradle without being turned off.

Peer Review

Peer review was scheduled for two days before the rough draft was due. The class exchanged files on the Palms for peer review at the beginning of the two hours scheduled for the research project. There were two unusual circumstances influencing the behavior of the class that day. The class had seven visitors from Texas Instruments, who had come to observe the classroom using the handheld computers and ask questions of the students. During the two hours designated for peer review and corrections, the visitors circulated among the students asking questions and engaging the students in conversation. Several comments from the students indicated they were eager to talk about the use of the Palms with the visitors. Another situation that might have changed the dynamics of the peer review process was the fact the gifted and talented students were out of the classroom and so didn't participate in the peer editing. The students diagnosed with dyslexia left together for their usual help session after the initial peer review exchange.

The teacher designed the procedure for the peer editing process. It took 30 minutes earlier in the day to explain the protocol for peer editing to the class.

- Beam the document to your partner. To beam from Palm to Palm, the handhelds must be aligned top to top. If the beam goes out of alignment the transfer stops, but the transfer can be re-established by realigning the Palms.
- The partner checks the document with spell check and for sentence structure and makes the changes in capital letters.
- The partner changes the name of the report by adding their initials to the title.
- The partner beams back the paper back to the author.
- Mrs. V. would then help them duplicate the document and rename it "final".

This procedure was too complicated for many of the students. Some forgot to capitalize the corrections, some forgot to rename the files, and some just didn't understand the concept of peer editing. When one person tried to beam the corrected paper back, she hit delete instead, and wiped out her corrections. As one student noted, "I really like it but some times it got a little confuzing (sic) and some times it did not work the way I like it."

Mrs. V. matched the students into pairs for the editing process. She would normally pair the gifted students with the students diagnosed with dyslexia, but because the gifted students were out, she paired strong regulars with the students diagnosed with dyslexia. There was much grimacing when the pairs were announced, but the students got straight to work. Several partners didn't realize they had to be out of the word processing program to beam. Once they discovered the problem, they were successful. Most of the students started the peer review process by spell checking their partner's document.

The spell checking function in FreeWrite didn't have suggestions for incorrect words and several students commented on not being able to pick from a list of suggested spellings as they were accustomed to doing in MSWord. One student expressed his frustration by writing, "In a way i dislike the spellcheck because it dosnt tell you how to spell the word the write way. [sic]" But some students thought the spellcheck function was better than just trying to determine on their own whether the words were misspelled. One student said, "The spell check is real easy because all it does is tell you if its wrong then you correct it and it goes to the next misspelled word." FreeWrite's spell checker also reported all contractions as misspelled. The spell check function in FreeWrite had the ability to add words into the dictionary and several students just kept adding misspelled words to their dictionary, which allowed misspelled words to look correct the next time they used the spell check function.

Many of the students didn’t do anything but check their partner's report for spelling before they beamed it back. When they received their reports back they immediately started correcting the mistakes.

At the end of the day, instead of completing a questionnaire, the researcher had them write what the peer editing was like; whether it was hard or easy, whether they liked it or not and why. They could beam their comments to the researcher or write their comments on paper. Twelve students chose to write their comments on paper in long hand and only four beamed their comments. This could be due to the fact that most of the Palms were put away for the day before the questionnaire was distributed. Most students liked the peer editing process and thought it was helpful for someone else to check over their work. One student summarized the process by saying, "My classmate

might not have found all of my mistakes but it's a start." They liked the novelty of beaming their reports back and forth, but still complained if they had had technical difficulties. One overriding concern was the uncertainty of the length of the paper. "It's a little bit harder because you don't realy [sic] know how long or how your paper is going to turn out page wise."

Sketchy and PicoMap

The day after peer editing, Mrs. V. suggested the class start working on their supplemental activities, an animated drawing created in Sketchy and a concept map created in PicoMap. At the end of each day the students worked on Sketchy or PicoMap, the students answered a questionnaire about the two programs. Data from those questionnaires are shown in Table 4.

TABLE 4 Frequency data from daily surveys during the period the class worked on the supplemental activities, Sketchy and PicoMap

Question	Available Reponses	Date of Survey		
		5-9	5-10	5-13
What did you work on today?	Sketchy	18	8	5
	PicoMap	8	2	5
	Writing	19	3	16
If you worked on Sketchy was it fun? (On 5-9, Each of the students who reported 'no', also said 'yes')	Yes	18	8	6
	No	2	0	0
	NA	4	11	16
If you worked on Sketchy did it help you understand your invention?	Yes	11	5	4
	No	5	4	3
	NA	4	10	15
If you worked on PicoMap was it fun?	Yes	5	2	4
	No	6	0	1
	NA	12	16	17
If you worked on PicoMap did it help you understand your invention?	Yes	5	3	3
	No	6	0	2

	NA	12	16	17

A Sketchy animation is a collection of drawings done on the Palm shown in sequence at one of three speeds to simulate action. It had several features supporting the creation of animations. The user could copy and insert whole frames or parts of frames so those elements could be reproduced many times without having to redraw them. Geometric shapes complement free hand drawing, so drawing skills, while still important, were supported by the program. To make the animations more interesting, shapes could be filled with different patterns and lines had adjustable width and pattern. While the students used the fill and line features, it was mentioned several times in the interviews the ability to animate the drawings, as opposed to just the ability to draw, was the compelling feature in Sketchy. See Figure 3 for an example of one of the animations created for the inventors project.

Most of the class liked Sketchy and enjoyed animating their drawings. They reported it was "really fun" and "real cool and very easy". One student said, "It is awesome to draw a chain of pictures and animate it." Sketchy engaged the students even during their free time. One student was creating extra animations when he was supposed to be doing other assignments and had his Palm taken away for the rest of the period. Another stated, "I like playing with it [Sketchy] when my parents are asleep because it's quiet and easy." That same student preferred Sketchy to a drawing program on a Sega® handheld.

> I have this Sega® game and it’s the exact same, you can go on there and use your Sega® handheld and you get to draw and paint and all that stuff, but it’s a lot easier to do it with your hand, kind of like a pencil.

She also preferred drawing on the Palm to creating a drawing in Paint® and importing into Microsoft PowerPoint®.

Even when the students were not creating an animation for the project with Sketchy, but just learning how to use the program, it appealed to them. For example, one student explained how she played with the features of Sketchy by saying:

> Once I got, I just got this big, the whole screen black and I got an eraser, the smallest one, and started just erasing the whole thing, it took me a long time to get the whole thing perfectly white again, when all you had to do was go to white box and do that, to make it white.

One student summed up the feelings of the class by noting, "Sketchy is probably my favorite thing on the Palm…I think that it's really cool."

Even though most of the students liked Sketchy, other students found Sketchy hard to control and confusing. They reported the line they drew didn't appear where they wanted and it was hard to erase exactly what one wanted. The student who preferred Sketchy to the Sega game also had trouble controlling the stylus. She said,

> The only thing I don't get is when you do it you have to do a little left or a little right to the side of where you want it because the computer screen you don't see exactly where you're writing.

Students with less drawing talent relied on drawing stick people because they were easier to draw. Even a student who said he "don't draw good" thought "it looks cool to play the animations and see like people running around."

The lack of color was a problem to some. "The bad thing was it dosnt [sic] have any color." Students in other studies have voiced problems about the lack of color

(Staudt, 1999). Today's students are accustomed to color on handheld devices, so there were many comments requesting color for the display.

Some of the students had difficulty trying to imagine how to animate static inventions, such as electricity and saran wrap. Someone noted,

> It was hard on my Sketchy because my inventor was Alessandro Volta and he invented electricity so I tried a lot to make my invention and I still wasn't geting [sic] how to draw it but I kep [sic] on try and I finly [sic] got how too [sic] draw it.

Problems figuring out how to animate static inventions would not be unique to the Palm.

Some students found it enlightening to create the animations. "It helped me see how my invention worked better." Others thought that the animations didn't teach anything. "The Bad thing is that it teaches you absalutaly nothing exept the inventors project [sic].” All but one of the students received a perfect score on their Sketchy animation when Mrs. V. scored the animation on whether it was relevant to the invention.

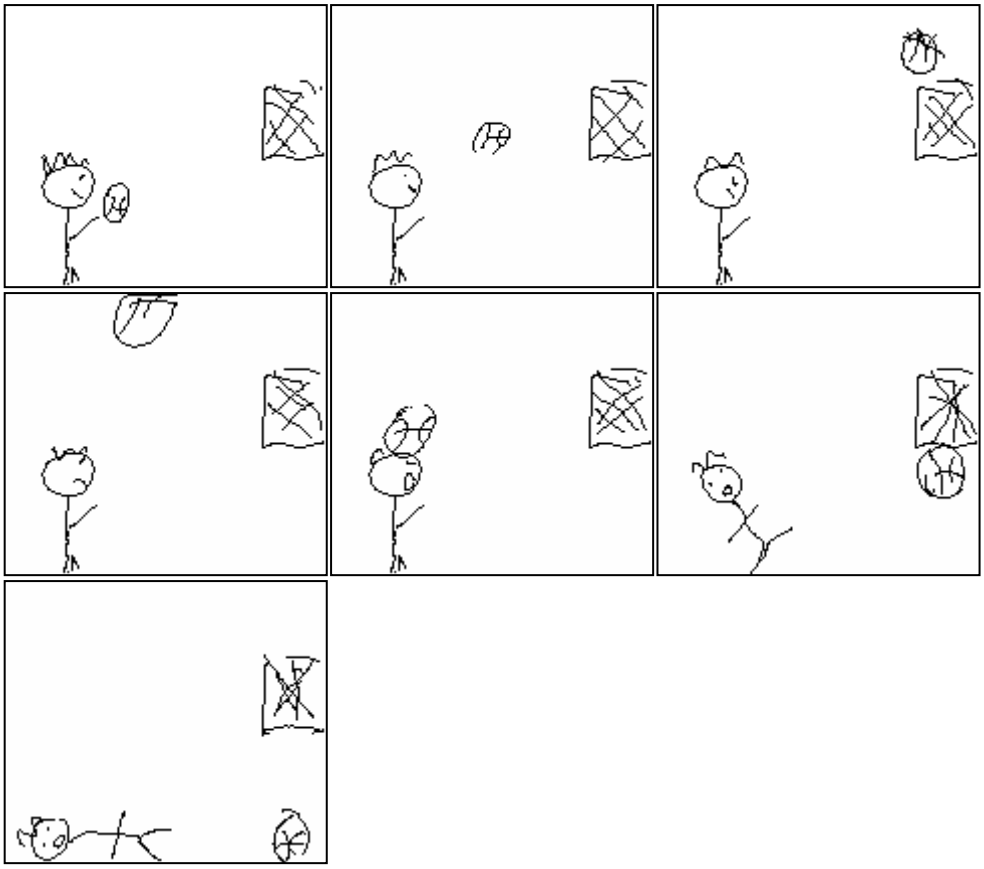
Many of the students used Sketchy to create animations unrelated to the inventors project. The ability to animate their ideas had immense appeal for these students. More than any other program on the Palm, Sketchy was categorized as fun and the animations themselves were categorized as funny. Humor was an important part of many of the Sketchys done for the project. Many times the humor was dark. People were being blown apart, struck by lightning, or otherwise harmed. For example, the student who researched Roper, the inventor of the steam cycle, drew the steam cycle being driven up a cliff and crashing down. Other times the humor was more

bizarre than dark. The boy who researched Epperson, the inventor of the Popsicle, had a man crawl out of the ocean, buy a Popsicle, and return to the ocean under a pulsating sun. Pride in creation was evident as students shared their Sketchys with the researcher, the teacher, and their peers.

As they developed their animations, they were eager to show others what they had done and share how they did it. When they learned new features of the program, they shared their findings with friends and soon everyone had mastered that skill. Spontaneous collaboration to share new skills has been observed in other studies (Staudt, 1999).

Sketchy appealed to almost all the students, because it was "fun." The two students who were most vocally enthusiastic about Sketchy were students who had been identifies as gifted. Both these students drew with Sketchy outside of class on their own time.

FIGURE 3 Sketchy demonstrating James Naismith, the inventor of basketball



A concept map created on PicoMap was also a requirement for the inventors project. The user created a center node containing the inventor's name and satellite nodes with words related to the inventor. An arrow connecting the nodes was labeled with the relationship between the inventor and the word in the satellite. The author labeled each node and line, but there was a limited amount of space, about seven to nine letters, for the annotation. The most often verbalized complaint about PicoMap was the students needed more room for annotations. One student noted he "wish[ed] you could have the nodes bigger, for bigger words."

There are also problems with creating the nodes and arrows themselves. It took practice to be able to create each element the way one wished. One student complained "when I try to make the circles it turns to a big blank." There was even a suggestion from another student "they should have it set up with at least ten [nodes] ready to go right when you open it". Sometimes instead of making an arrow, the node itself moved. Another problem was the size of the concept map. Even a simple concept map was too large to be viewed on the Palm screen. The students wanted to be able to view the whole concept map at one time. The students wanted the "space to be on one screen, so you don't have to scroll around."

PicoMaps can be beamed to the teacher, directly to the infrared printer, or synced with a desktop computer. A complete concept map made in Picomap was turned in with the final paper and was also presented during the final presentation. Each student had to scroll around the concept map when presenting PicoMap to the class.

Most students said they liked PicoMap on the survey, but there was a lot more oral complaining about PicoMap. Mrs. V reported when they practiced PicoMap, she had “never heard more kids moan and groan.” A third of the students said they thought PicoMap was hard or boring. One student thought "PicoMap is sort of boring because all you do is write and draw nodes." He also thought it took too much time to make a concept map with PicoMap. One student thought the program could be improved by the ability to add pictures to the concept map. On the positive side, many thought the concept map helped them understand their inventor better and helped them to organize their thoughts. One student commented, "PicoMap helps me understan [sic] my project more and more every day." Some actually thought making a PicoMap was "better than just writing out all the stuff to exsplane [sic] what you are talking about." One student summed up the abilities of PicoMap by saying,

> PicoMap is a very good program that a person, any age, could use to make a map of something and what that something does, how it does what it does, how it does affect us when we do whatever it is, and a whole lot more, probably inumerable. [sic]

Other students enjoyed PicoMap because they perceived the ability to create concept maps on a computing device as unique.

The PicoMaps were graded on the relevance to the inventor and inclusion of at least 10 nodes. Over one half the class received a perfect score on their concept map, however some of the completed concept maps were scored as low as 50. About the same percentage of students diagnosed with dyslexia received a perfect score on their

concept maps as the class as a whole. All four gifted and talented students received a perfect score on their concept maps.

Some of the students diagnosed with dyslexia liked PicoMap and some didn't. One such student said he organized his thoughts by added nodes to the PicoMap and double-checked in FreeWrite to see if those facts were in his report. The regular students only had a few complimentary things to say about PicoMap. One student thought the PicoMap helped her understand her inventor and draw conclusions about him. One regular student liked using PicoMaps for a diary. He said:

> But I like PicoMap because, uh, it's kind of like, kind of like a diary where you can write your feelings about certain things, stuff like that. You can put something in the middle that says something about that person or about you, and you can just put notes all around it telling, telling stuff how you feel about them is, and maybe feels, well I don't know how to explain it, but it's just it was a lot better doing it on the Palm.

Most of the regular students thought PicoMap was hard to use and fairly useless. The TAG students all complained about not having enough room to write in the nodes, but one TAG student thought it was fun trying to think of synonyms for the words she wanted to use.

Formatting the Report

The final day of creating the reports was devoted to formatting the documents from FreeWrite into MSWord on desktop computers in the computer lab. Each person's report was saved to their personal directory on the network, where they could retrieve it when they went to the lab. There was one technical glitch confronting several students.

When the paper was downloaded into MSWord, the margins of the FreeWrite document were transferred creating a paper with incomplete lines. Each line ended before the right margin and MSWord reported the initial word of the next line should be capitalized. Trying to correct all the problems created by this technical glitch required time during the period devoted to formatting in the computer lab.

Most students found it as easy or easier to correct mistakes on the computer than on a Palm. Only three students thought it was easier to find mistakes on the Palm compared to the computer (see Table 5). Reporting on her effort to format her paper, one student said, "I had to indent, make better and longer sentences, capitalizing and uncapitalizing, taking out uneccessary [sic] marks, and just stupid mistakes."

Referring to the inability of FreeWrite to suggest possible spellings of misspelled words, students mentioned they liked MSWord's ability to suggest possible spellings. One student reports, "it's easier to do spell check on the computer because it tells you how to spell the word." One misconception held by many students is the "spell check did it all." Sometimes mistakes normally detected by the spell check were left uncorrected, but spell check wouldn't have found many mistakes found in the finished papers.

At the end of the project, the class was asked about things that are easier or harder to do with the Palm. Many members of the class thought using the Palm was easier because it was fun. One student rationalized why they liked the Palm because "it seems faster and way easier." One student, who was very positive about the Palm, answered, "Just about everything is easier on the Palms, because Palms are not as complicated as other things." Several students commented on how easy it was to type

on the Palm with the full size keyboard. They appreciated being able to type instead of writing on paper or type on the computer. One student liked typing because "you don't have to waste time with your stylust [sic]." Several students thought Graffiti was the hardest part of using the Palm, especially remembering how to do punctuation. However, one student liked Graffiti better because "it [is] like normal writing."

Some students thought the programs they considered games, such as Sketchy and PicoMap, were easy. One advocate of Sketchy said, "Making animations are a lot easier on the Palm because without it you would have to draw every picture over and over again when on Sketchy, you just have to copy and paste." Other students thought PicoMap and Sketchy were hard. Students had a difficult time making their animations look they way they wanted.

Other students mentioned they found specific features of the Palm useful or easy. One student liked reading with AutoScroll instead of turning pages, because "the Palm does it for you." Another student mentioned they appreciated the automatic save feature. Other students mentioned the problems they were having with Palm, such as the time it takes to hook up the keyboard, charging the Palm, or remembering to turn the Palm off before removing it from the cradle.

TABLE 5 Frequency data from surveys during final two days of inventors project

Question	**Available Reponses**	**Date of Survey**	
		5-14	5-15
What things have you finished?	Paper Bibliography Sketchy PicoMap	14 11 18 11	18 17 17 17
Did you use more information from books or Web sites in your project?	Books Web sites	2 11	

	Equal	7	
Are you ready for your presentation on Friday?	Yes No	5 15	
Was it easy or hard to format and correct your paper on the computer?	Easy Hard		13 4
Are you pleased with your final paper?	Yes No		15 3
Is it easier to find mistakes in your report on the Palm or on the computer?	Palm Computer About equal		3 8 7

For the final requirement for the project, each student gave a five minute oral presentation. The student showed their Sketchy animation using a small TV connected to an Elmo during their speech. After the talk was over, students also showed their concept map. All the students seemed comfortable placing their Palm under the Elmo and adjusting the Palm for correct viewing. When it was time to show the PicoMaps, no one had any trouble switching programs and scanning the concept map so everyone could see the whole thing.

Final Interviews

At the end of the project after everyone had finished his or her oral presentation, each student was interviewed about the project. The researcher asked additional questions about each of the applications and how they were used, explored attitudes about the Palm, and gave each student a chance to add their comments on the project. The comments about Sketchy and PicoMap are included above in the section about those applications.

Fling-it

One of the subjects discussed in the interviews was the use of Fling-it in the project. Most of the responses about Fling-it were positive. One student summed up the

main advantage, "you already have the Web site with you and you just take it anywhere you want." They really appreciated not having to go back to the computer whenever they wanted to check a fact or do additional research. One student said,

> It was just easier to do your research paper, because you didn't have to go load up the computers, and come back, work on your research paper, go look on the computer for more information. We just stayed here.

One student mentioned appreciating having access to the site until they were done with it. It was especially appreciated when the student didn't have Internet access at home. Almost all the students reported using the downloaded sites as their primary source of information. This supports Bilal's (1998) finding that children are motivated and fascinated by the Web, and they prefer its use over traditional sources. Mrs. V. required two print sources, so the students also used books for their research; however some students only used sites they downloaded into the Palm. Several students used Web sites printed for them by their mothers. They reported it was easier to write in FreeWrite from the printed copy, rather than going back and forth from FlingIt to FreeWrite. Again they mentioned the Palm allows only one window opened at a time so they couldn't easily use the downloaded information to write from.

The problems students had with Fling-it included some problems integral to the process and some problems created by not knowing how to use the program correctly. Several students mentioned they had problems at the beginning trying to learn how to use Fling-it. Some complained about the slowness of the download process. Several times, when someone tried to download a frame-based Web site, the text was not in order so it was hard to read. Another problem mentioned several times was the inability

to click the links when only the first level of the site was downloaded. This is something that can be corrected by setting the download to include multiple levels. However, by increasing the number of levels downloaded, the length of time for the download and the amount of storage space increases. Some of the students weren't aware the URL of the flung site is captured when the site is downloaded, but others expressed appreciation for Fling-it saving and displaying the URL for their bibliographies. The problem of the screen size arose again when talking about the flung sites. Students complained the sites looked too long:

> When you do fling it, it seems it's really, really long like since they're so small, it looks like they're really, really, really long, like you have to read forever just to finish, but on a real computer, it's just barely anything, like, say if it's like twenty-five Palm pages, it will be like, I don't know, six pages long, just on a computer.

One student didn't see any advantage to Flinging sites, "because if you have a computer, you can always just type it in and it will be right there." It was too much trouble to hook his Palm to the computer and wait for the site to download.

The students who have been diagnosed with dyslexia seemed to appreciate the ability to have the sites with them whenever they wanted to look at them. Possibly having a few good sites to look at instead of the confusion of the whole web was helpful. One TAG student thought Fling-it was too much trouble to use and another one complained about not being able to read flung sites with frames. The regular students had some complaints, but generally appreciated the convenience of having the site available for reference. As one student reported, "You want to go to the Web site, you

just click home and you click…um, the Web site thing and you're there…it's like shorter and easier."

When asked in the interviews how they determined which sites to fling, the students reaffirmed many of the same answers given on the written survey, such as skimming the site to determine how much information was there or determining if the information was "needed", "helpful", "good", or "important". Again during the interviews, the factor mentioned the most was the amount of information. If there seemed to be lots of information about the inventor or invention, the site was downloaded. During the interviews, students shared additional factors determining relevance. Specific information sought, such as facts about the inventor's life or items to place in the conclusion, was mentioned as relevancy factors. During the interviews, students mentioned they were looking for unique information, information they didn't already have.

The TAG students mentioned they looked for a large amount of information and whether it was the "right" information. The assignment required information about the inventor's life and invention, so the information sought had to fit into the assignment. Half the TAG students mentioned uniqueness as a factor determining if they would fling the site. The students diagnosed with dyslexia looked for many of the same factors: uniqueness, amount of information, and the specific type of information required for the assignment, such as facts about their childhood and life. The regular students were predominantly looking for the amount of information. A few regular students mentioned in the interviews the information had to be interesting or "good".

FreeWrite

Students were asked about their perception of FreeWrite, the word-processing program. During the interviews they restated some of the problems they had mentioned in the surveys, such as how hard it is to tell how many pages had been written on the Palm and how long reading assignments seemed because of the large number of pages assigned. However some students reported the small pages were a benefit, because the writing and reading were perceived to go faster. Some students reported they liked writing in FreeWrite, especially their journal entries, while some students didn't like the writing process even on the Palm.

During the final interview the researcher asked about the use of paper during the project. Several students wrote their rough draft on paper and then transcribed it into the Palm. Others took notes from their downloaded sites on paper and then wrote from the notes into FreeWrite.

One student said FreeWrite was the program that helped him the most. Several students compared FreeWrite with MSWord, saying "it is just like on the computer," so comparisons with MSWord were inevitable.

Most of the students complained about the spell checking feature. The students had several complaints besides those reported in the survey results, such as FreeWrite not listing suggested words for the misspelled words and not accepting contractions as correctly spelled. Students also complained about how slow the spell checking process was.

Choice of Input

During the final interview, the students were asked which type of input they preferred. There are three types of input for the Palm, the external keyboard, a keyboard on the screen which you use with a stylus, and the character recognition area which uses Graffiti, a single stroke input language using a stylus. Most students reported liking keyboarding. One girl said, "When I start typing…I really can't stop, my hands are just like…they won't stop." A few students thought the on-screen keyboard was useful when the keyboard wasn't attached.

Several students reported they liked to use Graffiti. At the beginning of the project, Graffiti was introduced to the class and time to practice was offered. The initial scores for Giraffe, a Graffiti practice program, ranged from 150 to 1977 (mean=1084). At the end of the project scores ranged form 521 to 2810 (See Table 6).

TABLE 6 Practice Giraffe Scores

Day	Giraffe Score
Day 3	1084
Day 8	1193
Day 18	1260
Day 22	1489

Some of the students used Graffiti when inputting to FreeWrite, but mainly it was used while creating PicoMaps. It is more convenient to use Graffiti with PicoMap, because the user usually held the Palm in the hand to draw the nodes and lines, making it difficult to have the keyboard attached. Even those who used Graffiti with PicoMap sometimes reverted to the keyboard for entering numbers and punctuation, maybe because it was harder to remember the proper stroke for those characters. Mrs. V felt

enthusiasm for Graffiti was very high at the beginning, but decreased as time progressed. She thought Giraffe might not have been as exciting as the novelty wore off or because the students had an alternative input device so there wasn't much incentive for improving their scores.

Paper or Palm?

During the final interviews, the students were asked about their use of paper. In the surveys four of the students, three diagnosed with dyslexia and one regular student, reported writing their rough draft on paper. Seventeen other students reported writing their rough draft on the Palm. When asked during the final interviews, most students reported writing both their rough draft and final report on the Palm. However, four of the students diagnosed with dyslexia, took notes from the downloaded Web sites on paper then wrote the report in FreeWrite from their paper-based notes.

One of the regular students reported, "I just wrote on FreeWrite, I didn't do anything on paper, even though I know I should have." When asked why she thought she should have used paper, she said,

> Our last um, research project was a lot better and I think because I started out on paper and not on the computer…it was really confusing…it's a lot easier with pen and pencil to, to first write it down on paper instead of doing it on computer.

It was observed many students used paper at least as a memory aid when using the downloaded Web sites.

Complaints and Suggestions for Improvement

Several students suggested ways to improve the Palm handheld during the final interviews. They mentioned wanting improved functionality on the Palm, such as being able to touch the screen with fingers instead of a stylus or more color. One student would have liked the setup of the handheld in the keyboard cradle to be easier and another would have liked the keyboard to be smaller. Another suggested the keyboard be hooked up to the Palm and "just press a button and it just pops right out." The topic of having more than one window opened at a time resurfaced. It was suggested several times windows should be able to be minimized for easy access to programs currently being used.

The primary topic of both praise and complaint was games. The students liked to play games on the Palm, such as Giraffe and the puzzle game, but they wanted more elaborate games. They want "adventure games, like shooting games."

The students complained about the need to recharge the batteries on a daily basis. They were very aware of when the Palms were low on power. Sometimes they couldn't take their Palm home in the evening because they felt they needed to leave it at school to recharge.

They wished the Palm would not require a reset after a period of inactivity. Many were scared they would lose their data if they didn't perform the reset correctly thereby doing a hard reset instead of a soft reset.

Overwhelmingly the students reported they would use the Palms again if given a chance.

Comparison with other Research Projects

During the final interview, the students were asked to compare this research project with others they completed during the year. Many of the students reported this project was more fun due to the use of the Palm. They enjoyed using the Palms and mentioned it was a new experience. One student reported,

> It was much more interesting because I just didn't know about the Palm and I know so much about computers, I had no clue what Palms were, so it was a new experience for me.

They appreciated the one-to-one student-computer ratio. One student said, "[Other projects were] a lot harder to try to type your report because other people are always there [on the computers]." One student complained he worked on the last research project all night typing his paper, but this time the paper was already typed. In addition to be able to have access to a computer quickly, the students appreciated the Palm booted up quickly. It was perceived there was less "stuff" to carry home to work on the project. For example, on other projects one had to "pick up all your books, your research folder, all your notes."

When most students complained about this project it wasn't related to the use of the Palm, but other factors such as the unavailability of information on their inventor, though some students did complain about having to use the Palm and would have liked to do the project on paper. One student thought the other projects were easier because she had a computer at home and she could "just go home and type it all up and print it."

Attitudes and Roles

At the end of the project, a semi-structured interview with Mrs. V was held. One observation Mrs. V. made was the degree of cooperation among the students. She reported increased interaction within the class, one she had previously described as "very talkative." She observed the class helping one another to solve technical problems and beam information to one another. She felt the students helped one another more than she did. To corroborate her observation, the researcher also frequently observed students helping one another during the project. As previously mentioned, one student offered to download a Web site into another person's Palm during the information gathering phase. Other times, students would share ways to do a task on the Palm or work together to solve a problem.

One interesting interaction happened outside the Inventors' research project time. Mrs. V had downloaded a game for one student to test and report back to the class. By the end of the day, the game had been beamed to all the other students in the class without her even noticing. She felt other interactions probably were transpiring without anyone noticing. At another point, Mrs. V allowed the class to use PicChat, an application allowing whatever one writes on the screen to be beamed to another handheld. That application increased interaction and was enthusiastically used by the class.

Mrs. V. mentioned a change in attitude the researcher was not privy to. One of her students had almost failed in the previous six weeks, but had completely changed his attitude during the project and was actually getting an award for improvement at the end of the year in the work with the Palm.

When asked about her role within the research project, Mrs. V. reported she 'went from being an informant, to a facilitator, to really being not needed as much." This was supported by observation. At the beginning of the project, Mrs. V. was very interactive with the students, helping with the Palms and answering questions about the assignment. As the project progressed, she spent less time with the students and more time completing tasks for the end on the year. She reported thinking the students "got really good at being experts on their own Palm and knowing what they had to do." She felt the increased self sufficiency was helpful.

Rubberneck Log File Analysis

The log analysis program, Rubberneck, was added to the Palms on April 30, the second day of research and gathering information. The Rubberneck program reported when applications were opened and closed and also it attempted to record when files were created, deleted, and changed. A sample output from a Rubberneck file is shown in Figure 4. The time was reported in hours:minutes:seconds in military time. It was possible to trace when the students were using a program, whether it occurred after school, on the weekends, or during the time each school day designated for the Inventors project. When an application was launched, Rubberneck recorded the time and a four-letter code, which represented a specific application. That aspect of the program seemed to work without fault when the program was active. Unfortunately, the other component of the program, which attempted to record when files were created, deleted, and changed, created uninterpretable data. For example, each time Fling-it downloaded a file, many records were created and resized. The problem created a situation in which the data might show hundreds of Fling-it files created and only a few

removed even though there were only a few downloaded sites on the Palm after the project was over. Another problem occurred with Rubberneck when the Palm required either a soft or hard reset. The Rubberneck program would not restart automatically and many students lost data when Rubberneck was not reactivated. Only 15 of the 24 students had complete datasets.

```
4/30/2002 12:14:10 powerOn
 4/30/2002 12:14:11 appLaunch: appCreator=Gira
 4/30/2002 12:14:14 appLaunch: appCreator=lnch
 4/30/2002 12:14:18 appLaunch: appCreator=HHKd
 4/30/2002 12:14:24 appLaunch: appCreator=lnch
 4/30/2002 12:14:26 appLaunch: appCreator=fWrt
 4/30/2002 12:15:47 newRecord: recordID=8470539 newSize=120
 4/30/2002 12:37: 1 resizeRecord: recordID=1622017 newSize=1
 4/30/2002 12:37: 3 resizeRecord: recordID=1622017 newSize=1
 4/30/2002 12:37: 6 appLaunch: appCreator=lnch
 4/30/2002 12:37:10 appLaunch: appCreator=HHKd
 4/30/2002 12:37:13 appLaunch: appCreator=lnch
 4/30/2002 12:37:29 appLaunch: appCreator=fWrt
 4/30/2002 12:37:55 appLaunch: appCreator=lnch
 4/30/2002 12:37:57 powerOff
```

FIGURE 4 Sample Rubberneck output

There are some interesting findings from the Rubberneck data. By tracking when the students were using the Palm, Rubberneck allowed the analysis of which students were using the Palm more, both at school and in their free time. A summary of Palm access by the students with complete datasets is shown in Table 7. The table is divided by the three groups of students this study examines, regular students, students recognized as gifted and talented (TAG), and students diagnosed with dyslexia. The second and third columns of the chart show the number of days in the two weekends and the number of evenings in which Rubberneck showed Palm activity. The remaining columns are the number of times each application was opened and the last column is

the composite number for the four programs used to create the report, animation, and concept map. The students also used other applications according to their interests. One student used the address book almost as often as she used FreeWrite. Another student was fascinated by learning Graffiti. He opened that application 31 times. Several students played frequently with a puzzle game the class was given in the middle of the project.

There are some problems with assuming the Rubberneck data tracks the use of the Palm by the student. The Rubberneck data couldn't show whether it was the student, a family member, or friend who was using the Palm in the evening hours or on the weekend. Several Palms were repeatedly accessed late at night, which might indicate it was not the student who was using the Palm. Additionally, the Rubberneck data can't distinguish between whether the student was using the Palm for schoolwork or entertainment. Some of the students didn't take their Palm home on either weekend. Others used the Palm almost everyday after school. On average, the TAG students used the Palm handhelds more often than the regular students and the regular students used them more often than the students diagnosed with dyslexia. This was true both for working at school and at home.

One exception to this observation is the TAG student who never took his Palm home in the evening and who only worked on the Palm for one weekend day. He finished his paper on the first weekend, because he mistakenly thought the paper was due the next day. This may be relevant to why he never took the Palm home on any other evening or other weekend.

TABLE 7 Use of Palm in regards to time and application

Student	weekends	evenings	FreeWrite	Fling-it	Sketchy	PicoMap	Total
Regular Students							
Regular	2	8	144	24	23	11	202
Regular	2	4	95	29	26	6	156
Regular	1	7	156	61	31	10	258
Regular	1	4	72	10	23	2	107
Regular	0	5	153	37	32	11	233
Regular	0	3	66	36	40	3	145
Regular	0	3	82	33	6	6	127
Regular	0	0	44	7	7	3	61
Mean	**0.75**	**4.25**	**101**	**29.63**	**23.5**	**6.5**	**161.13**
TAG Students							
TAG	4	11	94	46	52	20	212
TAG	1	8	130	93	25	16	264
TAG	1	0	41	18	35	7	102
TAG	0	1	23	12	14	3	52
Mean	**1.5**	**5**	**72**	**42.25**	**31.5**	**11.5**	**157**
Students diagnosed with Dyslexia							
Dyslexic	2	4	105	8	6	22	141
Dyslexic	0	4	85	32	12	10	139
Dyslexic	0	2	53	41	20	7	121
Mean	**0.67**	**3.33**	**81**	**27**	**12.7**	**13**	**133.7**

Some interesting patterns developed by examining the order in which the students accessed the applications. For example, the TAG student who finished his paper on the Sunday of the first weekend didn't use the downloaded files at any time during the weekend, indicating he used other sources for his report. This is confirmed by his bibliography that only had two books and one Web site on it. When asked whether he used books or the Internet more for research, he was one of only two students who said he used books more than the Internet. Also, his Palm only had two downloaded sites on it when it was turned in. Several students had patterns in which FreeWrite alternated with Fling-it indicating they were referring to the downloaded sites then switching to FreeWrite to write their report without the intermediate step of taking notes on paper. These students reported in their final interviews they did go back and forth from FreeWrite to Fling-it when they were writing their papers. Many students thought going back and forth from FreeWrite to Fling-it was too difficult. One regular student reported in his final interview,

> Most of the time I would write it on the paper, because if you didn't take notes than each time, you would have to keep going back and forth and back and forth to get information. I…I tried that and I could only get one sentence and then I would have to go back to Fling-it again, get another sentence, go back, stuff like that.

Only one student's Rubberneck file indicated she referred to FreeWrite documents and Fling-it sites when she created her PicoMap.

The Rubberneck files also revealed a flurry of activity at the end of the project. Many students didn't start on their concept map until the end of the project. This

confirms the observation PicoMap was not a favorite among the students. Rubberneck also revealed one student worked the whole evening and the next morning before school finalizing her assignment.

There is some discrepancy between what the student reported and the Rubberneck data. On Monday after the first weekend, the students were asked whether they had worked on their paper over the weekend. Three Rubberneck files indicated the Palms hadn't been used all weekend, but the students reported they had worked on their project. This may be due to several factors such as trips to the library or note taking from books with paper. One student reported he didn't work on his paper over the weekend, but his Palm was used during that time which indicates he or another person was using the Palm for other reasons. During the final interviews, many of the students reported working many hours at home although the Rubberneck files didn’t show much activity. Several students reported using home computers for research on this project.

Examination of the Palm

Each student's Palm was examined at the end of the project to determine how many and which sites had been downloaded. How many sites each student reported downloading into their Palm, the number of sites on the Palm at the end of the project, and whether they cited the downloaded Web sites in their bibliography are shown in Table 8. Many times the number of sites the students claimed to have downloaded didn't match the number of sites in the Palm. This could be due to a number of reasons. For many students, they didn't report an exact number on certain days, they just reported they had downloaded over four Web sites. Additionally, sites could have been

deleted when they were found not to be necessary or were a duplication of sites previously downloaded.

There were many problems with the bibliographies. Most students had problems completing the bibliography in the required MLA format even though they had reference sheets and had practiced the format for other research papers during the year. Many of the bibliographies were not complete citations and many of the URLs were incomplete. Some students used search engines for a citation. When a site is downloaded into the Palm with Fling-it, the URL of the downloaded site is part of the description in the Palm, so the students weren't required to capture each source's citation as they were using the source. The students had to copy the URL from Fling-it into FreeWrite without cutting and pasting, because one can't cut from Fling-it.

The TAG students used only the sites they had downloaded into their Palms. Both the other groups used sites both from the Palm and sites not downloaded to the Palm, but which were still correct URLs. The regular students also had many citations that could not be determined to be correct, including search engines and incomplete URLs.

TABLE 8 Number of Web sites reported downloaded, number of Web sites downloaded to the Palm, and number of Web sites cited in bibliography

	Number of Web sites reported on the survey	# of sites on the Palm at the end of the project	Sites cited in the bibliography
Regular	>8	14	3 (two from the Palm, 1 search engine)
Regular	6	6	5 (one from the Palm, 2 search engines, 2 sites not on Palm)
Regular	4	3	3 (one from the Palm, 2 sites not on Palm)

Regular	>4	15	1 (1 search engine)
Regular	>12	5	4 (all from the Palm)
Regular	3	8	2 (one from the Palm and one made up URL)
Regular	>7	11	2 (2 sites not on Palm)
Regular	>4	1	1 (1 site not on Palm)
Regular	3	4	4 (3 from the Palm, 1 site not on the Palm)
Regular	3	3	2 (2 from the Palm)
Regular	3	7	3 (1 from the Palm, 2 made up URLs)
Regular	2	2	No bibliography
Regular	5	6	2 (2 search engines)
Regular	>6	0	4 (URLs are not correct enough to track)
Mean	**5**	**6.07**	
TAG	>4	5	4 (4 from the Palm)
TAG	> 4	7	No bibliography
TAG	9	5	5 (5 from the Palm)
TAG	9	2	1 (1 from the Palm)
Mean	**7.33**	**4**	
Dyslexia	> 10	NA	6 (Unable to determine if they were on the Palm)
Dyslexia	> 6	6	3 (3 from the Palm)
Dyslexia	5	NA	No bibliography
Dyslexia	0	3	0 (only used books)
Dyslexia	7	8	5 (5 from other sites)
Dyslexia	6	2	3 (3 from other sites)
Mean	**5.43**	**5.2**	

Examination of the Papers

Originally, the final papers were scored on an original rubric by two teachers in the school under study. The rubric used is shown in Appendix G. The inter-rater reliability was unacceptable on organization, content, and grammar with one scorer scoring twice the score of the other, so another method of scoring was sought.

The 6+1 trait scoring guide was chosen as a standard, reliable scoring method. The 6+1 guide was created in the early 1980's to provide reliable, accurate feedback, which would be valid and practical. The model uses common language to identify traits of good writing at different levels of achievement. The 6-11 Trait Writing model is used

in the United States, Great Britain, France, South America, and other areas around the world. It is also the model used in numerous state assessments.

The model scores 6 traits. Below is how Northwest Regional Education Laboratory (N.D.) in Portland, Oregon describes the six traits.

> Ideas - The Ideas are the heart of the message, the content of the piece, the main theme, together with all the details that enrich and develop that theme. The ideas are strong when the message is clear, not garbled. The writer chooses details that are interesting, important, and informative– often the kinds of details the reader would not normally anticipate or predict. Successful writers do not tell readers things they already know; e.g., "It was a sunny day, and the sky was blue, the clouds were fluffy white …" They notice what others overlook, seek out the extraordinary, the unusual, the bits and pieces of life that others might not see.
>
> Organization - Organization is the internal structure of a piece of writing, the thread of central meaning, the pattern, so long as it fits the central idea. Organizational structure can be based on comparison-contrast, deductive logic, point-by-point analysis, development of a central theme, chronological history of an event, or any of a dozen other identifiable patterns. When the organization is strong, the piece begins meaningfully and creates in the writer a sense of anticipation that is, ultimately, systematically fulfilled. Events proceed logically; information is given to the reader in the right doses at the right times so that the reader never loses interest. Connections are strong, which is another way of saying that

bridges from one idea to the next hold up. The piece closes with a sense of resolution, tying up loose ends, bringing things to closure, answering important questions while still leaving the reader something to think about.

Voice - The Voice is the writer coming through the words, the sense that a real person is speaking to us and cares about the message. It is the heart and soul of the writing, the magic, the wit, the feeling, the life and breath. When the writer is engaged personally with the topic, he/she imparts a personal tone and flavor to the piece that is unmistakably his/hers alone. And it is that individual something–different from the mark of all other writers–that we call voice.

Word Choice - Word Choice is the use of rich, colorful, precise language that communicates not just in a functional way, but in a way that moves and enlightens the reader. In good descriptive writing, strong word choice clarifies and expands ideas. In persuasive writing, careful word choice moves the reader to a new vision of things. Strong word choice is characterized not so much by an exceptional vocabulary that impresses the reader, but more by the skill to use everyday words well.

Sentence Fluency - Sentence Fluency is the rhythm and flow of the language, the sound of word patterns, the way in which the writing plays to the ear, not just to the eye. How does it sound when read aloud? That's the test. Fluent writing has cadence, power, rhythm, and movement. It is free of awkward word patterns that slow the reader's progress. Sentences vary in length and style, and are so well crafted that the writer moves

through the piece with ease.

Conventions - Conventions are the mechanical correctness of the piece– spelling, grammar and usage, paragraphing (indenting at the appropriate spots), use of capitals, and punctuation. Writing that is strong in conventions has been proofread and edited with care. Handwriting and neatness are not part of this trait. Since this trait has so many pieces to it, it's almost a holistic trait within an analytic system. As you assess a piece for convention, ask yourself: "How much work would a copy editor need to do to prepare the piece for publication?" This will keep all of the elements in conventions equally in play. Conventions is the only trait where we make specific grade level accommodations.

The traits are distinct enough to score individually. Each writing sample was scored on each trait. Some papers were strong in some categories and weak in others. The scoring in this study was based on a four point system based on the system the state test writing sample was scored. See Appendix H for a description of the scoring rubric.

Three fourth grade teachers trained to use the 6+1 scoring guide agreed to score the papers. Two teachers scored all the papers and the third teacher was available if the original two could not reach consensus. The third scorer was not needed at any point. Both teachers independently scored the papers on ideas, organization, and conventions, three factors which might show differences between being created on paper or on the Palm. The scorers recommended these three traits as ones that might show the most variability. After scoring the papers independently, they compared scores

and reached consensus on a single score for each of the three traits for each paper. Raw scores and means for papers from each class are shown in Table 9.

TABLE 9 Raw scores and means for each paper on the scoring rubric for 6+1 traits using three categories: Ideas, Organization, and Conventions

Paper number	Teacher	Ideas	Organization	Conventions
1	V	2	1	2
12	V	4	3	3
19	V	2	2	1
42	V	4	4	4
43	V	3	3	3
	Mean	**3**	**2.6**	**2.6**
2	K	3	2	4
11	K	3	2	3
13	K	4	4	3
15	K	2	2-	2
18	K	2	2	2
21	K	2	1	1
39	K	4	4	4
40	K	2	2	1
44	K	2	2	2
	Mean	**2.67**	**1.22**	**2.44**

The class's final papers were compared with papers written by a class in the same school that had done the same project earlier in the year. Mrs. V. felt the chosen teacher had much the same teaching style as herself. Selected papers were chosen to be scored because the students in the control group were allowed to choose duplicate inventors which resulted in fewer inventors overall. The inventors chosen by the students in the control group were generally well known and information about them was easy to locate. Five inventors were chosen by both classes: Alexander Graham Bell, Albert Edison, Benjamin Franklin, Eli Whitney, and the Wright brothers. Because

Mrs. V only allowed one student to pick each inventor, five papers from her class were scored. Nine papers about the same inventor from the control group were also scored.

Independent t-test demonstrated the difference between the means of the treatment group and the control group was not statistically significant (see Table 10).

Table 10 - Independent t-tests comparing the means of the 6+ trait scores for the treatment and control groups.

	Ideas	Organization	Conventions
t-score	0.52 (p>.05)	0.66 (p>.05)	0.91 (p>.05)

Mrs. V. remarked the written reports seemed to have more mistakes than other reports produced by the same students. In Robertson, Calder, and Fung's study, (Roberston et al., 1997) the English teacher thought students tended to make more punctuation errors using the handheld. Mrs. V. reported the final papers had more grammatical problems, such as spelling and spacing problems, than the papers the class had produced in the past.

One of the main concerns the students had during the project was determining how much they had written. The requirement for the paper was 2.5 pages, but the average length of the papers was shorter than the required length. The average length of the completed papers is shown in Table 11. Only two (14%) of the regular students and two (33%) of the students diagnosed with dyslexia turned in papers at least 2.5 pages long. One (25%) gifted student turned in a paper that was too short. From the control class, eight papers (32%) were less than 2.5 pages.

TABLE 11 Average page length of final papers

Group	Average page length of final paper	Percent papers with less than 2.5 pages
Gifted students	3.6	25%
Students diagnosed with dyslexia	2.1	33%
Regular students	1.8	85%
All Mrs. V. Class	2.2	71%
All the control group	2.9	32%

The papers from the two classes had different fonts and margins so comparisons of length do not reflect the actual amount of content in each paper. All Mrs. V's class used a 12 point font. All the control class except three students used a larger font. The reason for this discrepancy was not investigated.

Some of the papers had evidence of the peer review process even after the formatting process. One paper still had the words in all capital letters the peer reviewer had added to the paper. Another paper had capital letters at the beginning of lines. This problem was caused by the hard return the Palm put into the paper. When the student ran spell check in MS Word, it indicated the first word on each line was supposed to be capitalized.

Discussion

This study investigated the five research questions below. Each question will be individually addressed in this section. First, there will be a brief description of the results then a more extensive explanation of the results.

- Are there differences in information gathering and use with the Palm between gifted, dyslexic, and regular learners? – The three groups started with different levels of computer skills and usage and did not participate in the project equally, so the findings on this question may be suspect. TAG students used in their

bibliography only Web sites that had been flung to the Palm, while the other two groups included Web sites in their bibliography that had not been downloaded. TAG students reported using the Web less, but said it was more helpful than print sources. The students diagnosed with dyslexia were more consistent. They reported using Web sources more than print and reported that Web sources were more helpful.

- What relevance criteria do students use to evaluate a Web site to determine whether to download the site to the Palm? – Students reported several factors used to decide whether to download Web sites, but the predominant deciding factor was the amount of information. Due to the speed with which they decided whether to download a site, little other than the size of the page and the main topic could have been the determining factor.
- How do the Palms affect the writing process? – The students in Mrs. V's class used a combination of writing on paper and the Palm. Many students flipped between two programs, FreeWrite and Fling-It finding information and then writing the facts into the report. The peer review process was more difficult with the Palm. The students limited themselves to running the program to check the spelling on the report and did not focus on other errors. There wasn't a good method to report other types of errors, as there would have been on paper or in a word processing program with additional features. Most students had more grammatical errors in this research report than in previous research projects.
- Do the animations and concept maps produced on the Palm demonstrate understanding of the intended concepts? - By creating the animations, the

students demonstrated their understanding of the invention though sometimes the media or the student's drawing skills limited the quality of the final product. Creating the animations was motivational and addressed different learning styles than a written report alone. The PicoMaps demonstrated only simple concepts and relationships. Because they were created at the end of the project, the evolution of understanding of their understanding was not evident and the students couldn't use the concept maps to organize their thoughts because they created them after the written report was finished.

- Are there significant differences in results (i.e., final products grade) between Palm users and non-Palm users? – No statistically significant difference was found in the scores of the three 6+1 Traits categories, however the Palm users didn't meet the page-length requirement for the research project but the majority of the control class did.

Question 1

Question 1 asked what are the differences in information gathering and use with the Palm® (Palm, Inc.) between gifted, dyslexic, and regular learners. Examining the three groups' answers on the survey given at the beginning of the project revealed some interesting initial differences in a few categories (See Table 12). The gifted students reported better computer skills than the other two groups. All four of the gifted students self-reported good or excellent computer skills. Whereas, less than 60% of the regular students and 66% of the students diagnosed with dyslexia reported good or excellent computer skills. The gifted students used the computer more for schoolwork than the other students, but almost all the students from each of the groups reported

using computers to play games. All the gifted students used the computer for schoolwork, but only about 65% of the other students reported using computers for schoolwork.

TABLE 12 Frequency data from survey given at beginning of inventors project divided by student group. (Note: TAG = Talented and Gifted, REG = Regular Students, DYS = Students diagnosed with dyslexia)

Question	Answer	TAG (4)	REG (14)	DYS (6)	Results
How much do you use computers?	Almost every day	2	6	2	10
	Several times a week	1	4	2	7
	Weekly	1	4	2	7
	Only when I have schoolwork				0
What do you do on the computer?	Schoolwork	4	9	4	17
	Games	4	14	5	23
	Email	2	6	3	11
	Instant Messenger	0	7	2	9
	Surf the web	4	9	5	18
How much do you play with your Gameboys® (Nintendo Co., Ltd)?	Almost every day	0	1	1	2
	Once or twice a week	1	4	2	7
	Once or twice a month	2	2	0	4
	Hardly ever	1	6	2	9
How do you learn best?	Play with the program	4	5	5	14
	Have someone show me how	2	5	2	9
	Read the instructions	2	5	1	8
How are your computer skills?	Poor	0	0	1	1
	Average	0	6	1	7
	Good	1	8	3	12
	Excellent	3	0	1	4
When you use a Web site for a project do you take notes from the screen or print it out?	Write notes	2	8	3	13
	Print the site out	4	10	4	18
When you use a book do you write the paper with the book in front of you or do you use notes?	Use the book	3	7	3	13
	Use notes	4	11	5	20

In addition to having different levels of computer skills and usage, the three groups did not participate in the project equally. The students who were diagnosed with dyslexia were taken out of class for separate activities for forty-five minutes of the two hours devoted to the research project each school day. Including packing up time and the time to get back to work, the students who were diagnosed with dyslexia only spent half as much time in class working on their projects. This may account for the observation that the students who worked on other assignments during the time set aside for the research project were mostly either TAG students or regular students. Also the gifted students were gone for the peer review process.

Information Gathering and Use

The TAG students used only the sites they had downloaded into their Palms. Both the other groups used sites both from the Palm and sites not downloaded to the Palm, but were still correct URLs. Eight out 14 (57%) regular students had Web sites listed on their bibliography that were on their Palm; however only one out of six (17%) students diagnosed with dyslexia had Web sites listed on their bibliography that were on their Palm. The regular students also had many citations that could not be determined to be correct, including search engines and incomplete URLs. Two out of six (33%) students diagnosed with dyslexia and five out of 14 (36%) regular students had Web sites listed on their bibliography that were not on their Palms, but the gifted students didn't have any. Interestingly, two students diagnosed with dyslexia had a relatively large number of Web sites on their bibliography that were not on their Palm. These data suggest that the TAG students used only the downloaded Web sites from the Palm, while the other two groups reported using Web sites that weren't downloaded. Students

were never observed taking notes from the computers at school, so they may have been working on the Internet at home.

When asked whether they used the Internet or books for their research, most students had some variety in their answers. The percentage of each group of students reporting which data source was most helpful each day is reported in Table 13. Two students diagnosed with dyslexia and one regular student claimed they only used the Web for research at school and never used books. Eleven other students used the web exclusively for over half the days: 1 gifted, 1 student diagnosed with dyslexia, and 9 regular students. The six students diagnosed with dyslexia were divided among the three groups. Of the students diagnosed with dyslexia, three students used the web over half the time, one student used print material over half the time and one student balanced his time between the Web and print.

Table 13 Percentage of gifted students, regular students, and students who were diagnosed with dyslexia reporting which type of data source was most helpful in the information gathering phase of the research project.

	TAG	Regular	Dyslexic
Books	17%	12%	6%
Web sites	61%	44%	52%
Both	22%	34%	32%

Use of the Palm

All the gifted and all but one of the regular students reported writing their rough draft on the Palm. Three students (50%) who were diagnosed with dyslexia reported writing their rough draft on paper.

As reported earlier, the gifted students used the Palm handhelds more often than the regular students and the regular students used them more often than the students diagnosed with dyslexia, both at school and at home.

Some interesting patterns appeared upon examination of the order in which the students accessed the applications. Five of the six students diagnosed with dyslexia, 8 regular students, and only one gifted student had patterns in which FreeWrite alternated with Fling-it indicating they were referring to the downloaded sites then switching to FreeWrite to write their report without the intermediate step of taking notes on paper.

As mentioned previously, FreeWrite's spell-checking function does not offer suggested spellings. It may be important for the students diagnosed with dyslexia to use a spell checker that suggests the correct spelling for words. In Price's study (1994), the students who regularly used the spell checker started to recognize what types of errors they were making which gave them more self-confidence as spellers.

Attitudes

Attitudes about the various applications on the Palm were assessed for each group and found to be very similar. Sketchy was generally liked by almost all the students, whether they were regular, gifted, or identified with dyslexia. The two students who were most enthusiastic about Sketchy had been identified as gifted. All three groups of students appreciated being able to download sites with Fling-It, however two of the gifted students and some of the regular students had some criticism about the program. On the whole, attitudes towards PicoMap were much less enthusiastic. Some of the students diagnosed with dyslexia liked PicoMap and some didn't, while most of the regular and gifted students had a generally negative attitude toward the application.

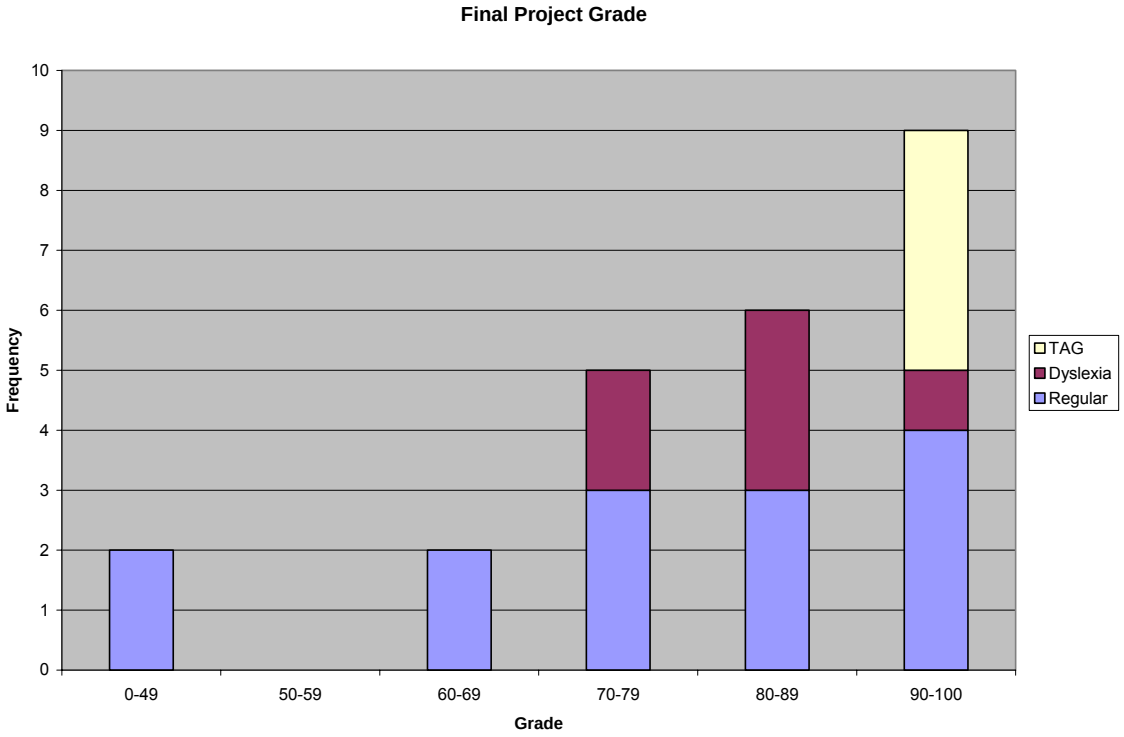
Final Grades

Final grades for the written report and the oral presentation are presented in Table 14 and Figure 5. The grades for the final project might have been affected by the presence of the Palm, but there was no evidence of that. The grades for the regular students demonstrated a bigger range than for the other two groups of students which might be due to the fact that there were a couple of slow learners and several very bright regular learners.

TABLE 14 Mean of the final grades for gifted, regular, and students diagnosed with dyslexia.

	Total Grade	Oral (out of 50 pts)	Written (out of 50 pts)
Gifted Students	98	50	48
Students with Dyslexia	82	43	35.8
Regular students	74.43	41.64	32.79

FIGURE 5 Frequency of final grades for gifted, regular, and students diagnosed with dyslexia



Question 2

Question 2 asked what relevance criteria students use to evaluate a web site to determine whether to download the site to the Palm. To answer this research question, criteria for relevance were gathered from the students through a variety of methods. Direct observation of searching and download behavior was conducted during the information gathering phase of the project. Questionnaires during the information gathering phase and semi-structured interviews after the study asked each student directly how he or she decided to download Web sites into the Palm. This study only examined relevance factors in regard to downloading Web sites into the Palm. Due to

the nature of the study, decisions about which search results were examined further on the desktop computer were not explored.

During the observation of information gathering, students moved through search results and Web sites so quickly only a quick skimming of major headings and subheadings was possible. Promising-looking search results were often ignored by the students. During the first few days of research, it appeared the students were in a hurry to find and download sites. These observations supported the findings of Hirsh's study of fifth grade students' interactions with electronic information sources (Hirsh, 1999). She explored relevance criteria and search strategies students used when searching for information related to a class assignment in a school library setting. She found students do not investigate sites in depth. The students in her study scanned the first paragraph and did not take time to read or evaluate the Web site.

Most students reported in the surveys and in the final interviews the amount of information about their inventor was the relevancy factor used most frequently to determine which Web sites to download. Other characteristics were mentioned much less frequently. Students mentioned they would fling the site if the information was "needed", "helpful", "good", or "important."

In the final interviews, students were more specific about how they decided to fling sites. For example, specific facts were sought, or the information had to be unique.

After the research project was over, the Palms were examined to determine what Web sites had been downloaded and compared with the student's bibliography. Most of the students used some of the Web sites they had downloaded. Unfortunately many of the bibliographic entries were not complete enough to be matched to actual Web sites,

however most of the students reported they used the downloaded Web sites as their primary source of information. Several students preferred print resources in this study. This study supports the findings of Large and Beheshti (2000) who found some students preferred print materials over information found on the Web, due to the difficulty in finding relevant information on the Web.

To Mrs. V's students, downloading Web sites into the Palm was much like gathering books off the shelf in the library by glancing at the title of the book. There was no need to spend a lot of time making a judgment of whether the Web site had the information they needed. It didn't "cost" to download a site, in fact, it was fun to download. Later when they read the Web site, they could determine whether it met their needs.

Question 3

The third question was how the Palm affects the writing process. The writing process for this project consisted of composing a thesis statement by the third day, writing a rough draft by 10th day, the peer review process and editing, rewriting and revising, and finally formatting the report on a desktop computer by the 16th day. The students had the option of performing all of these steps on the Palm except the formatting which was done on the desktop computers. How the Palm affected the final formatting of the paper will be considered because the document was created on the Palm. Access to the Palm at all times allowed students to write, edit, and revise the report on the Palm instead of transcribing it to a computer after the writing process.

Most students took all three days to complete the initial research and draft the thesis statement. Mrs. V. offered advice to most of the students while they were writing

their statement. She suggested most students had too much information in the initial draft of the thesis statement and should distill the ideas into a much more compact statement. It was not determined whether the students were writing too much for a thesis statement because they could not determine how much they had written on the Palm or whether they were novices at writing a thesis statement and would have written too much even if they had been writing on paper.

Many students preferred using paper and the Palm in combination while writing the thesis statement. Several students was observed writing the thesis statement on paper and transcribing it to the Palm; however most of the other students wrote the statement directly onto the Palm. One student referred to handwritten notes from a flung Web site to write the statement on the Palm. Other students referred to books while writing the statement on the Palm. However, several students were going back and forth between FreeWrite and Fling-it to compose the thesis statement and accomplished the task without the intervention of paper. Similar to writing the thesis statement, seventeen students reported writing their rough draft on the Palm. During the final interview, several students reported they wrote their rough draft on paper and then transcribed it into the Palm. Others took notes for the draft from their downloaded sites on paper and then wrote from the notes into FreeWrite.

In previous research projects, the students took hand-written notes on index cards from the Web sites or from books. After collecting the information, they would then sort the cards into the order in which they wanted the paper, and then write the paper by hand. In this project, the students could cut and paste sections of the document to rearrange the information.

Peer Review

Peer review was scheduled for two days before the rough draft was due. The class beamed their report to another student's Palm and made their editorial remarks on the Palm using the procedure for peer review described previously. Because this was the first time these students used the Palm for the peer review procedure, some students had difficulty following the directions and found the process confusing. Further experience with the process might make the review process easier for the students; however there are some limitations inherent in FreeWrite in its present configuration. For example, in many word processing programs there is a method to track changes by a second party not available in FreeWrite. Also, FreeWrite has no method for making comments to the other person on the document, which would be helpful in the peer review process.

After grading the papers and watching the peer review process, Mrs. V. felt the students had a difficult time editing with the Palms. Personal observation of the class supported her opinion.

Spell Check

Most of the students started the peer review process by spell checking their partner's document. The spell checking function in FreeWrite identifies misspelled words, but does not offer suggestions for the correct spelling. Mrs. V. felt her students were too dependent on other word processing programs suggesting the correct spelling

and because FreeWrite didn't suggest other spellings, the students had a more difficult time with editing.

Most of the students guessed the spelling of words FreeWrite identified as incorrect, but a few students looked the words up in the dictionary or asked an adult how to spell the word. Sometimes mistakes that should have been identified by the spell check were left uncorrected, but many mistakes found in the finished papers would not have been identified by a spell checking function. Most proper nouns are flagged as incorrect and some students tried to guess the correct spelling inadvertently adding errors to their partner's report. The spell check function in FreeWrite has the ability to add words into the dictionary and several students just kept adding misspelled words to their dictionary, which allowed misspelled words to look correct the next time they used the spell check function. Many of the students didn't do anything but check their partner's report for spelling before they beamed it back. The spell check function of FreeWrite can be quite lengthy, so the students might have thought they had done enough review when they had completed this lengthy process. Other reasons might have been the inability to easily make comments on the report or because the students were in a hurry. Most students liked the peer editing process and thought it was helpful for someone else to check over their work even though they realized the process is only as good as the person reviewing their paper.

Formatting the Report

The final day of creating the reports was devoted to formatting the documents from FreeWrite into MSWord on desktop computers in the computer lab. One student circumvented this process by having his mother type the report into a home computer

then printing it out to turn in. The other students formatted their reports in the lab. In addition to formatting the report, they also created a title page in the lab.

Many students found it easier to correct mistakes on the computer than on a Palm. Only three students thought it was easier to find mistakes on the Palm compared to the computer.

Question 4

The fourth research question was whether the animations and concept maps produced on the Palm demonstrate understanding of the intended concepts. As mentioned previously, students produced an animation in Sketchy for the project. To create an animation, the student created a series of drawings on the Palm shown in sequence at one of three speeds to simulate action. The amount of detail which could be produced on a Sketchy was limited, so only large concepts were conveyed through the animations. In addition, because of the size of the screen, the pictures were small, which also limited the impact of the animation for demonstrating complex concepts. Another thing limiting the impact of the animation was the drawing skill of the students. Some animations were easy to interpret, others were more difficult.

Several students added words to the animations to make the pictures more understandable. For example, the student who researched the inventor of the Popsicle labeled the Popsicle stand to make it clear what the salesperson was handing the customer. In another Sketchy, the student who researched the Wright brothers animated the flight and added the length of the flight to the animation.

When asked whether the creation of the animation helped them understand their inventor or inventions more clearly, the students reported a wide range of responses.

Some students found it enlightening to create the animations, while others thought creating the animations didn't teach them anything.

Mrs. V. scored the animation on whether it was relevant to the invention. All but one of the students received a perfect score on their Sketchy animation. On examination of the Sketchy animation, the majority demonstrated a basic understanding of at least one aspect of the invention. Many animations showed the invention in use. For example, the inventor of the steam cycle, an early form of the motorcycle, was demonstrated by someone riding up a mountain on the steam cycle. Another example of the use of the invention was demonstrated by a jail and Linus Yale appearing to unlock the door to allow the person to come out.

Because of the limitations of the program, detailed understanding of more complex concepts could not be demonstrated. Most of the students demonstrated clear understanding of the basic use of the invention, though some animations required more explanations. On both the clear and the unclear animations, when the student explained what they were trying to draw, it was usually clear they understood the concept they were trying to convey even though sometimes the media or the student’s drawing skills limited the quality of the final product.

A concept map created on PicoMap was also a requirement for the inventors project. While creating a concept map, the student consolidates understanding of the meanings and relationships between concepts. Creating a concept map may serve to facilitate learning by creating meaningful relationships between concepts (Zimmaro, Zappe, Parkes, & Suen, 1999). One advantage of using concept maps is it provides a

visual image of the concepts under study, which can be readily revised as new information or understanding occurs.

Many students reported the concept map helped them understand their inventor better and helped them to organize their thoughts.

The PicoMaps were graded on the relevance to the inventor and inclusion of at least 10 nodes. Over one half of the class received a perfect score on their concept map; however some of the completed concept maps were scored as low as 50. The maps scored low didn't have the minimum number of nodes. The PicoMaps created for the project had the inventor, not the invention, as the central node. Many students included biographical information such as birth and death dates. Students also included facts interesting to other children, such as nicknames, siblings, hobbies, and if the inventor got into trouble. Most of the relationships which were shown were simple, but accurate.

Question 5

The fifth research question was whether there are significant differences in results (i.e., final products grade) between Palm users and non-Palm users. No statistically significant difference was found in the scores of the three 6+1 Traits categories. One difference in the final reports between the Palm users and the non-Palm users was the length of the papers. The requirement for both classes was a 2.5-page paper. The average length of the Palm users was 2.2 pages compared to 2.9 pages for the control group. Seventy-one percent of Mrs. V's class did not meet the minimum requirement.

Interestingly, this finding supported the findings of Russell and Plati (Russell & Plati, 2002). This study compared the length of passages composed on paper, computers, and AlphaSmarts®, a portable word processing device that displays 4 lines of text. They found while there was not a statistically significant difference between the lengths of passages written by fourth grade students on paper or on AlphaSmarts, students who composed on computers wrote longer passages.

CHAPTER 5

CONCLUSIONS

This study was designed to examine the effect of Palm handheld computers on the information gathering and use of fifth grade students. Specifically, this study proposed that handhelds could create the one-to-one computer access research has shown is most effective for teaching and learning. Chapter 1 presented background information and an introduction to the subject. Chapter 2 reviewed the pertinent literature concerning the use of handhelds in the classroom and a brief overview of dyslexia and possible connections with handheld technology. The third chapter explained the methodology for data collection and analysis. Chapter 4 presented the data gathered by each collection method and how they informed each of the research questions. All field work was conducted by the researcher and was guided by the following five research questions:

- Are there differences in information gathering and use with the Palm between gifted, dyslexic, and regular learners?
- What relevance criteria do students use to evaluate a web site to determine whether to download the site to the Palm and afterwards whether to use the downloaded site's information in the report?
- How do the Palms affect the writing process?
- Do the animations and concept maps produced on the Palm demonstrate understanding of the intended concepts?

- Are there significant differences in results (i.e., final products grade) between Palm users and non-Palm users?

Based on the data presented and on the analysis, several findings emerged.

- In their bibliography, TAG students used only Web sites that had been flung to the Palm, but dyslexic and regular learners used Web sites that had not been downloaded.
- All three groups had positive attitudes toward the Palm
- The predominant deciding factor to determine whether to download Web sites to the Palm was the amount of information about the inventor.
- The students in Mrs. V's class used a combination of writing on paper and the Palm.
- Many students flipped between two programs, FreeWrite and Fling-It finding information and then writing the facts into the report.
- The peer review process was more difficult with the Palm.
- Most students had more grammatical errors in this research report than in previous research projects.
- The animations demonstrated the students' understanding of the invention though sometimes the media or the student's drawing skills limited the quality of the final product.
- Creating the animations was motivational and addressed different learning styles than a written report alone.
- The PicoMaps demonstrated only simple concepts and relationships.

- No statistically significant difference was found in the scores of the three 6+1 Traits categories between the papers created by the control group and the class using the handhelds.
- The Palm users didn't meet the page-length requirement for the research project but the majority of the control class did.

The following chapter presents the conclusions developed from the data, how the conclusions may be biased by the limitations of this study, and the future research needed.

Conclusions

The conclusions to be discussed are the ability for the Palm handheld to solve the one-to-one computer/student ratio which research has shown to enhance teaching and learning and suggestions for improving the Palm handheld for use in the classroom. In this study, the Palm handhelds were used to gather information sources, acted as a word processing program, and allowed students to create animations and concept maps. Desktop computers were used when the students were finding Web sites to download to the Palm and when the students were formatting their reports. In these situations, the handheld enhanced and extended the uses of the desktop computer. With the handheld computer, the students could take the information from the Web sites to other locations and have the information with them as they wrote the papers. Each day, the students had access to the information they had chosen to download instead of having to refer to notes or to go back to the computer to take additional notes. Whether at home or a school, they could read and take notes from the Web sites. Additionally,

they each had their own word processor in their handheld. They didn't have to wait in line to use the desktop or use up valuable computer lab time to write their paper. Finally, each student could work on their animation or concept map whenever they had time. While the desktop computer assists in some functions, the handheld served valuable functions and could be used as the computational device of choice.

There are several changes to the Palm handheld which would make it more functional in the classroom. During the information gathering phase, it would be convenient if the handheld computer connected directly to the Internet, bypassing the need for a desktop computer. The students would be able to directly search for sites to download to the Palm. If the students could connect to the Internet at home or a school, they would have access to all the information on the Internet without the use of the computer.

Another thing that would make the information gathering phase easier is an automatic citation generator. The citation the students produced were many times so poorly executed as to make it impossible to find the Web site it referred to. If the downloading program could fill in some of the blanks for the citation and prompt the student to immediately find the other bits of information for the reference, the problem would be minimized.

There are several enhancements that would be helpful in the writing and editing phase. Many of the students wanted to quickly switch from the downloaded Web sites to the word processing program. If the handheld had the ability to switch back and forth between programs at the press of a button, the students would not lose their place and it would be easier to write from the sites.

One of the biggest problems for the students was determining the length of their writings. The assignment was to write a 2.5 page paper and they didn't know how to count their Palm pages. If the Palm offered a way to count the number of words in a document, the teacher could assign by number of words. This change would have the added benefit of not having the ability to manipulate the page length by changing the font size.

Another modification that would make the handheld easier to use for writing would be a fully functional spellchecking function. If the spellcheck program offered possible correct spellings, the students could pick the correct word, minimizing the possibility of incorrect spelling. Another option that would help during peer review is the ability to write comments. Students could write comments to their partner explaining other types of errors or perhaps suggesting other ways to word a sentence.

Other Considerations

There are several factors playing a significant role in the findings of this study. Several limitations were discussed earlier in this paper, such as the novelty effect, the Hawthorne effect, and the short duration of the project. Evidence of these limitations was reported by the students themselves. When talking about peer editing on the Palm, one student reported, "I like it because it is new but if you do it again and keep on doing it, it will get boring." One student when interviewed about creating animation with Sketchy noted, "It will be really fun the first couple weeks but then it will be kind of boring and it will become an every Palm day thing."

Doing this study at the end of the school year also had an influence on this study. Mrs. V. stated it was easier to keep the students focused on school because of their

engagement with the Palm. She said other classes were having a harder time staying focused, because the fifth graders had already been to visit the middle school and the Texas Assessment of Academic Skills (TAAS) test was over, Field Day was over, and it looked and felt like the end of school. The problem was especially evident on Fridays, when no one, not even the most enthusiastic supporters of the Palm, wanted to work.

However the project might have been completely different at another time of year. Mrs. V stated she would have liked to do the project at the beginning of the year when the students “want to do a good job. They are out to impress you, they want you to think they are bright…They work hard.” She felt the quality of the previous research paper was higher and the product “would have been a lot better” at a different time in the school year. On the other hand, the students were still cooperative with the researcher. For example, at the end of the day on Friday, the students were given an hour of free time to do what they wanted to do. It was during the time designated for the research project, but it was a standing tradition in Mrs. V’s class. When the researcher asked them to answer a questionnaire at the end of the work day, when they could be playing, they didn't seem to mind too much. Mrs. V felt the cooperation from the students occurred because using the Palm “was fun and it was different.” Despite this, the students' attention and motivation might have been higher if this project was done at another time of the year.

Additionally, the research project was done after lunch at the end of the day. This resulted in some students attempting to finish other work that was due at the end of the day or the next morning when they could have been working on the project.

Another factor that caused students not to work on the project for the complete time and could have influenced the results of this study was the daily interruption of the research process when the students diagnosed with dyslexia left the classroom for other activities. These students had substantially less time during the school day to work on their projects.

Another factor having a big influence on the students' attitude and ability to accomplish work with the Palm was technical difficulties. The major difficulties arose from the use of the Happy Hacker® cradle used to connect the Palm with the keyboard. This technical problem caused students' to lose work and was a source of irritation to the students. The students continued to use the keyboard, because even with the technical difficulties, the keyboard still seemed to be a more convenient input device than the alternatives. With a better connection between Palm and keyboard, the students would have accomplished more and would have had to cope with quite a few less problems.

Another factor influencing the students' attitudes about the Palm was the expectation of games. The Palm is about the size and configuration of the Gameboys® (Nintendo Co., Ltd) and almost 40% of the students reported playing with a Gameboy at least every week, so it could be assumed the students might expect the same kind of interaction with the Palm as the Gameboy. The expectation the Palm would entertain with games was expressed many times. When asked how to make the Palm better, the most frequent answer given was better and more advanced games. As Mike Lorion, Vice President for Education at Palm, Inc. points out, "Now, if we could finally get to the

point where in classrooms students could show the same affection to learning as they do to games" (Staudt, 2000)

On the other hand, students knew the Palm was usually reserved for adult use and they knew they were given the Palm to use for school work. One student commented, "When I use my Palm with a cradle and keyboard, I feel more like an adult and more important."

The students used the Palms every day of the study, both for this research project and in other subjects such as reading and math. By the end of the study, most of the students had become very proficient in knowledge and use of the various applications and the various pieces of equipment. Most students progressed from no knowledge of the Palm to being able to accomplish most functions without difficulty.

Additional Research Needed

Research involving the use of handhelds in the classroom is lacking and any studies conducted are exploratory and groundbreaking. Further examination of the use of handhelds is needed and could be of value to both information scientists and educators. A particularly useful study would be a longitudinal study of the use of the handheld for educational purposes and how attitudes and the use of the handheld change over time. A more exhaustive study of the change in attitudes during an extended period of handheld use would undoubtedly demonstrate a more accurate picture of attitudes if the handheld became a common instrument in the classroom. Studies of different ways students invent to use handhelds in school would also provide valuable data. Finding better ways to integrate the handheld computers into educational curriculum would also be a fruitful avenue of research.

Another research topic showing interesting possibilities centers on the quality and use of the Web sites downloaded to the Palm. Many Web sites were downloaded, but not referenced in the final paper. Further questioning about why students discarded some of the Web sites might illuminate the decision making process.

Finally, studies are needed which go beyond the focus of this research and consider the immediate and long-term effects of the use of handhelds on teaching and learning. Opportunities for research in relation to the handheld in the classroom are plentiful. Studies, both qualitative and quantitative, focused on this practical computing device would provide empirical data for verifying or modifying the findings in this study.

APPENDIX A

UNIVERSITY OF NORTH TEXAS COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS RESEARCH CONSENT FORM

UNIVERSITY OF NORTH TEXAS COMMITTEE FOR
THE PROTECTION OF HUMAN SUBJECTS
RESEARCH CONSENT FORM

Subject Name: Date:

Title of Study: **Study of the information seeking behavior of students using Palm handhelds.**

Principal Investigator: Cathleen Norris

Co-investigators: Martha Peet

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the proposed procedures. It describes the procedures, benefits, risks, and discomforts of the study. It also describes the alternative treatments that are available to you and your right to withdraw from the study at any time. It is important for you to understand that no guarantees or assurances can be made as to the results of the study.

Purpose of the study and how long it will last:

The purpose of this study is to find out how students gather and use information when they have access to a Palm handheld. The study will last through the end of the school year.

The Palms are self contained units that do not have access to the Internet except through other computers. By using a program called Fling-it, web sites can be downloaded to the Palm for use at other times. Because the only access to web sites will be through the computers in the school, the precautions such as filtering and acceptable use policies will be the standard precautions used at that school. Hebron Valley does filter their Internet access. These Palms will not be able to

provide email capabilities and we will not be using any of the calculating capabilities of the Palm.

There are several educational software packages that we will be using that have been produced by the Center for Highly Interactive Computing in Education, www.handheld.hice-dev.org

The first program is a word processing program called FreeWrite. It will allow the students to take notes from their sources, write and edit their papers, and send their completed work to the teacher's computer. The program has spell checking capabilities, but does not have all the features of a desktop word processing program such as MSWord.

The second program, PicoMap, allows the student to create concept maps. The concept maps created by the students will demonstrate their knowledge of their research subject by graphically representing the concepts and the relationship between the concepts.

Fling-it compresses Web sites to fit on the Palm for use at home or when the student doesn't have access to the school computers. Fling-it can download electronic encyclopedia articles available through the Texas Library Connection from the school's computers.

Another program the students will use is called Sketchy. Sketchy is a graphics animation program. Students will sketch and animate a presentation for the class as a final project.

Description of the study including the procedures to be used:

Students will be given Palm Handheld computers to use during the remaining part of the school year. The students will become acquainted with the functionality of the Palm through activities such as Giraffe, a game to teach users how to write on the Palm, and practice activities, such as activities to prepare for the TAAS. After the TAAS test, the students will begin their end-of-the-year research project on inventors. The students will use their Palms to capture information from the Internet, write and edit their papers, create concept maps, and animate their inventions for their final presentation.

Students will be interviewed during the research project to find out how they are using the Palm handheld. Students will be asked questions such as "I see you have downloaded this site, did you use the information from the site in your report?" or "Did you find the sites you downloaded to be useful?"

Description of procedures/elements that may result in discomfort or inconvenience:

Procedures in this study will not cause discomfort. The interviews will take place during regular school hours.

Description of the procedures/elements that are associated with foreseeable risks:

There will be no foreseeable risks involved with this study.

If the student hits another person with a Palm, district policy on violence will be in effect.

While we hope that students will be careful with the Palm Handheld, they or their parents will not be liable for any damage that occurs to the Palm.

Benefits to the subjects or others:

Each student will be given a handheld to use during the course of the study. Each student will also receive instruction and software for their use. The Palms will be returned to the company that donated the Palms for their use. Unfortunately at this time, schools don't use handhelds regularly in the classroom, so the students are not likely to encounter them in later school years. The research we are conducting will help school officials to make informed decisions about the use of handhelds in a classroom environment.

Confidentiality of research records:

Student interviews will be coded for confidentiality and only the primary investigator and co-investigators will have access to the codes.

Review for protection of participants:

This research study has been reviewed and approved by the UNT Committee for the Protection of Human Subjects (940) 565-3940.

RESEARCH SUBJECTS' RIGHTS: I have read or have had read to me all of the above.

Martha Peet has explained the study to me and answered all of my questions. I have been told the risks or discomforts and possible benefits of the study. I have been told of other choices of treatment available to me.

I understand that I do not have to take part in this study, and my refusal to participate or to withdraw will involve no penalty or loss of rights or benefits or legal recourse to which I am entitled. The study personnel may choose to stop my participation at any time.

In case there are problems or questions, I have been told I can call Martha Peet at telephone number 940-565-2963 or 972-492-2380.

I understand my rights as a research subject, and I voluntarily consent to participate in this study. I understand what the study is about and how and why it is being done. I have been told I will receive a signed copy of this consent form.

Subject's Signature	Date
Witnesses' Signature	Date

For the Investigator or Designee:

I certify that I have reviewed the contents of this form with the person signing above, who, in my opinion, understood the explanation. I have explained the known benefits and risks of the research.

Principal Investigator's Signature	Date

STUDENT ASSENT FORM

By signing this form I agree to participate in the research study about using handheld computers in the classroom conducted by Martha Peet under the direction of Dr. Cathleen Norris of the University of North Texas. I understand that the research is looking at the use of information while using the Palm handheld and will not affect my grade in any way whether or not I participate. Ms. Peet will be observing me using the Palm and will ask me questions about my use. I understand that I can refuse to answer any question that the researcher asks or refuse to allow the researcher to see my files and that I will still be able to use the Palm with the rest of the class.

The Palms will allow me to save Web sites for further use, word process notes and papers, create concept maps and make animations. I will not be able to directly access the Internet or use it for email. Keyboards will be available for my use.

The Palm handheld will be given to me to use for school activities. I will follow Mrs. V's rules about the Palm.

I will try to take care of the Palm handheld, but I will not have to pay for any damage that happens to the handheld. I will return the handheld at the end of the research project.

It is okay for the researcher to look at the files I create and to ask me questions about what I did. Some of the questions might be "I see you have downloaded this site, did you use the information from the site in your report?" or "Did you find

the sites you downloaded to be useful?" I understand the researcher will be able to see the programs I used every day.

My name will not be used in any reports about this project.

I want/don't want to participate in this project.

APPENDIX B

PARENTS' LETTERS

April 2, 2002

Dear Parents and Guardians:

Our fifth grade class has been asked to take part in a University of North Texas research project on Palm Pilots. This is a very exciting and educational opportunity for your student. During the week of the 8th, each student will be assigned a Palm ™ handheld computer and protective case. This handheld device will become the student's computer for the time of the study at no cost to you.

The Palm™ handhelds will be used to help with basic development, problem-solving, organizational skills, and much more. Students will be required to demonstrate responsibility and interest before they will be allowed to take them home. Once students demonstrate these qualities you will be asked to review and sign an agreement, reinforcing the rules of use for the Palm ™. In addition, you and your student will have to sign a consent form allowing the student to participate in the research study. A researcher will be in the classroom as an observer at times during the project and will conduct interviews with the students.

On Tuesday, April the 9th we will be holding a parent information session from 6:30-7:30 in the H V library. During this time we will provide a demonstration of the Palm and an outline of the project. Please respond by filling out the bottom portion of the letter and returning it with your student as soon as possible.

I am looking forward to working with your student on this wonderful project. Please feel free to contact me if you have any questions or concerns.

Sincerely,

L V

_____ Yes, I will be attending the Palm information session on Tuesday April 9, 2002.

_____ No, I will not be attending the Palm information session.

Parent's Name:_____

Student's
Name:_____

Dear Parents and Guardians:

We are sorry you will not be able to attend the informational meeting about the University of North Texas research project on Palm Pilots. You still have an opportunity to have your child participate in this exciting research. The researchers from UNT met with the class to explain the research to the students and you can have any questions answered by Martha Peet at 972-492-2380 any evening.

Each student will be assigned a Palm ™ handheld computer and protective case for their own use during this project. This handheld device will become the student's computer for the time of the study at no cost to you. We hope that the students will take every precaution with the handheld, but if something happens to it, you will not be held responsible for the damage and we will try to replace the Palm. At the end of the research project the Palm handheld must be returned.

During the research project, investigators from UNT will be in the classroom observing the use of the handhelds. They will also record interviews with the students who have agreed to participate in the research. The students' privacy will be maintained at all times. Interviews and observations will not be linked to individual student's names except by a coding system that will only be known to the investigators. Student names will not be used in any publication that comes from this research. Each student will have the opportunity at any time to drop out of the study and still have the use of the Palm handheld.

I am looking forward to working with your child on this important research project. Please feel free to contact me if you have any questions or concerns.

Sincerely,
Martha Peet
peet@coefs.coe.unt.edu
972-492-2380

APPENDIX C

INVENTORS ASSIGNMENT

1. Inventor Research Paper Rubric and Requirements

Over the course of the next few weeks you will be conducting research to create a biography of a famous inventor from the time period of the 1700's –1920.

You will be required to gather and formulate information from various print media to generate the best possible work that you can. Though we will dedicate the majority of the class time available in the next three weeks, you will also need to conduct your investigations outside school hours. This means that you not only need to have your materials each day for class, but you will also need to make steady progress at home. ***Plan your time wisely.***

Paper Structure and Requirements

This research paper will be at least 2 ½ pages in length (double spaced using a 12 point font) and will also include a cover page as well as a bibliography. We will review how to import FreeWrite into Word to format. You will also review how to compile a bibliography in class. (Remember http://www.noodletools.com is a great source for helping you cite correctly! Remember to click on NoodleBib.) You will need at least 5 sources of information for your paper, 2 of these sources must be books.

This assignment should reflect *your* thoughts and findings concerning the topic you chose. **Plagiarism will not be tolerated and will result in an automatic zero**. (Plagiarism is the intentional use of another person's words or ideas and trying to present them as your own.) In short, if I find out that you are just copying sections out of a book, your grade will be greatly reduced.

In addition to a written paper you will also be required to turn in the following:

1- A concept map (using the PiCoMap program) that demonstrates how the inventors invention has impacted our daily lives.
2- An animated drawing of the inventors creation, using Sketchy.

This assignment will be graded on the following criteria:

A five minute oral presentation over your topic. This means that you will not have your paper to refer to as you present. After two weeks you should be very familiar with the topic. Remember that the addition of pictures or models that you may choose to include always improves any presentation.

Your paper will be graded as follows:

“A” Papers

These papers will be well developed in both thought and writing. There will be clear evidence that you conducted quality research to formulate the best possible biography. There will be less than 5 spelling/grammar errors. The concept map and animation are provided and well thought out.

”B” Papers

These are almost identical to “A” papers with the following exceptions: They will have 6-10 spelling/grammar errors. They may have minor and unclear portions, but reflect a great deal of quality work spent on developing your research biography. The concept map and animation are present, but could use a few improvements.

“C” Papers

These papers will have 11-15 spelling/grammar errors. There may be more pronounced biography development problems. This may mean that you simply did not follow a clear chronological order or fell well short of the 2 ½ page length expectations. Given the amount of time you will have to work on this project in class, sloppy or hurried work will not be of “A” or “B” quality and will most likely end up in this category (this includes the work provided on your concept map and animation).

"N" Papers

These papers are of exceptionally low quality. They fall far short of the requirements mentioned above and show a general lack of concern on your behalf. I do not expect any papers to fall into this category, as you will have more than adequate class time to keep this from happening to you. These papers will also lack a bibliography, concept map and animation.

I know that you will all do wonderful work and I am looking forward to reading your research biographies!

Big Dates

Thursday April 25th:Assignment Given
Wednesday May 1st: Thesis Statement Due
Friday May 10th: Rough Draft Due
Wednesday May 15th: Final Copy Due
Friday May 17th: Presentations

Inventors

Alessandra Volta *
Alexander Graham Bell *
Alfred Noble
Anders Celsius
Benjamin Franklin *
Christopher Latham Sholes
Clarence Cranke
Cyrus McCormick
Edwin Perkins
Eli Whitney *
Elias Howe *
Elisha Graves Otis *
Erik Rotheim
Frank Epperson *
George Washington Carver *
George Eastman *
Henry Ford *
Humpry Davy *
James Edwin Brandenberger *
James Naismith *
James Watt *
James Hargreaves
John Logie Braid
John Pemberton *
John Hadley
Joseph Etienne Montgolfier
Leo Gertenzang
Levi Strauss *
Linus Yale Jr. *
Louis Braille *
Louis Pasteur
Nickola Tesla
Orville Wright *
Robert Wilhelm Bunsen *
Samuel Finley Breese Morse *
Slyvester Howard Roper *
Thomas Alva Edison *
Whitcomb L. Judson

APPENDIX D

PRE-SURVEY

Name:_____

Do you like to use computers?	Yes No
Do you use a computer at home?	Yes No
How much do you use computers?	Almost every day Several times a week Weekly Only when I have schoolwork
What do you do on the computer?	Schoolwork Games Email Instant Messenger Surf the web
Do you have a Gameboy?	Yes No
How much do you play with your Gameboy?	Almost every day Once or twice a week Once or twice a month Hardly ever
How long have you had your Gameboy?	A month or less Since Christmas A year More than a year
How do you learn best?	Play with the program Have someone show me how Read the instructions
How are your computer skills?	Poor Average Good Excellent
When you use a website for a project do you take notes from the screen or print it out?	Write notes Print the site out
When you use a book do you write the paper with the book in front of you or do you use notes?	Use the book Use notes

APPENDIX E

AFTER A DAY OF RESEARCH SURVEY

Name _____

What kind of resources did you use today?	Books Electronic sources Both
How many sites did you fling today?	0 1 2 3 4 more than 4
Did you take notes from web sites that you **didn't** fling?	Yes (If yes - did you take your notes on paper or on the Palm? Paper Palm No
Which resources were most helpful?	print electronic
Did you take notes on paper or on your Palm?	Neither Paper Palm Both
How much information did you find about your inventor?	None Some Lots
Did you have any problems with Fling-it today?	Yes No

The First Week
Day 1 - no additional questions
Day 2 - How do you decide what sites to Fling?
How is your research going so far?
Day 3 - Who is your inventor and what did he invent? (This was the day the thesis statement was due)
Day 4 - What did you do today on your inventors project?
Day 5 - What did you do today on your inventors project?
What you would change about the Palm?

APPENDIX F

PICOMAP/SKETCHY

Daily Survey for PicoMap and Sketchy

Name _____

What did you work on today?	Sketchy PicoMap Writing
If you worked on Sketchy was it fun?	Yes No NA
If you worked on Sketchy did it help you understand your invention?	Yes No NA
If you worked on PicoMap was it fun?	Yes No NA
If you worked on PicoMap did it help you understand your invention?	Yes No NA

APPENDIX G

SCORING RUBRIC FOR FINAL PAPERS

Scoring Rubric

Fulfills requirements

Length - (example 1 1/3 page) _____

Number of sources in bibliography_____

Organization of Paper

Over all organization

□ well organized □ some things out of order □ hard to follow

Information about life in chronological order

□ well organized □ some things out of order □ many things out of order

Content of research

Number of facts _____

Accuracy of content □no errors □ a few errors □many errors

Grammar and punctuation

Number of punctuation mistakes _____

Number of spelling errors/wrong words _____

APPENDIX H

6+1 SCORING RUBRIC

Ideas

1 - Developing

The reader can understand the main ideas, although they may be overly broad or simplistic, and the results may not be effective. Supporting detail is often limited, insubstantial, overly general, or occasionally slightly off-topic. The writing is characterized by:

- an easily identifiable purpose and main idea.
- predictable or overly-obvious main ideas or plot; conclusions or main points seem to echo observations heard elsewhere.
- support that is attempted, but developmental details that are often limited in scope, uneven, somewhat off-topic, predictable, or overly general. (expository, persuasive, for example)
- details that may not be well-grounded in credible resources; they may be based on clichés, stereotypes or questionable sources of information.
- difficulties when moving from general observations to specifics.

2 - Competent

The writing is clear and focused. The reader can easily understand the main ideas. Support is present, although it may be limited or rather general. The writing is characterized by:

- an easily identifiable purpose.
- clear main idea(s).
- supporting details that are relevant, but may be overly general or limited in places; when appropriate, resources are used to provide accurate support.
- a topic that is explored/explained, although developmental details may occasionally be out of balance with the main idea(s); some connections and insights may be present.
- content and selected details that are relevant, but perhaps not consistently well-chosen for audience and purpose.

3 - Experienced

The writing is clear, focused and interesting. It holds the reader's attention. Main ideas stand out and are developed by supporting details suitable to audience and purpose. The writing is characterized by:

- clarity, focus and control.

- main idea(s) that stand out.
- supporting, relevant, carefully selected details; when appropriate, use of resources provides strong, accurate, credible support.
- a thorough, balanced explanation/exploration of the topic; the writing makes connections and shares insights.
- content and selected details that are well-suited to audience and purpose.

4 - WOW!

The writing is exceptionally clear, focused and interesting. It holds the reader's attention. Main ideas stand out and are developed by strong support and rich details suitable to audience and purpose. The writing is characterized by:

- clarity, focus and control.
- main idea(s) that stand out.
- supporting, relevant, carefully selected details; when appropriate, use of resources provides strong, accurate, credible support.
- a thorough, balanced in-depth explanation/exploration of the topic; the writing makes connections and shares insights.
- content and selected details that are well-suited to audience and purpose.

Organization

1 - Developing

An attempt has been made to organize the writing; however, the overall structure is inconsistent or skeletal. The writing is characterized by:

- attempts at sequencing, but the order or the relationship among ideas may occasionally be unclear.
- a beginning and an ending which, although present, are either undeveloped or too obvious (e.g., "My topic is...", "These are all the reasons that....").
- transitions that sometimes work. The same few transitional devices (e.g., coordinating conjunctions, numbering, etc.) may be overused.
- a structure that is skeletal or too rigid.
- placement of details that may not always be effective.
- organization which lapses in some places, but helps the reader in others.

4

2 - Competent

Organization is clear and coherent. Order and structure are present, but may seem formulaic. The writing is characterized by:

- clear sequencing.
- an organization that may be predictable.
- a recognizable, developed beginning that may not be particularly inviting; a developed conclusion that may lack subtlety.
- a body that is easy to follow with details that fit where placed.
- transitions that may be stilted or formulaic.
- organization which helps the reader, despite some weaknesses.

3 - Experienced

The organization enhances the central idea(s) and its development. The order and structure are strong and move the reader through the text. The writing is characterized by:

- effective sequencing; the organizational structure fits the topic, and the writing is easy to follow.
- an inviting beginning that draws the reader in and a satisfying sense of resolution or closure.
- smooth, effective transitions among all elements (sentences, paragraphs, ideas).
- details that fit where placed.

4 - WOW!

The organization enhances the central idea(s) and its development. The order and structure are compelling and move the reader through the text easily. The writing is characterized by:

- effective, perhaps creative, sequencing; the organizational structure fits the topic, and the writing is easy to follow.
- a strong, inviting beginning that draws the reader in and a strong, satisfying sense of resolution or closure.
- smooth, effective transitions among all elements (sentences, paragraphs, ideas).
- details that fit where placed

Conventions

1 - Developing

The writing demonstrates limited control of standard writing conventions (e.g., punctuation, spelling, capitalization, paragraph breaks, grammar and usage). Errors begin to impede readability. The writing is characterized by:

- some control over basic conventions; the text may be too simple to reveal mastery.
- end-of-sentence punctuation that is usually correct; however, internal punctuation contains frequent errors.
- spelling errors that distract the reader; misspelling of common words occurs.
- paragraphs that sometimes run together or begin at ineffective places.
- capitalization errors.
- errors in grammar and usage that do not block meaning but do distract the reader.
- significant need for editing.

2 -Competent

The writing demonstrates control of standard writing conventions (e.g., punctuation, spelling, capitalization, paragraph breaks, grammar and usage). Minor errors, while perhaps noticeable, do not impede readability. The writing is characterized by:

- Control over conventions used, although a wide range is not demonstrated.
- correct end-of-sentence punctuation; internal punctuation my sometimes be incorrect.
- spelling that is usually correct, especially on common words.
- basically sound paragraph breaks that reinforce the organizational structure.
- correct capitalization; errors, if any, are minor.
- occasional lapses in correct grammar and usage; problems are not severe enough to distort meaning or confuse the reader.
- moderate need for editing.

5

3 - Experienced

The writing demonstrates strong control of standard writing conventions (e.g., punctuation, spelling, capitalization, paragraph breaks, grammar and usage) and uses them effectively to enhance communication. Errors are so few and so minor that they do not impede readability. The writing is characterized by:

- strong control of conventions.
- effective use of punctuation that guides the reader through the text.
- correct spelling, even of more difficult words.
- paragraph breaks that reinforce the organizational structure.
- correct capitalization; errors, if any, are minor.
- correct grammar and usage that contribute to clarity and style.
- skill in using a wide range of conventions in a sufficiently long and complex piece.
- little need for editing.

4 - WOW!

The writing demonstrates exceptionally strong control of standard writing conventions (e.g., punctuation, spelling, capitalization, paragraph breaks, grammar and usage) and uses them effectively to enhance communication. Errors are so few and so minor that they do not impede readability. The writing is characterized by:

- strong control of conventions; manipulation of conventions may occur for stylistic effect..
- strong, effective use of punctuation that guides the reader through the text.
- correct spelling, even of more difficult words.
- paragraph breaks that reinforce the organizational structure.
- correct capitalization; errors, if any, are minor.
- correct grammar and usage that contribute to clarity and style.
- skill in using a wide range of conventions in a sufficiently long and complex piece.
- little need for editing.

6+1 Traits developed by Northwest Regional Educational Laboratory, Portland, Oregon.

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