Students Using Handheld Computers to Learn Collaboratively in a First Grade Classroom

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Dedications

This dissertation is dedicated to my family for the support, love, advice and encouragement they have given me.

First and foremost, to my husband Keith whose support and encouragement led me through this amazing journey. I could never have completed this degree without you. It is also dedicated to our daughter Madison whose amazing energy and happiness gave me the drive and persistence to stay focused. And, to baby number two who will arrive in October, 2005.

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Abstract

Students Using Handheld Computers to Learn Collaboratively in a First Grade Classroom

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This ethnographic study investigated how first grade students used handheld computers to learn in collaboration with others throughout the learning process. This research focused specifically on how the use of handheld computers impacts students' learning outcomes and relates to technology standards.

A qualitative methodology was used to capture detailed descriptions of 23 first grade students' experiences, attitudes, beliefs, and interactions while they used handheld computing devices to learn. Data collection included observations, interviews, and student artifacts. The researcher observed students while they used handheld computers to learn. She also conducted informal small group interviews to capture the students' and teacher's perspectives. The researcher collected and analyzed student artifacts which included items from the students' handheld computers, items beamed from one handheld computer to another, and documents they created on paper as a result of work completed on the handheld computer. Documents were assessed according to content standards and technology standards.

The results are that students achieved learning outcomes while using handheld computers. The students learned content through collaboration with others. The students also met technology standards through individual discovery and collaborating with peers.

The researcher stated five conclusions. Handheld computers facilitated collaborative learning which in turn helped the students learn content and meet

technology standards. The students themselves said that the handheld computers helped them learn content and technology. The teacher's role is critically important as a facilitator in providing support for helping students learn to use the handheld computers. The discovery approach of teaching students how to use the handheld computers leads to independent learning.

This study is significant for several reasons. This study supports and extends various studies. The students learned how to use the handheld computers in a holistic nature. Students used reflective thinking about their use of technology. This study contributes to the expanding group of researchers who are looking at technology and learning using a qualitative approach.

Chapter 1: Introduction to the Study

Access to technology continues to be a problem in America's schools. According to Glennan and Melmed (1996) "There are many challenges to making extensive use of technology for improving the performance of the educational [*sic*] system in the United States" (p. 48). One of those challenges is how technology is integrated meaningfully. In order to support meaningful learning, technology should be used to "…engage students in active, constructive, intentional, authentic, and cooperative learning" (Jonassen, Peck, & Wilson, 1999, p. 7). Other challenges include the cost of purchasing and maintaining technology for schools, size of computers, mobility, access, inability to use computers for collaboration and sharing due to lack of access, and ease of use (Soloway, Norris, Blumenfeld, Fishman, Krajcik, & Marx, 2001; Soloway, Norris, Curtis, 2001; Wood, 2002).

Such challenges have prompted researchers to begin looking at handheld computers as a way to integrate more technology into K-12 classrooms. Since 1996, handheld computing devices have been a widely used technology in the business world and today are just beginning to make their way into classrooms. In the few classrooms that have pioneered the use of handheld computers, it was determined that the handheld computers did in fact enhance teaching and learning (Crawford & Vahey, 2002; Curtis, Williams, Norris, O'Leary & Soloway, 2003; Robertson, Calder, Fung, 1997; Soloway, 2002). The existing studies focus on older students and the benefits of using handheld computers (Crawford & Vahey, 2002; Curtis, Luchini, Bobrowsky, Quintana, & Soloway, 2002; Malm, n.d; Staudt, 1999); administrative uses for handheld computing devices (Pownell & Bailey, 2003), and the use of handheld devices to learn through

games (Rodriguez, Nussbaum, Zurita, Rosas, and Lagos, 2001). Research is needed in order to learn more about the effect the introduction of this tool has on younger students, and more specifically, on ways that young students communicate in collaborative learning.

This study focuses on first grade students and their use of handheld computers to learn collaboratively. The study explores and describes what happens when first grade students use handheld computers throughout the learning process to collaborate with one another.

A need for information on the educational benefits of handheld computers exists because they have the same capabilities as laptops and desktops and they present several conveniences for classrooms. The handheld computing device has several of the same features such as the ability to word process, send email, and access the Internet; however, there are some features that a handheld computer has that make it a more valuable tool for education. Handheld computers are significantly less expensive, smaller, have a wireless connection to the Internet, and can send data from one device to another through an infrared connection. All of these characteristics allow the handheld computer to be more mobile, easily used by students, and affordable; yet the laptop, desktop, and handheld allow users to do the same important tasks such as enter data, word process, search the Internet, and share information. Handheld computers can provide K-12 teachers and students with constant access to technology resources that support their learning (Curtis, et al., 2003; Soloway, 2002) and "…the ability to take the learning tool where the learning happens - whether at school, outside, or at home" (Curtis, et al., 2003, p. 17).

Background of the Problem

There is a need for students to have access to technology anywhere, anytime to enhance learning and assist in meeting technology standards. Students need not only access to technology, but also technology that can be used as a tool to enhance the learning process anywhere and anytime. New technologies are constantly emerging that present schools with less expensive opportunities to improve teaching and learning and assist students in meeting standards. Handheld computers give students less expensive, anytime, anywhere access so that technology can be used throughout the learning process.

Currently, many schools do not provide students with access to technology and therefore, it is not part of the learning process. Rather, technology is often an add-on and considered a separate class.

> While information technologies have had an enormous impact within America's offices, factories and stores over the past several decades, our country's K-12 educational system has thus far been only minimally affected by the information revolution (President's Committee of Advisors Panel on Educational Technology [PCAPET], 1997, p. 3).

Schools are continually struggling to put technology in the hands of every student.

According to the National Center for Education Statistics, technology investments are being made; however, they are not adequate to improve student learning. Skinner (2002) reports that in 1998 the number of students per Internet-connected computer was 19.7 and the number of students per instructional computer was 6.3. In 2002, the number of students per instructional computer was 3.8 and per Internet-connected computer was 5.6 (Skinner, 2002). Progress has been made in providing students with a better chance of getting access to computers in their schools, but having 3.8 students to every computer is

not the perfect scenario. “Among those who did say they use computers, the machines were most often used for playing games or engaging in drill-and-practice activities, rather than more sophisticated uses such as simulations or demonstrations of new topics” (Skinner, 2002, para. 4). This type of access does not provide students with tools to enhance their learning as determined by the learning situation. Educators need a tool that will be accessible to students as the need is determined by their learning situation.

Because students do not have one-to-one access to technology when they need to research a topic, collect data, organize information, put together a presentation, or publish writing, they may need to wait their turn on the computer or they may need to wait until the day arrives when they visit the computer lab. This type of access allows occasional, supplemental use rather than frequent, integral use (Roschelle & Pea, 2002). Crucial learning is lost because the use of technology is not seamless in schools.

Deficiencies in the Literature

Because handheld computers are new to the field of education, there are few studies that investigate the effects these devices can have on the teaching and learning process particularly with younger students. These studies do not present descriptions of what happens when students use handheld computers to learn in first grade, particularly the process of using handheld computers to learn collaboratively from the perspective of first grade students.

Significance of the Study

The data from this investigation will provide insights to educators and researchers about how young students use handheld computers to learn collaboratively, how it impacts learning outcomes and how their learning is related to technology standards.

Qualitative studies are needed that describe how students can use handheld computers as tools to enhance collaborative learning. This study is significant because first grade students will be the focus of investigation. No formal studies exist that address the use of this emergent technology with young students. “In many K-2 classrooms with handheld computers, the handhelds are in the teacher’s hands and not the students’” (Curtis, et al., 2003, p. 12). Unlike existing studies, a descriptive account of students’ collaborative experiences will be presented. Educators and researchers will use this information to make decisions that improve the status of technology use in schools.

The results of this study will include descriptions of students’ learning from the point of view of the student and teacher. Results will also include evidence of students meeting technology standards. Knowledge about student learning helps shape teachers’ decisions about the appropriateness of using these technology tools to enhance their teaching. As a result, educators can influence decision makers in their schools about purchasing handheld computers.

Researchers may be able to use the results from this study to further their knowledge about the use of handheld computers, which are emerging in the field of education. This study will contribute unique information to the literature that assists educators in making decisions about using handheld computers throughout the learning process. Researchers may take the results of this study to initiate related studies in the classroom and to inform educators about the uses of handheld computing devices.

Purpose of the Study

The purpose of this ethnographic case study is: a) to describe what happens when first grade students use handheld computing devices to collaborate throughout the

learning process; and b) to fill a gap in the existing literature on the use of handheld computers in education. The study will investigate how the use of handheld devices relates to student learning outcomes and technology standards.

Research Questions

The research questions to be answered are:

1) In what ways do first grade students use handheld computing devices to learn in collaboration with others throughout the learning process?

   a) How does the use of handheld computing devices to collaborate impact students' learning outcomes?

   b) How does collaborative learning through the use of handheld computing devices relate to technology standards?

Methodology

A qualitative ethnographic case design will be used to conduct this study in a first grade classroom. This type of design will allow the researcher to capture the experiences of the students as they use handheld computers to learn collaboratively. A first grade class in a school district is purposefully chosen because it is participating in a handheld computer pilot program.

Data collection methods will span six weeks and include informal group observations, student and teacher interviews, and analyzing student documents. Observations will occur throughout the learning process. An outside observer will add her perspective to data collected. Field notes will be taken during observations to capture students' actions while using handheld computing devices to learn collaboratively. Informal group interviews will be videotaped and used to hear the students' perspectives

of learning with the handheld computers. The teacher will be interviewed to add her perspective to students' learning. Student artifacts that are beamed to one another by the students will be used to provide the researcher with information about their communication throughout the learning process. These documents will be compared to the International Society for Technology in Education (ISTE) National Educational Technology Standards (NETS) for Students (see Appendix A), ISTE Performance Indicators for Technology—Literate Students Grades PreK-2 (Appendix B), Writing Rubric (see Appendix C), Reading Response Rubric (see Appendix D), and Mathematics Rubric (see Appendix E). Other assessments will be used that are determined by the learning situation to look for evidence of meeting standards and learning outcomes in a constructivist learning environment (see Appendix F).

Definition of Terms

1. Beam - The process of sending and receiving data between handheld computers using infrared (IR) light (Curtis, et al., 2003).
2. Browser - "A computer program used for accessing sites or information on a network (as the World Wide Web)" (Merriam-Webster's Collegiate Dictionary, n.d.).
3. Collaborate - "To work jointly with others or together especially in an intellectual endeavor" (Merriam-Webster's Collegiate Dictionary, n.d.).
4. Collaborative Learning - "…Children's learning with one another" (Zemelman, Daniels & Hyde, 1998, p. 12).
5. Constructivism, Constructivist learning - Constructivism involves students actively making meaning (Jonassen, Peck, & Wilson, 1999).

6. Cradle - The handheld computer sits in this device which is connected to the desktop. The cradle has a button that when pushed, allows the handheld computer to synchronize with the desktop.
7. Desktop Computer - A desktop computer is designed to fit on top of a desk and typically has a keyboard, mouse, speakers, monitor, and processor attached.
8. Digital Literacy - "The literacy skills for the digital age include language proficiency, namely reading, writing, listening and speaking.." (CEO Forum, 2001, p. 32).
9. Ethnography - The study of an intact cultural group in its natural setting. The primary source of data collection is participant observation and the research process evolves over the time of the study (Cresswell, 2003).
10. Graffiti® Alphabet- A method to input text on a handheld computer. It is handwriting recognition that uses characters drawn on the screen with the stylus (Curtis, et al., 2003).
11. Handheld Computer - A computer that you can hold in your hand (Curtis, et al., 2003). The handheld computers used in this study are Palm™ m130 Handheld Computers.
12. HotSync® Operation- The process through which a computer and a handheld computing device communicate. The handheld computer is connected to the desktop/laptop through a cable or cradle. A mirror image of the data is created on both computers. The HotSync operation is also a way for software to be installed on the handheld device (Curtis, M. et al., 2003).
13. Infrared - "This is a form of short-range wireless signals used to control TVs, VCRs, motion detectors, and other common items" (Pownell & Bailey, 2003, p. 191).

14. Inventive Spelling - Beginning writers are encouraged to sound out words by writing down the sounds/letters they hear. It is stressed that writing is more important than the correct spelling. It is also stressed that before an audience reads their writing, spelling should be corrected.
15. Just In Time Learning - Learning that meets the needs of students and is delivered exactly when the student needs it.
16. Laptop Computer - A laptop computer is designed to fit in one's lap. It has a keyboard, monitor, and speakers attached in one unit.
17. Palm™ - "Palm is the trade name for a popular personal digital assistant, a form of handheld device that is also known as a palmtop computer. Originally the Palm™ handheld, which is used mainly for personal organization, wireless e-mail, note-taking, and electronic games, was called the PalmPilot. It was introduced in 1996 by Palm Computing, Inc." (Pownell & Bailey, 2003, p. 191).
18. Palm OS® - "The OS stands for operating system. …The handheld computer uses an operating system called Palm OS" (Curtis, M. et al., 2003, p. 20).
19. Personal Digital Assistant (PDA) - "PDA is a term for any small, mobile handheld device that has computing and information storage and retrieval capabilities for personal or business use. It is often used for keeping schedule calendars and address book information handy" (Pownell & Bailey, 2003, p. 192).
20. Personal Information Manager (PIM) - "A PIM is a device or software that helps users organize small bits of information, such as calendar events, notes, contacts, and tasks. This information is stored and linked in such a way as to make it useful to the user" (Pownell & Bailey, 2003, p. 192).

21. Server - “A computer in a network that provides services (as access to files or shared peripherals or the routing of E-mail) to other computers in the network” (Merriam-Webster’s Collegiate Dictionary, n.d.).
22. Stylus - An instrument stored in a slot on the side of the handheld computer. It is used to touch the screen to navigate, enter text, etc. (Curtis, M. et al., 2003).
23. Ubiquitous Computing - “Ubiquitous computing is the trend toward increasingly universal and connected computing devices. [Handheld computing] devices are part of the environment and can usually transfer information wirelessly” (Pownell & Bailey, 2003, p. 193).
24. Wireless - “The term refers to telecommunication in which electromagnetic waves (rather than some form of wire) carry the signal over part or all of the communication path” (Pownell & Bailey, 2003, p. 193).

Delimitations

This study will focus on first grade students at Rider Elementary School, which is a suburban elementary school in Pennsylvania. It will be limited to the 28 students in this class. It will view those aspects of learning which involve using handheld computers as a tool to collaborate.

Limitations

Participants in this study were selected purposefully because of their access to handheld computers. For that reason, generalizations are not made for all first grade students. Descriptions of collaborative learning through the use of handheld computers are limited to the students in this class.

Another limitation of this study is time. This study will be limited to a time period of 6 weeks.

Summary

Currently, the lack of access to technology in America's schools is preventing students from meeting standards and learning outcomes (Soloway, Norris & Curtis, 2001). Educators also face the challenges of cost, size and mobility of technology and most importantly the ability to integrate it into the curriculum (Soloway, Norris, & Blumenfeld et al., 2001; Soloway, Norris, & Curtis, 2001; Wood, 2002). In 2002, it was reported that students did not have one-to-one access to technology and as a result, the machines were used for playing games or engaging in drill-and-practice activities (Skinner, 2002). This type of access does not provide students with tools to enhance their learning.

New technologies have emerged that give students access to tools throughout the learning process. Handheld computers may provide students with one to one access and as a result, improve learning (Soloway, 2002). Handheld computers are being used in classrooms across the United States and it was found that they enhanced teaching and learning (Crawford & Vahey, 2002; Curtis et al., 2003; Robertson, Calder, Fung, 1997; Soloway, 2002;). Although studies have been conducted that show the benefits of using handheld computers with older students, administrative uses, and the use of handheld devices to learn through games, no one has studied their use in a first grade classroom. Specifically no one has investigated how students use handheld computers as a tool to learn in collaboration with one another.

A need for information on how the devices facilitate collaborative learning in a primary classroom exists. Handheld computers have many of the same capabilities as laptops and desktops and a unique ability to beam information from one device to another. The small, inexpensive devices can provide teachers and students with a mobile, inexpensive computer that will allow them to complete necessary tasks. Handheld computers can provide students with one-to-one computing that enhances their learning anywhere, anytime (Curtis et al., 2003; Soloway, 2002).

Currently, many students do not have access to technology so that it can be used as a tool throughout the learning process. Because technology is often considered a separate class, it has had only a minimal affect on the educational system (PCAPET, 1997). Schools are reacting to this claim and beginning to put technology in the hands of students; however, students need access to tools determined by the learning situation. Students do not have one-to-one access to technology when they need to research a topic, collect and organize data, present information, and publish information. Access to technology needs to be frequent and integrated into the curriculum so that crucial learning is not lost (Roschelle & Pea, 2002).

This study will show how handheld computers can be used to provide students with access to technology throughout the learning process. Specifically, the study will describe how first grade students learn collaboratively through the use of handheld computers. Further, this study will investigate how handheld computing devices impact learning outcomes and facilitate students meeting standards. The qualitative ethnographic study will present a detailed description of how the devices facilitate collaborative learning, impact learning outcomes, and help students meet standards.

Chapter 2: Review of the Literature

Introduction

This study will describe how students learn together through the use of handheld computers and how student learning relates to learning outcomes and technology standards.

This literature review is divided into five sections to give the reader background information on the historical development of handheld computers in education, technology use in the classroom, the current use of handheld computers in education, collaborative learning, and collaborative learning through the use of handheld computers.

Historical Development of Handheld Computers in Education.

Handheld computing devices are being seen as the next tool that could revolutionize learning. Handheld computers are defined as, "…held in the hand; *especially*: designed to be operated while being held in the hand" (Merriam-Webster's Collegiate Dictionary, n.d.). They have evolved from electronic planners to "…universal-access devices, able to ferret out essential information wherever it happens to be stored--on the desktop PC, the home-office server, or the Internet" (as cited in Pownell & Bailey, 2000, para. 3).

Handheld computers have 200 times the memory of the Apple II, which was introduced in 1970, and cost 1/20th of what the Apple II cost (Bull, Bull, Garofalo, & Harris, 2002). Pownell and Bailey (2003) describe four waves of technology evolution. The first wave of computing included the large, expensive mainframes that were used mostly in engineering and business. In 1970, computers were called mainframes and were used mainly for administrative tasks. During this time, technology in education was used

for mathematical and scientific calculations which made the management of schools easier (Pownell & Bailey, 2003).

The second wave of computing brought desktop computers to education along with the idea of computer literacy. During the late 1970s, came the idea of the personal computer. The desktop computer began to have an impact on more individuals as it was used for word processing, spreadsheets, databases, graphics, and presentations. The processing power of computers significantly increased and therefore, multimedia was created (Pownell & Bailey, 2003). During this time, computer literacy meant that students learned about technology and how to use it.

In the 1990s, the third wave included the introduction of the Internet and the World Wide Web, which brought about higher levels of electronic communication, collaboration and publishing. People began to purchase goods and conduct business on the Internet. In schools, networking was a priority. During this time, learning with technology began to take on a more constructivist perspective. Students began to use technology for project-based learning (Pownell & Bailey, 2003).

The fourth wave of technology provides handheld computing devices that introduce anytime/anywhere learning due to their smaller size and wireless connectivity. Several tools are making their way into classrooms that provide students with mobile computing. AlphaSmart's Dana Wireless is about the size of a piece of notebook paper, includes a keyboard and has a screen large enough to display a paragraph. Students can use the Dana Wireless to perform many of the same tasks as a desktop computer however, "…Danas are not perfect for all uses because of their limited graphic capabilities, especially since images are displayed in shades of gray" (Schalansky, 2004,

p. 26). Schalansky (2004) feels that the Danas are best used for e-mail and text-based tasks.

Another tool that has emerged is the tablet computer. These devices allow users to enter text by using handwriting instead of Graffiti® characters. Tablet computers are thin and lightweight and offer many of the same features as a desktop or laptop computer. However, tablets are expensive, fragile, and include a stylus that is costly to replace (McLester, Ohler, Parham, Warlick, 2002).

The PalmPilot is another tool that was introduced primarily for the business world in 1996.

> Business-people use them to keep track of critical information on the road. Doctors use them to take notes and keep abreast of the latest medical information. Senators use them to keep track of important contacts (Schwartz, 2000). Even the American Red Cross is using them to automate blood donations (Pownell & Bailey, 2003, p. 17).

In the year 2000, the Palm™ handheld computer held over 70% of the market. Pownell and Bailey (2003) projected that in 2003, the number of handheld computers sold could exceed personal computer sales. Today, they continue to be a frequently used tool in the business world and are referred to as the PalmPilot™, Palm™, personal digital assistant (PDA), or personal information manager (PIM). All three of these terms refer to a small electronic device that can assist the user with e-mail, note-taking, electronic games, calendars, address book, etc (Pownell & Bailey, 2003). These terms refer to organizational tools that do not have relevance in a classroom. “This device helped people organize their lives by providing instant, anytime access to schedules, important phone numbers, addresses, to-do lists and other key information” (SouthEastern Initiatives Regional Technology in Education Consortium [SEIRTEC], n.d., p. 27).

In contrast, educators refer to the PalmPilot, Palm, PDA, or PIM as a handheld computer, which can also be called a handheld computing device. Educators call the device a handheld computer because when used in a classroom as a teaching or learning tool, it can perform many of the same functions as a desktop computer (see Table 1 for handheld computer features).

> While a handheld computer does not have the full functionality of a desktop/laptop computer, access is more important than functionality. And further, there are functions that handheld devices afford that desktop/laptops do not afford that are particularly suited to the K-12 context. For example:
>
> - Handheld computers, being truly ready-at-hand, conveniently support cycles of document construction and revision, and they support the immediate sharing with classmates of artifacts through infrared beaming (Curtis et al., 2003, p. 1).

A handheld computer can meet the needs of students. There are many different types of these devices and how they are used in business or education determines what they are called. For the purposes of this study, the device will be used as a teaching and learning tool and therefore will be referred to as a handheld computer or handheld computing device.

Recently, handheld computers have made their way into the field of education because of their cost, mobility, wireless capability, size, ability to store large amounts of data, access, and ease of use. “The scaled-down capacity of handhelds together with their lower cost actually makes them an attractive alternative for many of the educational roles currently provided by desktop computers, especially for younger learners” (Concord Consortium, 2002, para. 1).

Table 1 - Handheld Computer Features

Computing Task	Handheld Computer Solution	
	Hardware	Software
Word processing	Keyboard, Stylus	Documents to Go, WordSmith, Thesaurus, FreeWrite, PiCoMap, iKWL
Spreadsheet	Keyboard, Stylus	Documents to Go, QuickSheet
Database	Keyboard, Stylus	Filemaker Mobile, MobileDB
Drawing and Painting	Keyboard, Stylus	TealPaint, Diddlebug, BugMe, Sketchy
Digital photography	PalmPix camera	
Printing	Keyboard	TealPrint, PalmPrint, PrintBoy
Internet connectivity	Keyboard	AvantGo, Fling-It
Calculators	Keyboard, Stylus	ImagiMath, PowerOne
Scientific probes	Keyboard, Probes	ImagiProbes
Stories, texts, authoring	Keyboard, Stylus	eTatles, PalmReader Palm, DropBook
Assessment	Keyboard	Learner Profile, Grade Busters

Note. From *Palm Education Training Coordinator Program* (p. 3), by Palm Computing, 2002. Copyright 2002 by Palm Computing. Adapted with permission.

However, handheld computing devices are not only an inexpensive version of full-sized computers. They allow students to "…investigate, record, reflect, and

communicate outside the classroom and teaching lab, in the cafeteria, at home, in the bus, and in the field. They make it possible for anyplace to provide a rich learning context" (Concord Consortium, 2002, para. 2). This type of technology will promote student-centered learning because it is constantly accessible. The constructivist nature of learning with handheld computers will transform teaching and learning (Pownell & Bailey, 2003).

Since 1970, technology has been making major transformations in the field of education. Today, the handheld computer is beginning to make its way into classrooms and transform teaching and learning. Their ability to meet the needs of students anywhere and anytime in addition to their cost, mobility, size and ease of use make the handheld device an effective tool for education.

Technology Use in the Classroom

Educators are working hard to implement Standards, Best Practices, meet demands from the No Child Left Behind (NCLB) Act, and to ensure their students can make a successful transition from the student of today to the worker of tomorrow. Changes in the classroom are ongoing which ensure the highest level of learning for students. In June 1998, the ISTE released the National Educational Technology Standards for Students (NETS) which requires students to use technology throughout the learning process (see Appendix A for NETS). For students, meeting the NETS includes using technology to work cooperatively and collaboratively with peers and communicate with others. In order for technology to be at the hands of students when they need it, research needs to be done to find less expensive but just as powerful alternatives to the technology demand in schools.

In order to meet the NETS for Students, schools have to equip classrooms with technology so that students have access to technology. In addition to the challenge of meeting the technology standards, on January 8, 2002, President Bush signed into law the NCLB Act. The Facts About 21st Century Technology (2002) made one of the challenges for America's educational systems "to improve student achievement through the use of technology" (para.1). It is important that educational systems respond to this challenge by giving students equitable access to the use of technology as a learning tool in the classroom (The Facts About 21st-Century Technology, 2002; PCAPET, 1997; Soloway, Norris, Blumenfeld, et al., 2001; Soloway, Norris, & Curtis, 2001; Wood, 2002). The solution to President Bush's challenge is to "teach children how to use the technological tools available to them and integrate that technology into the curriculum to improve student achievement" (The Facts About 21st Century Technology, n.d., para. 2). In response, U.S. Secretary of Education Rod Paige announced an Enhancing Education Through Technology (ED Tech) initiative. He stressed the importance of making technology a part of the learning process and using it as a tool to enhance teaching and learning.

Unfortunately, many schools cannot provide students with ubiquitous access to technology so that it enhances the learning process. Education Week's Technology Counts 2003 report noted in its vital statistics on U.S. public schools that on average, the number of students per instructional computer is 3.8 and the number of students per instructional computer in classrooms is 9.2 (Vital Statistics on U.S. Public Schools, 2003, para. 1). In a survey of teachers in 4,000 schools across the country, Elliot Soloway (as cited in Wood, 2002), found that 45% of the teachers say their students use computers

less than 15 minutes each week due to the fact that the computers are in the lab or back of the classroom. According to an Education Week survey, 30% of teachers said students use computers one hour a week (Gahala, 2001). The CEO Forum (2001) reported on the frequency of student computer use for school work and found that of fourth graders, only 9% use computers everyday, 20% use it once or twice a week, 17% use it once or twice a month, and 55% use it never or hardly ever. Computers should be used as tools to support meaningful learning. Technology should be a partner in the learning process (Jonassen, 2000).

Ansell & Park (2003) surveyed schools across the United States in 2002 to find how many students had access to computers in their classrooms, computer labs, and library media centers and found that the numbers continue to improve (see Table 2).

Table 2 - Students Per Instructional Computer

Computer location	Students per instructional computer	Students per instructional computer with Internet access
Classroom	9.2	11.1
Computer Lab	13.6	16.3
Library/Media Center:	72	81.2

These figures indicate that the number of students that have access to computers in the classroom still needs to be improved in order for students to be able to use the tools

throughout the learning process. Because computers are not an integral part of the curriculum, Soloway, Norris, & Curtis (2001) claim that "…networked personal computers have had essentially no impact on how K-12 teachers and students do their knowledge work" (p. 33). In addition, Schmeltzer (2000) comments

> … routine, daily, pervasive use of computing leads to increased productivity and effectiveness. Laptop computers are too expensive to give to each child. Desktop computers are used by a different group of children in each of the eight class periods in the day. Typically, a child will use a computer for only an hour a week in school (para. 16).

In 1997, the President's Committee of Advisors on Science and Technology noted that in order to benefit from the promise of educational technology, "…significant investment[s] in hardware and infrastructure will be required" (p. 5). Smerdon, Cronen, Lanahan, Anderson, Iannotti, and Angeles (2001) reported that in 1999 access to technology was the most frequently reported barrier by teachers.

Crawford and Vahey (2002) found that in order to implement technology, teachers encountered several barriers: the need to schedule time in the computer lab (a location often away from the classroom); the need to have students share a few computers located in the back of the classroom; and/or the need to use expensive laptop computers which are often obtrusive. The barriers limit the impact that computers can have on teaching and learning.

The NETS, Best Practices, and the NCLB Act have all caused an increased demand for the use of technology as a tool to enhance teaching and learning. Currently, students do not have access to technology that supports meaningful learning. Significant purchases need to be made by schools so that students can benefit from the use of technology in their classroom.

Current Use of Handheld Computers in Education

Cost is one of the main causes of the lack of technology in America's classrooms. Cost of purchase, maintenance, and upkeep is the main cause for the high prices of technology. In addition, once technology is purchased, there are costs for training and support for teachers. In 2003, school budgets are worse than ever and therefore, technology continues to be lacking.

Since 1997, handheld computers have become the forefront of technology. They are significantly less expensive than desktops and laptops however and they provide students with all of the necessary benefits in addition to other features such as infrared beaming (See Comparison of Handheld Computers, Laptops, and Desktops, Appendix G). Ansell and Park's (2002) survey found that in the United States, only 7% of schools have purchased handheld computers for teacher use and only 3% of schools have purchased them for student use. Few schools are using handheld computing devices in classrooms because of their novelty in education and the lack of research to support their use.

In schools where handheld computers are available, they are being used to meet technology standards and fulfill requirements from Best Practice Learning and the NCLB Act. The devices are being used across many disciplines and across all grade levels. Elementary, Middle and High School students, teachers, and administrators are using handheld computing devices for various tasks.

Currently, the number of studies involving handheld computing devices in education is limited. Of the studies that have been completed and published, they deal with students in grades two through twelve and whether handheld computers are a useful

classroom tool, how the use of handhelds can enhance learning, what students can do with handhelds that they could not do with another type of technology, and how to implement handhelds in schools.

Researchers for SRI International realized the potential benefits of handheld computers and proceeded to do a study with over 175 grade two through twelve classroom teachers who were using handheld computers. This study was called the Palm™ Education Pioneer (PEP) program and was designed to gather a knowledge base of teachers who use handhelds in the classroom and determine how handheld computers are useful as educational tools. Before beginning the study, the PEP researchers and teachers had several doubts about using handheld computers as tools in K-12 education. Their doubts included: the small number of education appropriate software; inability for young students to have the motor coordination to use handheld computers successfully; a perception that the devices are too fragile for K-12 students; and doubts that the handheld computing device, which was designed for the business world, is not appropriate for the world of education (Crawford & Vahey, 2002).

Results from the PEP study are based on data collected from 102 classrooms, grades two through twelve, during the 2001-2002 school year. The survey method was used to examine the benefits and limitations of handhelds for education. Teacher reports were also examined (Crawford & Vahey, 2002). Crawford and Vahey (2002), researchers from SRI International, found that 90% of teachers who integrated handhelds into instruction found they were an effective instructional tool and 85% noted that handhelds can improve the quality of learning activities and have a positive effect on teaching practices.

Specifically, teachers in the PEP study stated that handheld computing devices can improve the quality of learning in all curricular activities. It was found that "…inquiry-based science and open-ended writing tasks are particularly effective for handheld computer use, and both of these are generally considered constructivist use of technology" (Crawford & Vahey, 2002, p. 12). The teachers concluded that "using handhelds, each student can work on his or her own assignment, then beam it to other students for editing, beam to an IR-enabled printer, or synchronize to a computer to hand the work in" (Crawford & Vahey, 2002, p. 12). In addition, elementary teachers were most enthusiastic about the use of handheld computers and found the largest educational benefits for their students. "…It is clear from these findings that young students *are* able to use handheld computers as a productive learning tool" (Crawford & Vahey, 2002, p. 8). In spite of criticism that young students may not be technically savvy or have the fine motor coordination to use the touch-screen, it is clear from PEP findings that they are able to use handheld computers as a productive tool for learning.

Overall, teachers who participated in the PEP program reported many benefits of using handheld computers as teaching and learning tools. First, it was found that they had increased time using technology and increased proficiency because one-to-one computing was accompanied by more intense use of the devices. The portability and accessibility of the devices contributed to their increased use and made handheld computers a personal learning tool. Students could take responsibility for their own learning and were in turn more engaged in learning. Second, the teachers noticed increased motivation, collaboration, and communication. Through the use of handheld computers and their infrared beaming capability, information can be shared by the touch of a button with all

users. Participating teachers found that the beaming feature facilitated small-group work. Finally, the handheld computing devices assisted students in being more organized. Students used the computers to record assignments, notes, data, and appointments. Handheld computers became personal management tools and also portfolio tools for the students.

At the conclusion of their study, Crawford and Vahey (2002) summarized several advantages to using handheld computers as educational tools. Because of the portability of handheld computing devices, they allowed new possibilities for learning activities (p. 62). "…Handheld technology is so powerful for many learning activities: It allows students to focus on the problems and questions at hand, rather than on the logistics of completing the activity" (Crawford & Vahey, 2002, p. 62). The area of assessment is also where the PEP teachers and researchers believe handheld computers can be of benefit to education. Although inappropriate use of the beaming function can lead to cheating on tests, Crawford and Vahey continue to see the benefit of using handheld devices for assessment. They believe the devices are more applicable for formative assessment rather than summative assessment.

Another area where PEP teachers and researchers saw the benefit of handheld computers is providing students with a personal learning device that supports autonomous learning, student responsibility for learning, and cross-disciplinary long-term projects (Crawford & Vahey, 2002, p. 63). In addition to using handheld computers to support autonomous learning, teachers found great benefits to using them for collaborative group work.

> Because handhelds are unobtrusive and portable, students are able to quickly and easily move between different classroom formats….then, once students

> have a final product that they are proud of, they can easily share it, either by beaming to other students, or by passing around their handheld….The student suddenly transforms from an autonomous worker fully absorbed in her own task to a collaborative team member, sharing insights and discoveries with fellow students (Crawford & Vahey, 2002, p. 64, 65).

In another study, Carolyn Staudt (1999) from the Concord Consortium tested second grade and fifth grade students in their use of the handheld computers for note taking and data collection. Staudt (1999) was especially interested in "…comparing the readiness of different age students to use handheld computers" (para. 18). Students worked in pairs and shared devices. They were taught how to use the handheld computers and were sent to a pond to collect and record data. Students took notes, drew pictures, and used a probe to measure temperature. Throughout the study, second graders showed much more excitement about using the tools, while the fifth graders were more focused on teacher directions (Staudt, 1999).

Comparing the two classes and their use of the handheld computers, Staudt found that the fifth graders completed more tasks than the second graders, and the second graders showed a lack of collaboration; this finding was believed to be because the students had to share devices. Most importantly, Staudt (1999) found that students were at ease while using the computers for note taking and data collection. Staudt concluded that "…portable technologies and software - in the hands of young students - provide enhanced opportunities for systematic investigation, critical thinking and cooperation" (para. 22).

A third study conducted by Curtis, Luchini, Bobrowsky, Quintana, and Soloway (2002), described ways handheld computers were used by third, sixth, seventh, and eighth grade students. Results listed several uses of handheld computers for each grade level.

The uses included: animating science concepts, research, word processing, note taking, graphing, and data collection. In addition,

> Handheld computers also support collaborative activities and increase student-student interaction. Students are able to divide group projects and then beam their individual work to their classmates, allowing the entire group to benefit from individual students' expertise (Curtis et al., 2002, p. 30).

Pownell and Bailey (2003) completed a study on the use of handheld computers in schools. Although their focus was on implementing handheld computing devices into schools from an administrative perspective, they discussed educational benefits and uses of handheld computers.

Another study conducted by Rodriguez, Nussbaum, Zurita, Rosas, and Lagos (2001) in Chile used handhelds computer to present video games to students to investigate the behavior of 263 children while using the device. However, the researchers used the video games Gameboy and Nintendo and referred to them as handhelds throughout this study. Through qualitative and quantitative measures, researchers found that the children's motivation, level of attention, and concentration increased during the game sessions.

A sixth study currently being funded by Kent State University is investigating the use of handheld computers to teach social studies in a fourth grade classroom. Malm (n.d.) is specifically looking for the effects of handheld use on student achievement and the differences in student achievement between students who use and who do not use handheld computers in fourth grade social studies.

In addition to the few studies that have been conducted on the use of handheld computers in education, many articles have been written about districts that are using the tools on a daily basis. Students in Marysville, Kansas use handheld computers as a

graphing calculator for algebra, a stopwatch in physical education, to download current events from USA Today online, and take notes through the use of a Palm™ keyboard or stylus. For special needs students in this school, the devices are a tool for writing. The device is then put on a HotSync cradle and notes are uploaded into a word processing program or beamed to another person. “Where students used to have trouble reading their own notes, now legibility is not an issue, and grammar and spelling can be corrected when the pressure to pay attention to the lecture is off” (Crane, para. 10).

In Carolyn Staudt’s high school math class, students used handheld computers to “…understand linear equations through explorations of positive and negative slopes and y-intercepts” (Staudt, 2002, para. 5). The students then used the device as a writing/drawing tool to explain in their own words and drawings what they learned. Results were beamed back and forth to check for understanding and beamed to the teacher upon completion.

Students in a New Jersey high school science class take their handheld computers on field trips to local parks. While there, they use probes attached to the devices to conduct studies on water quality (Valenza, 2003). Similarly, a Pennsylvania second grade class took their handheld devices to Valley Forge National Park to collect data, take pictures, and draw sketches comparing life now to life in 1776 (Valenza, 2003).

In a social studies class, students are constantly using their handheld computing devices to organize information, write, research, access primary sources, conduct surveys, collect data, and gather information/complete tasks on field trips (Whitworth, Owings Swan, & Berson, 2002).

An English class with handheld devices uses them to facilitate collaboration. Students individually drafted a letter to the school newspaper on their handheld computers, and created a single letter by beaming their writing back and forth to each other (eschool News Staff, 2000). In a similar activity, students in Tony Vincent's fifth-grade classroom use their handheld computers to improve writing skills through what he calls a Roving Reporter project. Each day, a different student takes notes and pictures in his/her handheld computer. Those notes are beamed to several students who in turn compose articles. For homework, students use those notes and graphics to write stories which are then either beamed to the teacher or synchronized to Vincent's computer and then put on the website (Valenza, 2003).

Another feature of the handheld computer that is being used in schools is wireless connectivity to the Internet and each other's device (eSchool News staff, 2000; SEIRTEC, 2002). Students in Wilmington, NC completed their senior projects through the use of these features. "…The handheld devices were efficient and effective ways to manage their research and writing time and to provide greater access time to the Internet than using the one school computer lab" (SEIRTEC, 2002, p. 11).

The few studies that have been conducted show that handheld computers are being used to enhance teaching and learning in many disciplines and across many grade levels. These studies show that the benefits of using handheld computers are numerous and include: providing students with a tool to collect and record data anywhere and anytime, the ability to focus on the problems and questions at hand, rather than on the logistics of completing the activity, assessment, autonomous learning, student responsibility for learning and collaborative learning. Articles have also been written

about many cases of schools using handheld computing devices. Elementary, Middle and High School students, teachers, and administrators are using handheld computing devices for various tasks.

Little is known about how younger students use handheld computers to learn and collaborate with others. Existing studies do not show what it looks like for first graders to use handheld computing devices to achieve learning outcomes and meet technology standards. Most research has stated that young children can use handheld computers but fail to explain in a descriptive manner exactly what the students do, what they say about their learning and use of the tool, and what their teacher says about the students' learning and the use of the device. No one has asked first graders how a handheld computing device helps them learn and communicate with others. The few existing research studies and articles state that all children can use handheld computers. Thus, a qualitative study of first grade students using handheld computers to learn and collaborate with others, focusing on student learning outcomes and technology standards, will help to address that research gap.

Collaborative Learning

Providing students with anytime, anywhere access to technology will enable them to meet the demands of the NCLB Act and the NETS which both include collaborative learning through the use of technology. According to the International Society for Technology in Education (ISTE) (n.d.) and the Educational Research Service (2001), new learning environments include but are not limited to the following: student-centered learning, collaborative work, information exchange, inquiry-based learning, critical thinking, real-world context, and multi-sensory stimulation. Students in the 21st

century are required to have certain skills that include digital literacy, inventive thinking, effective communication, teamwork, and the ability to create high quality products (CEO Forum, 2001, p. 2; Educational Research Service, 2001, p. 1; ISTE, n.d.). Dede as cited in Hopson, Simms, and Knezek (2001) further comments that higher-order thinking skills are best acquired when learners construct knowledge, use information-gathering tools, and collaborate with peers.

"Resnick has pointed out (1988) that throughout most of their lives people learn and work collaboratively, not individually, as they are asked to do in many schools" (as cited in Brown, Collins, & Duguid, 1989, para. 58). Vygotsky (1981) and Tinzmann, Jones, Fennimore, Bakker, Fine, and Pierce (1990) believe that higher forms of human behavior come from social interaction and communication and "…it is through others that we develop into ourselves" (Vygotsky, 1981, p. 161). Brown and Duguid (1993) feel that schools are faced with the challenge of designing learning environments so that participants can partake in authentic social practice and steal the knowledge.

This social practice is called collaboration and is defined by Zemelman et al. (1998) as children learning with one another. The following are characteristics of a collaborative classroom: students talk to learn; learning is active and constructive; knowledge is shared among teachers and students; both teachers and students bring knowledge and personal experience to the learning situation. Collaborative learning requires students to share thinking and as a result, work together to construct conversations, concepts, and experiences. Students work together to identify and solve problems through higher-order reasoning and problem-solving. Focus is on higher levels of understanding. Students take responsibility for their learning. Learners are diverse

students grouped heterogeneously. Tinzmmann et al. (1990) state that "segregation seriously weakens collaboration and impoverishes the classroom by depriving all students of opportunities to learn from and with each other" (para. 14). Students articulate their own points of view and listen to others' views (Gerlach, 1994; Palinscsar & Herrenkohl, 2002; Roschelle, 1992; Smith & MacGregor, 1992; Tinzmmann et al., 1990). Tinzmmann, et al. (1990) believe that when students learn in collaboration with their peers, more meaningful learning occurs and in return, students can solve problems better than they could individually.

> Students who are taught individually rather than collaboratively can fail to develop skills needed for collaborative work. In the collaborative conditions of the workplace, knowing how to learn and work collaboratively is increasingly important. If people are going to learn and work in conjunction with others, they must be given the situated opportunity to develop those skills (Brown, Collins & Duguid, 1989, para. 61).

Skills for meeting demands of the NCLB Act, NETS and succeeding in the 21st century include being able to work in collaboration with others. The ISTE, the Educational Research Service, and the CEO Forum highlight collaboration, information exchange, effective communication, and teamwork as critical to new learning environments. When children learn with one another, the result is more meaningful, higher level learning.

Collaborative Learning Using Handheld Computers in Education

Collaborative learning can be accomplished through the use of technology (Educational Research Service, 2001; Hopson et al., 2001; Jonassen, 2000). Specifically, according to recent research evidence, handheld computing devices support collaboration and sharing in the classroom (Crawford & Vahey, 2002; Curtis et al., 2003; Soloway, et al., 2001;). Kathy Norris (as cited in *West Virginia Statewide Technology Training*

Program to Include Palm Handhelds, 2003) InSTEP project manager states that "the Palm handheld is leading-edge technology whose size and mobility make it an ideal collaborative tool" (para. 3).

Collaboration is especially possible because of a unique feature called beaming. Handheld computers have a feature called beaming which allow devices to communicate with one another using an infrared (IR) light. IR is a wavelength of light that is used to send and receive information (Curtis et al., 2003). The IR port on handheld computers is a dark red plastic window, similar to remote controls. Beaming occurs when two handheld computers are directly aligned with one another, about six inches to three feet apart, and a button on the screen is pressed. Data and information, including records, applications, and documents, can be beamed from one handheld to another (Curtis et al., 2003). Not only can handheld computers beam documents and applications from one device to another, but they can also beam information to a printer which in turn tells the printer to print the document on the handheld computer. According to Curtis et al. (2003), beaming supports collaboration, peer-editing, and students sharing information. It was noted by Crawford and Vahey (2002) that there are other forms of wireless networking but believe that beaming is of greater value to education. They cited the following as important features of beaming:

> …there are no cumbersome steps between the physical parties and the act of collaborating. Beaming does not require that one look up an email address, remember an alias, or choose a name from a buddy list. Instead, beaming simply requires that the collaborators are physically near each other, and a beam is initiated through a simple button click or menu selection. Because of this, beaming is often felt to be an "intimate" action, almost like shaking hands. This may partly explain why beaming is so compelling to students: students are not required to translate between the person they are facing and that person's network name: instead they interact directly with the person in front of them (p. 65).

Beaming is a unique feature of handheld computers that allows students to communicate with each other using an IR light. Students can beam documents, notes, etc. from one handheld to another. The result of the beaming action is collaborative learning. The beaming ability of handheld computers gives them greater educational value than other forms of technology.

Summary

We need to better understand how first grade students use handheld computers to communicate throughout the learning process. Students do not have access to technology that facilitates the learning process and as a result, do not meet technology standards (Soloway, Norris & Curtis, 2001). These facts have led to educators searching for and using new technologies.

We know little about how handheld computers help young students learn collaboratively. Handheld computing devices are making their way into the field of education. More and more schools are seeing them as a way to enhance teaching and learning (Soloway, 2002). Demands from the NETS and the NCLB Act are forcing educators to find ways to bring technology to the students for enhanced learning. Studies of students using handheld computers apply to older children.

A technology evolution is ongoing and has brought many changes to the tools we learn with. In 1970, the evolution began with large, expensive computers that were used for administrative tasks. The second wave of computing included the desktop computer and the idea of computer literacy. Students were taught how to use a computer. The third wave occurred in the 1990s and included the introduction of the World Wide Web into education and constructivist learning through the use of technology. Currently, the fourth

wave of technology includes the use of handheld computers as teaching and learning tools (Pownell & Bailey, 2003). They are used widely in business and are starting to be seen more in schools.

This wave of technology is driven in part by the implementation of technology standards and the NCLB Act. Schools are striving to meet the challenge of equipping each student with technology that will enhance learning. In many districts, handheld computing devices are seen as the tool that can meet these challenges.

According to a study on the benefits of handheld computers in grades two through twelve, most teachers felt that handheld computers were an effective instructional tool and they can improve the quality of teaching and learning (Crawford & Vahey, 2002). Most research on using handheld computing devices has focused on the negative and positive aspects of using the new technology for teaching and learning. Articles and informal studies show that handheld computers are being used in all grade levels and all subject areas across the United States. Educators are beginning to grasp the power of handheld computers because they perform functions necessary to enhance learning that desktop computers perform. No formal studies exist that focus on using handheld computing devices in a first grade classroom; however, articles mention the benefits to using handheld computers with young learners (Concord Consortium, 2002).

Education professionals have written articles on how many teachers are using handheld computers in classrooms. The devices are being used in all subject areas and all grade levels (Crawford & Vahey, 2002; Curtis, et al., 2002; Rodriguez et al., 2001; Staudt, 1999; Valenza, 2003). Specifically, educators highlight how the handheld computing device enhances learning as a tool for collaborative learning (Crawford &

Vahey, 2002; Curtis et al., 2003; Soloway, Norris & Curtis, 2001; *West Virginia Statewide Technology Training Program to Include Palm Handhelds*, 2003). The NETS, NCLB Act and Best Practices stress the importance of students learning through social interaction and communication. According to research, handheld computers support collaborative learning environments (Crawford & Vahey, 2002; Curtis et al., 2003; Soloway et al., 2001). The unique beaming feature on the handled computing device allows users to share documents, data, and information with the press of a button.

No one has described how first grade students use handheld computers to collaborate and learn, and how their learning relates to outcomes and technology standards. Thus, a qualitative study of how first grade students use handheld computing devices to collaborate, learn, and meet learning outcomes and technology standards can make an important contribution.

Chapter 3: Methods

Overall Approach and Rationale

This chapter outlines the methodology for the qualitative research study on first grade students using handheld computing devices to collaborate throughout the learning process. The use of the qualitative paradigm will be discussed. Specifically, an ethnographic case design was used. "Ethnographic case studies are quite common, for example, wherein the culture of a particular social group is studied in depth" (Merriam, 2002, p. 8).

A description of the setting, Southeastern Community School District, is provided along with the sampling procedure for the participants chosen. Ethics for working with children were taken into consideration and discussed in this section. Methods for data collection and analysis are provided.

Approach

This study used a qualitative approach because the researcher observed students using handheld computers as they learned in their classroom, their natural setting. Marshall and Rossman (1999) described qualitative research as being emergent and interpretive, taking place in the natural world, and using interactive and humanistic methods. "…A qualitative case study seeks to describe that unit in depth and detail, holistically, and in context" (Patton, 2002, p. 55). The social interactions between students were observed. Patton (1997) believes that "Qualitative data consist of detailed descriptions of situations, events, people, interactions, and observed behaviors; direct quotations from people about their experiences, attitudes, beliefs, and thoughts; and excerpts or entire passages from documents, correspondence, records, and case histories"

(p. 273). A qualitative researcher is "…highly involved in actual experiences of the participants" (Cresswell, 2003, p. 181). This research on first grade students using handheld computers was best suited for this qualitative research methodology.

Specifically, the researcher used an ethnographic case study design. Merriam (2002) notes that a case study is an intensive description and analysis of a social unit such as a group, in this case, a first grade class. Ethnography is a type of qualitative research that "…allow[s] investigators to study the complex interactions of individuals within their immediate environment" (Schloss & Smith, 1999, p. 87). This design allowed the researcher to give detailed descriptions of interactions between teachers and students.

Throughout this qualitative ethnographic case study, the research questions were:

1. In what ways are students using handheld computing devices to collaborate?

    1a. How does the use of handheld computing devices to collaborate impact students' learning outcomes?

    1b. How does collaborative learning through the use of handheld computing devices relate to technology standards?

Research Design

An ethnographic case design was chosen because of its ability to capture the interactions between students using handheld computers. "The intent of ethnographic research is to obtain a holistic picture of the subject of study with emphasis on portraying the everyday experiences of individuals by observing and interviewing them and relevant others" (Fraenkel & Wallen, 1990 as cited in Cresswell, 2003, p. 199-200). The researcher observed participants throughout the collaborative learning process. Detailed field notes were taken as students used handheld computers to work together. In addition,

informal conversational interviews took place. This type of interview emerged from the observations, was matched to the students and their circumstances, and increased the salience and relevance of questions (Patton, 2002). The researcher videotaped the students so that she was sure to capture all important data. Documents and text shared between students through the beaming process provided the researcher with rich data about their communication throughout the learning process. The ethnographer wasn't simply interested in "…"events" and "activities" themselves but in the ways in which they are engaged, guided, described, and generally assigned significance by group members" (Emerson, 2001, p. 27-28). The researcher secured beamed documents and text that allowed her to become engaged with the students as they learned with each other.

Site Selection

The site selected for this study was a public elementary school in Southeastern Community School District (SCSD), which is located in Southeastern Pennsylvania. This district is located in a suburban community made up largely of single family homes and developments. It is also home to large industry, wholesale and service companies. The school district comprises an environment of mostly rolling hills and farmland in its 72.3 square miles. SCSD has approximately 5200 students in grades K-12. The district has one high school, two middle schools and six elementary schools.

Southeastern Community School District is a standards-based school district. In September 2002, SCSD put a framework in place to address the state and national standards, with the flexibility to develop the curriculum and instructional strategies which meet the needs of all students, K-12 (The School District, 2002). In order to meet the

needs of all students and have them meet high standards, SCSD implemented several strategic goals. The goals included: implement, support, and continually evaluate the K-12 Academic Standards; provide staff development for teachers that allows them to grow professionally; develop programs to assist needs and talents of all students; increase support to teachers that enhances services to at-risk students; and establish high standards for the use of technology in instruction and provide necessary tools to teachers and students (The School District, 2002).

In addition to meeting high standards, all students are required to use technology to meet standards and curriculum goals. Since 1998 the administration has been putting technology in the hands of teachers and students throughout SCSD. In 1998, every teacher was issued a laptop and printer for use in their classroom. In 1999-2000, the district received an Educate America Grant which put 10 laptops in each elementary building in addition to 10 laptops purchased by the district. Since then, technology has flourished throughout the district and in 2002, all teachers received an upgraded laptop computer. This allowed the old laptops to be placed in the hands of students throughout the district, bringing the total number of laptops in each building to 30. At the present time, each elementary classroom has four desktop computers allowing teachers to focus on the integration of technology.

Continuing in its efforts to put technology in the hands of teachers and students, SCSD began a pilot program with handheld computing devices during the spring of 2003. The following goals were the driving force of this project: to introduce handheld computers into the classroom and evaluate their use as an instructional tool; and to explore the benefits of a 1:1 student to computer ratio.

Participating classes were chosen based on the technology level of the teacher and principal in each elementary school. Also taken into consideration were spanning the project among different grade levels and schools throughout the district. One first grade, one third grade, one fourth grade and one fifth grade were chosen.

In the beginning of the project, participating teachers were given a full day training workshop in March 2003. Training included basic use of the handheld computer and curriculum connections to implement in their classroom. Training was designed to teach the participants how to use the handheld computers as teaching and learning tools. The Instructional Technology Coordinator met with the teachers throughout the project to assist in planning the integration of the handheld computer in teaching. Teachers were provided with the following: *Palm Handheld Computing: A Complete Resource for Classroom Teachers, 101 Great Educational Uses for Your Handheld Computer*, access to an on-line forum called NiceNet to begin a reflection process on the use of handheld computers in their classroom and their own handheld computer and keyboard. They were also provided with the following technology for their classroom: thirty m130 Palm™ Handheld Computers; one 515 Palm™ Handheld Computer for the teacher; five Palm™ portable keyboards; two 10-slot charging cradles. After receiving training, teachers trained their students in the use and responsibility of the handheld computers. Students took the handheld computers home and were held responsible, as they would be for any textbook or library book that is loaned to them (Kozloski, 2003).

Students that were part of the pilot also had access to several different software applications for their handheld computers. The main applications used by the elementary students were part of a suite of software called the Handheld Learning Environment

(HLE) and was produced by GoKnow. The HLE included productivity software programs that can be integrated with one another. Included in this suite of software were the following applications: FreeWrite™, PiCoMap™, Sketchy™, and FlingIt™. Students and the teacher also had access to word processing, spreadsheet, presentation software and an application called iKWL™ on their handheld computers. All of these applications were used as productivity software to enhance the teaching and learning process in the pilot classrooms.

The iKWL software application assists students in organizing their thoughts and generating ideas about what they know, what they want to know, and what they learned about a topic. It includes a function that allows students to generate a word list which they can refer to at any time during the program. When listing what they want to know about a topic, iKWL provides questions words such as why, where, and how that prompts students to generate meaningful questions. When using a word from the list or a question prompt, students simply click on the word and it appears in their text. This type of activity is frequently used by teachers at the beginning of a new unit, to begin research, or to discuss a new topic.

FreeWrite is a word processing program that has auto-capitalization and spell checking capabilities. Students can also use the infrared capabilities of the handheld computer to beam documents to one another. This application can be used to create text documents, peer edit, take notes and journal.

PiCoMap is a concept mapping tool that allows students to create and share documents with one another. Concept maps can be used for brainstorming, organizing

thoughts, outlining, and assessment. When students beam concept maps to one another, their ideas become integrated on each other's screen.

Sketchy is a tool that allows students to draw and animate objects. With this tool, students can diagram cell structures, animate growth cycles, write and share stories.

FlingIt™ is a tool that saves and sends Web pages from the desktop computer to the handheld computer. This application allows students to view Web pages offline on their handheld computer when it is convenient for learning. The teacher and students can beam Web pages from one handheld computer. FlingIt makes online research available offline and allows students to create a personal reference library, and take part in group research projects.

Because these programs are all part of the Handheld Learning Environment, they are directly linked together. FreeWrite, PiCoMap and Sketchy documents can be brought together into one overall project document.

> Now in a PiCoMap, each node can contain other documents. For example, clicking on one node could take you to a Sketchy animation, while clicking on the central node could take you to a FreeWrite document with questions posed by the teacher. Web pages can also be incorporated to add rich content for student research (GoKnow, Inc., 2003, para. 5).

Before using the above software, the teachers introduced their students to the handheld computers. Specifically, in first grade, students were taught how to print all the letters of the alphabet before they were introduced to the Graffiti alphabet. Once students knew all of their letters and could print them, the teacher showed them how to write using Graffiti characters. Once the teacher introduced the Graffiti alphabet to the students, each day, when they used their handheld computers, the use of the characters was reinforced. In addition, students were taught how to turn the handheld computer on, access different

programs, beam, etc. These skills were integrated into their learning experiences. Use of the handheld computer was reinforced through each lesson.

The SCSD handheld pilot program is an example of how one school district integrated handheld computing devices into the elementary curriculum. SCSD was chosen specifically because they had access to and were using the devices. Wiersma (2000) stated that ethnographic research is "…not amenable to random sampling, at least not for the site selection" (p. 284). Therefore, the type of sampling used for this study was purposeful sampling. Purposeful sampling allowed the researcher to select information-rich cases to study in depth (Patton, 2002).

Student Sample (Purposeful Sampling)

A first grade class in the Rider Elementary School was chosen because it was information-rich for the data. This first grade class was part of the SCSD handheld computer pilot program.

Rider Elementary School celebrated its 75th year as a school in SCSD and housed approximately 350 students in kindergarten through fifth grade. The school had two sections of kindergarten, first grade, and third grade. There were three sections of second, fourth, and fifth grades. Generally class size was about 24 to 27 students per classroom. The ethnic distribution at Rider Elementary School included seven African American students, 27 Hispanic students, six Asian students, and 307 Caucasian students.

In addition to 14 classroom teachers, there were two resource room teachers who supported 29 students at the primary and intermediate levels. Other support available to students included a speech and language therapist, special interest teacher, reading specialist, guidance counselor and an instructional support teacher (IST). Rider

Elementary School also provided before and after school enrichment support to 15 students and remediation to 37 students. The English as a Second Language (ESL) teacher served eight children. Sixty-three students qualified for the free lunch program and 37 students took part in the reduced lunch program. The special interest teacher served eight students. Twenty-six students participated in Student Council.

The role of the guidance counselor is to give support to students, parents and teachers in an effort to help each child achieve success. The guidance counselor worked with 12 students individually and in groups, and conducted classroom guidance lessons two times a year in each classroom.

The IST is responsible for joining parents, the principal, guidance counselor, reading specialist, and teachers to work together to help students meet academic standards and experience success in school. The IST served 68 students during the school day. He worked with the group to devise a plan of strategies and then provided support for students experiencing academic, behavior, or social difficulties.

A third support to students at Rider Elementary School is the reading specialist. She ran a Title I reading program for 35 students and provided additional reading support to 13 students.

Rider Elementary students participated in art, physical education, music, and library classes once a week. They had the option of participating in an instrumental program beginning in fourth grade.

The class chosen for this study was a first grade class and was comprised of 23 students. Of those 23 students, twelve were girls and eleven were boys. Six students received support from the reading specialist and were part of the Title 1 reading program.

Title 1 is a federally funded program based on the free and reduced lunch counts at Rider Elementary School. It was the reading specialist's job to identify the students who needed support in reading and writing based on data she collected and teacher input. The Title I instruction included students reading familiar books, reading new books on their Instructional reading level (90-95% accuracy with comprehension) while applying reading strategies, and engaging in word work and writing. Two students from this class participated in Read to Succeed which is a grant that SCSD received several years ago. The funding no longer comes from the government, but the district took over the responsibility. These students were close to or at proficiency, but still needed some support with reading and writing. They were pulled out of the classroom approximately two out of every four cycle days to work in a small guided group that worked on reading, word building and writing.

A high school intern and a pre-student teacher from a local university also visited this classroom on a regular basis. Both individuals had been visiting this first grade classroom since the beginning of the 2004-2005 school year. The intern was part of a district program in which students who were seniors at Southeastern Community High School and wanted to pursue teaching as a career spent time in a classroom for part of the school year. This intern visited the classroom everyday from 9:30 until 11:00 in the morning. The pre-student teacher visited this classroom two days each week until the end of December, 2004. It was the responsibility of the high school intern and the pre-student teacher to observe teaching and learning in this first grade classroom.

This class was chosen because it was part of the district-wide handheld project and it had access to handheld computers for each student and teacher. The teacher

participated in the handheld project for two years. Each year, she integrated the use of the handheld computer into the students' learning experiences. Students learned how to use the devices while they completed content area tasks. The teacher modeled the use of the handheld computer showing the students what to click on so that they would learn what each of the buttons did and how they worked. Specifically, the class had 25 handheld computing devices, four desktop computers and access to laptops for each student. In addition to the student computers, the teacher had a handheld computer, laptop and printer in the classroom.

Both the teacher and students received a contact letter from the principal of Rider Elementary School (see Appendix H) and from the researcher (see Appendix I) and completed a consent form agreeing to participate in the study. On the consent form, the parent/guardian had the option of allowing his/her child to participate in this study but could object to his/her child being videotaped during interviews. There was a box below the signature that they could check. If they signed this form and checked the box, their child participated in the study but was not videotaped. He/she participated in all of the same learning experiences as the other students. His/her daily routine was not changed. The researcher kept a class list that had a column for each of the following after each student's name: students are participants who can be videotaped, students are participants who cannot be videotaped and students cannot take part in the study. After looking at the returned consent forms, the researcher put appropriate check marks next to each student's name. The researcher, teacher, principal investigator and outside observer were the only people who saw this list. Students wore nametags so that the researcher, principal observer, and outside observer knew each student's name. If a parent/guardian did not

sign the consent form or if the parent did not send the form back to school, that child did not participate in the study. They continued to take part in the normal daily activities of the class but were not interviewed or videotaped. All data collected was coded so that the participants had privacy.

Data Collection

Data was gathered through observations, interviews, videotaping, and student artifacts (see Table 3 Data Collection and Analysis Timeline). Triangulation was used to compare data to decide if it corroborated (Wiersma, 2000). “It is in data analysis that the strategy of triangulation really pays off, not only in providing diverse ways for looking at the same phenomenon but in adding to credibility by strengthening confidence in whatever conclusions are drawn” (Patton, 2002, p. 556). Data was collected during the second marking period of the 2004-2005 school year at Rider Elementary School. Students began using the handheld devices during the first marking period of the school year. The students learned how to use the handheld computers while they were using the devices to complete tasks. The teacher integrated skills instruction into content area learning experiences that met district standards. Because students learned how to use the handheld computers and learned how to read and write, the teacher scaffolded instruction so that students were successful when using the handheld computers. Mrs. Smith drew pictures on the board and printed out pictures of the icons for the software applications to show the students what their screens should look like and what they should click on.

Table 3 - Data Collection and Analysis Timeline

Research Questions	Method	Timeline	Analysis
1. In what ways are students using handheld computing devices to collaborate?	Observation (Field Notes) Interview Guide Student Artifacts	Weeks 1-6	Outside observer Video Analysis Content Analysis
1a. How does the use of handheld computing devices to collaborate impact student learning outcomes?	Interview Guide Student Artifacts	Weeks 2-6	Video Analysis Content Analysis
1b. How does collaborative learning through the use of handheld computing devices relate to technology standards?	Interview Guide Student Artifacts	Weeks 2-6	Video Analysis Content Analysis Standards Based Rubrics (See Appendix B, C, D, E)

Role of Researcher

During this study, the researcher played the role of participant observer. She interacted with the students as they participated in learning experiences. Ms. Fritz was a former elementary teacher and had experience working with students at this level. Therefore, she understood and described the learning process as it occured. "…To understand behavior, the observer must understand the context in which individuals are thinking and reacting" (Wiersma, 2000, p. 248). Ms. Fritz taught third grade in this school district in a different elementary school. An outside observer, Ms. Ann Jones, the Instructional Technology Coordinator at SCSD will validate the observations.

While teaching in SCSD, the researcher had access to computers in the classroom. This access showed her the power of the integration of technology. This experience drove her to pursue her current job as Technology Skills and Technology Integration Facilitator for grades kindergarten through eight in a local school district.

She worked with teachers to integrate technology into the curriculum. She provided a model for using technology as a teaching tool at all grade levels. Her experiences as a teacher and in her current position were her motivation for this study.

The inability to meaningfully integrate technology into the curriculum in her current district drove her to pursue this topic of study. Teachers in her current school district did not have access to technology in the classroom. They took their students to a computer lab once each week for instruction. In response to the need for technology in her district, Ms. Fritz sought alternatives for the desktop computer as a tool for enhancing the instructional process. She became a Palm™ Education Certified Trainer in September 2002. During this training, she learned not only how to operate a handheld computer, but

also how to use it as a tool throughout the teaching and learning process. This training motivated her to look more closely at how handheld computing devices can impact learning for elementary students.

Because Ms. Fritz knew that Southeastern Community School District had access to a vast amount of technology, including handheld computers, Ms. Fritz chose this district as her research site. The Superintendent of Schools for SCSD sent a letter to the researcher giving her permission to conduct the study (see Appendix J).

Observations

In order to capture exactly how the students used handheld computers to collaborate, the researcher was immersed in the field situation. The primary method of data collection was observation. The researcher will "…investigate, experience and represent the social life and social processes that occur in [the] setting…" (Emerson, Frets, & Shaw, 2001, p. 352). The frequency and duration of each observation varied based on the use of handheld computers by students. "The overall time spent on the site, the number of visits, and the number of observations made per visit cannot be precisely determined ahead of time" (Merriam, 1988, p. 92). While observing students, field notes were taken and immediately following observation, were synthesized, summarized, and written as a narrative (Wiersma, 2000).

Observation was the primary method of data collection because this focus has not been specifically researched before. Handheld computers are not widely used in education, especially in first grade classrooms. Therefore, it was necessary to document exactly what happened when first graders used the devices throughout the learning process. Specifically, the researcher observed lessons that required the students to use the

handheld computers as learning tools. As an example, a lesson on the signs of spring (see Appendix K) required the students to brainstorm and list what they know about spring, share their ideas with a partner and then list what they wanted to learn about spring. Students attached a special camera to their handheld computer and took pictures of the signs of spring outside their school. They inserted those pictures into a document and write what they learned about spring. The teacher used the PAAM™ software to view student work and assess their writing based on a rubric (see Appendix L). It was through actual authentic learning experiences that showed the power of these tools in a primary classroom. Close observation provided the data necessary to describe through narrative accounts how students used the handheld devices to learn collaboratively, how it related to their learning outcomes and how technology standards were met.

Observations took different forms throughout the study (Lincoln & Guba, 1985). Prior to the observations, the researcher spent time in the classroom getting to know the teacher, students, how they worked together throughout the learning process and how they used handheld computing devices. The researcher's immersion in the setting during the beginning of the study gave her a chance to get to know the students which was important so that an atmosphere of trust was formed. Her immersion in the setting lessened the obtrusiveness of her presence and provided "…a baseline of cultural accommodation and informational orientation that will be invaluable in increasing both the effectiveness and the efficiency of the formal work" (Lincoln & Guba, 1985, p. 251). Observations of young children in their natural setting gave research a "real world edge" and lessened the obtrusiveness (Greig & Taylor, 1999). In the early stages of observation, the researcher made a "…holistic description of events and behavior" (Marshall &

Rossman, 1999, p. 107). During this time, the researcher looked for recurring patterns of behavior and relationships while students used handheld computers to learn collaboratively. Analysis of field notes throughout the observations helped the researcher define patterns which in turn assisted in forming questions and checklists of behaviors for more in depth study during later observations (Emerson et al., 2001; Marshall & Rossman, 1999). This developed over time throughout the observations.

Field notes were taken to describe what happened when students used handheld computers to learn collaboratively. Field notes were taken, recording date, time, location, participants involved, description of the physical setting, social interactions that occured, and activities that took place (Patton, 2002,). The researcher arranged the field notes in two columns (see Appendix M). On the left hand side of the form was a detailed description of what occured during the observation and on the right hand side was the researcher's comments. "Observer's comments are often a quite fruitful source of analytic insights and clues to focus data collection more tightly" (Marshall & Rossman, p. 108). Extensive notes were taken throughout observations and reviewed at the conclusion of the observation to fill in details and ensure what the researcher wrote made sense (Patton, 2002).

After field notes were taken, they were reviewed, compared to the outside observer's field notes, and written in narrative form to provide a clear description of how the students used the handheld computers.

Interview Guide

In addition to observations, the researcher used interviews as a method of data collection to fully capture the first grade students' perspective of what they experienced

as they used handheld computers. Interviews with the teacher gave her perspective about the students' learning through the use of handheld computing devices. Using both observations and interviews helped the researcher obtain valid responses and strengthen data (Eder & Fingerson, 2002). First hand accounts of the students and teacher strengthened what the researcher noted from observations. Interviews allowed the teacher and students to have input as to their thoughts and feelings when they used handhelds to learn collaboratively.

The researcher used the following strategies when interviewing the students: (a) established trust before interviewing; (b) interviewed children in a small group; (c) interviewed children in a familiar, convenient, casual setting; (d) interviewed children while they are actively completing a task; and (e) enlisted the children's help during the interview (Parkinson, 2001). "Group interviews can also be used successfully to aid respondents' recall of specific events (e.g., a disaster or a celebration) or experiences shared by members of a group. (Cicourel, 1974)" (Fontana & Frey, 2000, p. 651).

The researcher also asked students' permission for interviewing and videotaping in order to establish trust between the participants and researcher. Interviews were videotaped and each student's parent was asked to sign an informed consent form. If parents were opposed to their child being videotaped, the outside observer observed the interviews and wrote what she saw.

An interview guide was used to capture interviews with students. The interview guide (see Appendix N) listed questions and issues that were explored during the interview. It allowed the researcher to focus on the same topic for each interview but explore, probe and ask questions relative to the student(s) and situation. Throughout

interviews, notes included a subject heading, opening statements, key questions, space for recording comments and space for reflective notes (Cresswell, 2003). Students' answers to questions often determined the next question(s); therefore, the researcher sought to answer a set of questions and generated further questions from those interviews (Parkinson, 2001; Powney & Watts, 1987). The first set of questions included:

1. What did you learn?
2. Did your handheld computer help you learn?
3. What did you use the handheld computer for?
4. Did a friend help you get that information?
5. How did your friend get that information to you?

Interviews were videotaped so that the researcher could focus on the students. A benefit to using video was that it recorded students' facial expressions and helped the researcher decipher unclear responses easier than from audiotape (Graue & Walsh as cited in Parkinson, 2001). Videotaping allowed the researcher to be more attentive to the interview; formulate the next question; and write short, quick notes which included key terms or phrases so the young students weren't distracted. The researcher also was able to review the videotape to look for nonverbal behavior and communication and their use of the device to demonstrate how it was used to learn. The researcher did not have to take copious notes and risk missing information. Students were asked to show the researcher how they used handheld computers to learn.

Videotapes captured not only the actions of students but also what they said about their learning. Having students demonstrate their actions was important especially for those students who could not verbalize their thoughts. Tammivaara and Enright (as cited

in Parkinson, 2001) noted that young children had more success during an interview when they had something in their physical presence that they could do something with and then talk about it. Another benefit to using videotapes was that when interviewing children, they were interviewed in small groups in order to capture the collaborative nature of their interactions. The researcher focused on the groups' interactions, conversations, and questions without having to worry about writing everything down. After the interview, the tape was reviewed and details were noted. During the videotape review, the researcher reflected and elaborated on her notes (Patton, 2002).

Throughout the six week data collection period, students were interviewed three times. Interviews took place in small groups in the classroom during the learning experience so that the collaborative learning was captured. The students were selected for an interview when they used the handheld computer with a peer(s) to take part in a task. The researcher interviewed small groups of students, one group at a time. The researcher had a list of all of the students in the class. She unobtrusively made a check mark next to each student's name each time he/she was interviewed. Students were selected for the interviews if they were engaged in a learning experience with a peer using the handheld computer. Not all students were interviewed at the same time. Therefore, the researcher moved throughout the room during each learning experience and talked with students as they worked. Rich discussion came from interviews that occurred when students talked to each other as opposed to when students answered questions one on one (Parkinson, 2001).

First graders had difficulty sitting for long periods of time and participating in long discussions, therefore, the researcher joined them in their activity, asked simple

questions, used child friendly language, and created a climate for focused "talk" (Marshall & Rossman, 1999). Becoming a participant, being on their level, using students' names, eye contact, and smiling were important in gaining the students' trust and having them feel comfortable and confident during the study (Powney & Watts, 1987). Interviews were conducted throughout the study and arose from observations. The researcher conducted interviews as the collaboration naturally occurred. It was not developmentally appropriate for young students to be able to answer abstract questions; therefore, interviews occurred "…while they are *doing*, which tends to be less intimidating than sitting down and having a face-to-face question-and-answer session" (Parkinson, 2001, p. 145). When conducting group interviews, Merton et al. (as cited in Lincoln and Denzin, 2000) suggested keeping one student from dominating, encouraging all students to participate, and obtaining responses from all students in the group in order to ensure full coverage of the topic.

Students were asked to interpret the messages they received through beaming each other, and discuss what happened throughout the collaborative process that could not be observed through daily conversations and interactions (Eder & Fingerson, 2002). In order to get a complete picture of how the students used handheld computers to learn collaboratively, the devices were used to focus the interview. Students were asked to show the researcher how they used the device to learn collaboratively. It was necessary to get the reasoning behind why and how the students shared information with peers and what they learned from that. The nature of the collaboration determined the question(s) the researcher asked students. The researcher described what the students experienced, how they felt about it, what the devices helped them do.

The teacher was also interviewed to get her perception of how the students used handhelds to learn collaboratively, how that impacted learning outcomes and if it assisted the students in meeting technology standards. Interviews with the teacher took place during non-instructional times (while the students were at lunch, recess, or a special class) in her classroom and gave her perspective about the students' learning through the use of handheld computing devices.

Student Artifacts

During interviews and observations, the researcher collected documents from students that showed evidence of using the handheld computer to learn collaboratively. A benefit to using student artifacts is that it was unobtrusive; student work was not disturbed in any way (Marshall & Rossman, 1999). "Material culture is thus *necessary for* most social constructs. An adequate study of social interaction thus depends on the incorporation of mute material evidence" (Hodder, 2000, p. 706). Student artifacts were examined for evidence of meeting NETS and curriculum outcomes.

Throughout the study, the researcher gathered data from the students' handheld computers and any products they completed during the process of using the devices to collaborate. The children used handheld computers to share information and documents with each other and their teacher on a daily basis. It was already part of their normal routine. They also used their handheld computer to download their documents onto a computer for Mrs. Smith to see. The students were used to doing this on a daily basis therefore; the researcher used the same procedure to look at their documents.

A program called Palm OS™ Archive and Application Manager (PAAM™) was used to secure copies of students' work from their handheld computers. PAAM™

"…enables teachers to effectively manage and assess students' documents created on their handheld computers" (GoKnow, Inc., 2003, para. 4). PAAM™ was created by Elliot Soloway and his team of researchers at GoKnow, which is a company that was founded by a group of professors who lead the University of Michigan's Center for Highly-Interactive Computing (HI-CE). GoKnow is a research-based provider of educational software, curriculum, and professional development for handheld computers. In order to use the PAAM™ software, children put the handheld computer into a cradle that was connected to a computer, which was connected to the Internet. The computer that was connected to the handheld computer had PAAM™ software running on it. Once the user pressed the HotSync button on the cradle, PAAM™ retrieved all the files from the child's handheld computer and sent them, over the Internet, to a secure server and stamped them with a time and date. When Mrs. Smith or the researcher logged onto the server, on a computer using a regular browser she got a web page that listed all of the students; the teacher then selected a student, and viewed that student's documents on the desktop. Using PAAM™ to gather and organize student documents allowed the researcher to "…compare versions of documents, and look for evidence of improvement, collaboration, and presents a clear picture of what documents students are producing…" (Curtis et al., 2002, p. 24). PAAM™ allowed the researcher to view and manage student documents in an organized manner.

It was important to collect student documents because they accurately reflected correspondence between students and they were a rich source of information that added to the interviews and observations (Lincoln & Guba, 1985). Student artifacts included items beamed from one student to another, text entries on handheld computers, and

printed items. All documents collected were compared to a content area specific, standards based rubric. Students in this first grade classroom used a writing rubric, math rubric, and a reading response rubric daily to evaluate their work. The researcher worked with the teacher to assess whether or not artifacts showed that students were meeting standards and learning outcomes using rubrics from the appropriate subject area.

Data Analysis

This section explains how the researcher completed the following tasks: data organization, theme development, interpretation, and narrative writing (Marshall and Rossman, 1999). Final analysis resulted in a descriptive report of the results. "In qualitative studies, data collection and analysis typically go hand in hand to build a coherent interpretation of the data" (Marshall & Rossman, 1999, p. 151). Marshall and Rossman (1999) suggested that "…analytic procedures fall into six phases: (a) organizing the data; (b) generating categories, themes, and patterns; (c) coding the data; (d) testing the emergent understandings; (e) searching for alternative explanations; and (f) writing the report" (p. 152).

Content analysis was used to analyze interview transcripts, field notes from observations, and documents from the students' handhelds. Much of the collaborative learning occurred through the use of beaming. Students beamed documents to one another, which was observed; they told the researcher about the beaming, which was discussed in an interview; but it was only through the analysis of the documents on their handheld computers that the researcher was actually able to see the information they shared with one another. Documents were obtained through the use of PAAM™ and analyzed for evidence of collaboration. Student documents were assessed according to

the ISTE Performance Indicators for Technology—Literate Students Grades PreK-2 (Appendix B) and content area standards (Appendix C, D, and E) to measure whether standards and learning outcomes were met.

Content analysis included identifying, coding, categorizing, classifying, and labeling patterns in the data (Patton, 2002). Field notes, student documents, and videos from observations and interviews were examined after each site visit. While reading the field notes and documents, and watching the videotapes, the researcher highlighted key phrases and wrote notes. As the researcher watched the video, she marked each note with the time code from the videotape. Time coding the video notes made it easier to find video segments later. Notes from field notes, documents, and videotapes were coded using color coded Post-its to form categories which allowed the researcher to "…spot quickly, pull out, then cluster all the segments relating to the particular question…" (Miles & Huberman, 1984, p. 56). The researcher reread the field notes, documents, interview transcripts, and re-watched the video to ensure all data was accounted for. Codes emerged during data collection and were revised throughout the field experience (Marshall & Rossman, 1999; Miles & Huberman, 1984). "As coding categories emerge, the investigator links them together in theoretical models. One technique is to compare and contrast themes and concepts. When, why, and under what conditions do these themes occur in text?" (Ryan & Bernard as cited in Lincoln & Denzin, 2000, p. 783). Codes related to the research questions. The researcher made a list of the codes on a separate piece of paper to refer to throughout data collection and analysis (Patton, 2002).

After coding of the data was complete, both Denzin and Lincoln (2000) and Miles and Huberman (1984) suggested writing memos. Memos included the researcher's deep

thoughts while coding and brought together analytic interpretation and empirical reality (Charmaz as cited in Denzin & Lincoln, 2000). Memos were dated, labeled with a key concept, and linked to research questions.

After coding and memo writing, the researcher wrote a site summary "…which provide[d] a synthesis of [what she] knows about the site, and indicates what is still left to find out. It reviews findings, looks carefully at the quality of the data supporting them, and states the agenda for the next waves of data collection" (Miles & Huberman, 1984, p. 75). Site summaries were generated based on the codes. The researcher wrote a site summary after each visit to the site.

The researcher used the Constant Comparative Method as was suggested by Lincoln and Guba (1985). Because this study developed a narrative and not theory, the researcher substituted the word "theory" with the word "narrative" (See Table 4).

Table 4 - Combination of Marshall and Rossman's 6 Phases and Constant Comparison Method

<table>
<tr><td colspan="2">Stage 1 Stage 2
Each step in stages 1 and 2 are ongoing throughout the data collection/analysis processes and lead into stage 3.</td><td>Stage 3</td><td>Stage 4</td></tr>
<tr><td>Collect Data</td><td rowspan="2">Look for key issues, recurring events in the data that begin to form categories</td><td rowspan="4">Delimit the narrative
Step 1: Compare data from categories
Step 2: Reduce categories which results in more select and focused collection, coding, and analyzing of data</td><td rowspan="4">Write the narrative</td></tr>
<tr><td>Organize data
Read and sort through data; develop codes</td></tr>
<tr><td>Write memos; look for themes</td><td rowspan="2">Integrate categories and their properties</td></tr>
<tr><td>Write site summary</td></tr>
</table>

The Constant Comparative Method was applied "…to any kind of qualitative information, including observations, interviews, documents, articles, books, and so forth" (Glaser & Strauss, 1967, p. 104). The Constant Comparative Method involved the following four stages: "(1) comparing incidents applicable to each category, (2) integrating categories and their properties, (3) delimiting the [narrative], and (4) writing the [narrative]" (Glaser & Strauss, 1967, p. 105).

Up to this point, data analysis was inductive because the researcher searched for themes in the data (Patton, 2002). Through the coding process, themes emerged from the

data (Wiersma, 2000). “Once patterns, themes, and/or categories have been established through inductive analysis, the final, confirmatory stage of qualitative analysis may be deductive in testing and affirming the authenticity and appropriateness of the inductive content analysis, including carefully examining deviate cases or data that don’t fit the categories developed” (Patton, 2002, p. 454).

The next step in the Constant Comparison Method included delimiting the narrative. The researcher made major modifications in the data as categories were compared and reduced. “Later modifications are mainly on the order of clarifying the logic, taking out nonrelevant properties, integrating elaborating details of properties into the major outline of interrelated categories and-most important-reduction” (Glaser & Strauss, 1967, p. 110). Consideration, coding and analyzing of data became more select and focused through the comparison of data (Glaser & Strauss, 1967).

The final stage of analysis included writing the narrative. The narrative was organized according to the research questions and analytic insights and interpretations that emerged during data collection (Patton, 2002). It included detailed description and direct quotations which took the reader into the classroom setting (Patton, 2002).

Triangulation

An outside observer also observed and took field notes to allow for triangulation of sources. In addition to being the Instructional Technology Coordinator for Southeastern Community School District, Ms. Ann Jones is a PhD Candidate. She has her Master’s degree in Education from Rosemont College and an Instructional Technology Specialist Certificate from DeSales University. She is a Palm™ Education Certified Trainer and has expertise in using handheld computers throughout the curriculum. Ms.

Jones was responsible for implementing the handheld computer pilot program in Southeastern Community School District. She observed and took field notes that were reviewed and analyzed. Because Ms. Jones was responsible for implementing this program throughout SCSD, she had an appreciation for this study. She had a desire to examine how students used handheld computers. Ms. Jones was present to observe and take field notes for approximately 50 percent of the study. Her field notes gave the researcher another perspective to the study.

"Group interviews can also be used for triangulation purposes or can be used in conjunction with other data gathering techniques. For example, group interviews could be helpful in the process of "indefinite triangulation," by putting individual responses into a context (Cicourel, 1974)" (Fontana & Frey 2000, p. 651).

Triangulation was used to compare data to decide if it corroborated (Wiersma, 2000). "It is in data analysis that the strategy of triangulation really pays off, not only in providing diverse ways for looking at the same phenomenon but in adding to credibility by strengthening confidence in whatever conclusions are drawn" (Patton, 2002, p. 556).

Triangulation of sources was used to check the consistency of different data sources (Patton, 2002). The researcher compared observations, interviews and student documents. "…Triangulation of data sources within qualitative methods may not lead to a single, totally consistent picture. The point is to study and understand when and why these differences appear" (Patton, 2002, p. 560).

Trustworthiness

The researcher worked in an educational setting for eight years. She had experiences with all grade levels of students and is knowledgeable in the field of technology in education. She is also a Palm™ Education Certified Trainer and has a vast knowledge of using handheld computers for teaching and learning.

Her experiences as a former teacher in Southeastern Community School District, staff development facilitator for technology, and Palm™ Education Certified trainer enabled her to earn the trust of the participants of this study. The researcher spent time with the students and teacher prior to the study to build trust and relationships (Marshall & Rossman, 1999).

Political and Ethical Issues

This study did not harm the students or teacher involved. Students who did not wish to participate or whose parents did not wish for them to participate, were not interviewed, observed, or videotaped.

Legal permission forms were sent home to all first grade students' parents before the start of the study. Those who did not return the permission form did not participate in the study.

The results of the study did not include students' names, to protect their identities. The names of the district, school, Principal, Superintendent, and Instructional Technology Coordinator were also changed. The study was not intrusive, because the students took part in their normal, daily activities as the researcher integrated into their routine.

The site was chosen because the researcher was familiar with the school district and the students used handheld computing devices. The Superintendent of Schools wrote his letter of support and permission to conduct the study.

The video recording did not list or mention students' names and it did not list the name or location of the research site. The anonymous video of the students will be kept until all students are eighteen years of age plus seven years, because the students were minors.

All paper data was coded with numbers during the data analysis. The researcher kept student names locked and off site during the study. At the end of the study, the researcher gave numbers to each name and shredded the original list of student names. At the end of the study, all paper data was shredded and the video was destroyed. When writing the findings of the study, pseudonyms were substituted for the numbers.

Chapter 4: Results

As presented in chapter 1, the study documented here recounts how students used handheld computing devices to collaborate throughout the learning process. The chapter is organized in terms of the three research questions: 1) In what ways do first grade students use handheld computing devices to learn in collaboration with others throughout the learning process?, a) How does the use of handheld computing devices to collaborate impact students' learning outcomes?, b) How does collaborative learning through the use of handheld computing devices relate to technology standards?

An ethnographic case design was chosen because of its ability to capture the interactions between students using handheld computers. Observations, informal interviews, and student artifacts were used as data throughout this study (see Table 5). The researcher observed participants throughout the collaborative learning process and took detailed field notes as students used their handheld computers to work together. In addition the researcher conducted informal interviews that were videotaped. The researcher also secured documents and text shared between students through the beaming process. Documents were collected and assessed on whether or not they met content learning objectives and technology standards.

Table 5 - Data Collection and Analysis Timeline

Research Questions	Method	Timeline	Analysis
1. In what ways are students using handheld computing devices to collaborate?	Observation (Field Notes) Interview Guide Student Artifacts	Weeks 1-6	Outside observer Video Analysis Content Analysis
1a. How does the use of handheld computing devices to collaborate impact student learning outcomes?	Interview Guide Student Artifacts	Weeks 2-6	Video Analysis Content Analysis
1b. How does collaborative learning through the use of handheld computing devices relate to technology standards?	Interview Guide Student Artifacts	Weeks 2-6	Video Analysis Content Analysis Standards Based Rubrics (See Appendix B, C, D, E)

Site Setting

The study took place at Rider Elementary School, a suburban elementary school for grades K-5, located in Southeastern Pennsylvania. The study lasted for six weeks, between November 2004 and January 2005. The study took place in a first grade classroom.

The name of the school has been changed and the names of all individuals who participated in this study have been changed; pseudonyms were used to protect their anonymity.

The neighborhood around Rider Elementary school has twin homes and single homes with front yards and walkways to the street. There are 369 students that attend this school. Because the school is very close to many homes, 241 students walk to and from school and 128 take the bus. People can enter the school from 7th Street. The large two story brick building on 7th Street is the oldest school building in continuous use in the School District. It was built in 1929 and was initially used as a junior-senior high school. Most visitors park in front of the school on both sides of the one way street. There is a sidewalk that runs parallel to the street and then a walkway that leads visitors up to the three old wooden front doors of the building. Between the sidewalk and the front of the building is beautifully landscaped grass and trees.

Rider Elementary School is used at night for student activities. The building is used for cheerleading, middle school basketball practice, and color guard practice. The playground is also used after school by the community. The custodian often finds the playground littered after the weekend. Some of the basketball hoops have been broken by basketball teams that use the playground courts on the weekend.

As you drive down South 7th Street, one cannot miss the noisy bulldozers tearing up the football stadium in front of Rider Elementary School. A chain link fence separates the stadium from 7th Street.

When the researcher would arrive, she heard students at recess or before school playing in the school yard next to the school. Some students sat at the picnic table under

the small pavilion and others played basketball on the nearby court. The researcher walked up the pavement to the door of the school, and a saying that was engraved into the cement above the door said, “Enter to Learn. Leave to Serve”.

As the researcher opened the heavy old wooden door of the 75 year old school, she was greeted by student work throughout the lobby. To the left, pictures of children at Winter Wonderland with Santa covered the wall. Straight in front of her was a sign that said: Rider Panther Pride Wall – Reaching the Standards. Next to this sign was a list of District standards for each of the following subjects: math; social studies; science; reading, English, language arts (RELA); music; physical education; health; library science; and art. On the opposite wall were pieces of work from students in all grades that met standards in the different content areas. The student work included: stories about red eyed tree frogs; reports on how things work - lightning rod, lightning, and electromagnet; Valentine’s Day graph of hearts to show 100; Guess who - writings which included students’ clues about themselves; story maps from *Charlie and the Chocolate Factory*; social studies tests; and math performance tasks.

Immediately to the right was the window to the office where the friendly secretary greeted the researcher everyday. She immediately opened the window, took the pile of visitor badges from the basket on the right, and handed her a badge with her name on it; which was usually the last one in the pile. Just past the window to the office were three boxes filled with Campbell’s soup labels and General Mills Box tops for a fundraiser. A third box held computer ink cartridges and old cell phones for The Nephcure Foundation to fight kidney disease.

There was a hallway past the lobby that extended down to the left and right. When the researcher entered the building everyday, to the left she heard voices of students and teacher aides working together in this hallway. As she looked to the right, she saw Bert from Sesame Street on the wall at the end of the hallway. She heard little children singing and playing in the kindergarten room.

After walking through the lobby, the secretary pointed her in the direction of Mrs. Smith's classroom. Just past the lobby were two doors which led her into the cafetorium that was used as a cafeteria and auditorium. Every day as the researcher walked through the cafetorium, she smelled that afternoon's lunch. The custodian was setting up chairs and tables for lunch and then at the end of the day, he took them down and wet mopped the floor. Straight ahead on the wall in the cafetorium was a huge sign that said, "Rider Panthers - Paving Their Way Past the Book Standard". Each class had paws under the teacher's name for students who met the reading standard; the students read at least twenty-five books and/or book equivalents each year, which included reading within as well as outside of school (Reading, English, Language Arts Elementary Student Learning Benchmarks/Indicators, 2000) There were nine paw prints next to Mrs. Smith's name indicating that nine students in her classroom met the reading standard.

After walking through the cafetorium, the researcher entered the first grade hallway. On the wall, she saw the Rider Elementary School rules:

- Show respect to others
- Show respect to school
- Practice good safety rules
- Practice good learning habits

She continued down the hallway to Mrs. Smith's classroom, and saw snowflakes hanging from the ceiling and student work from each class hanging on the walls. The content area standards that the students met were listed next to their work. Mrs. Smith had to get permission from parents as to whether or not she could post students' work in the hallway. One parent initially did not want his child's work posted in the hallway however he changed his mind after speaking with Mrs. Smith. Outside Mrs. Smith's classroom was student work. Next to the each group of work was a sign that listed the standard that the students met. Only students that met the standard or exceeded the standard had work posted in the hallway.

- 1st grade illustrates the setting in *Polar Express* (reading standard #3.1 – students respond to literature).
- Who's In a Family/Lost in Museum writing (reading standard #2 content reading – standards read and comprehend a story to develop understanding and produce written work that makes a personal connection to the story). Mrs. Smith put a sticker on each piece of writing that showed how the student scored in content and conventions.
- Several "Science Solids" posters were on the wall. Students made a poster with the following words: This solid is, and then pictures from a magazine to label what type of a solid it was.
- The last group of stories that were posted on the wall was written by the students after they used their handheld computer to make a web of their ideas. Students read a few stories about whales, used PiCoMap on their handheld computer to brainstorm ideas for a story, beamed their ideas to a peer and then

used the web to write their story. (reading standard 2.1 - read and comprehend informational material to produce written work that summarizes information).

The researcher walked into the classroom. The walls were filled with charts, word lists, poems, and the letters of the alphabet with each student's name under the letter it began with. On the front board was a pocket chart with the daily schedule. In each slot the time was drawn on a clock and written in numbers to help the students learn how to tell time. Next to each time was the subject or special. Also up front were a weather chart, student absence tally, lunch tally, calendar, and hundreds, tens, and ones chart; all of which got changed in the morning by a student. In the back of the room hanging on a closet next to where the students put their coats and schoolbags was another type of pocket chart. Each child had his/her name on a pocket and they put their homework in their pocket. Next to that pocket chart was a job chart which listed the jobs students had to do throughout the day to keep their classroom neat and in order. Attached to the blinds were several posters. Many of them were word lists that the students came up with. One was a list of the district RELA standards.

As soon as the researcher walked into this classroom, she noticed a humming noise. As she moved further into the room, she noticed the noise coming from the back of the room. The researcher walked toward the noise and saw it was the chargers for the handheld computers. They were on a grey table underneath the windows. Two black machines were plugged into an outlet (Figure 1).

Figure 1 - 10-Slot Charging Cradle Copyright iGo™. Used with permission.

Each machine held ten handheld computing devices. Students put their handheld computer in one of the slots if it needed to be charged during the day.

The students' desks were arranged in four groups; green triangle, orange rhombus, red trapezoid, and yellow hexagon. Above each group was a sign that indicated their group and matched the shape and color of their name. Certain students' desks were separated from their group so that they could work more efficiently. Each student had a water bottle on his/her desk and the ceiling fans were on in an attempt to facilitate air circulation.

In the center of the room was a round table. Mrs. Smith met with students at this table for guided reading groups or to help a student or group of students while the others worked. Children also met at this table if they were ready to print one of the documents from their handheld computer. The wireless printer sat on this table.

In the back of the room below the windows were bookshelves with bins full of books. A few bins had author names on them if the students were interested in reading

books by a certain author. Mercer Mayer, Stan and Jan Berenstain, Dr. Seuss, Paul Galdone, Bill Peet, and Ezra Jack Keats were just a few of the author names on the bins.

The rest of the bins each had a letter of the alphabet and books were placed in the bins by the author's name. The researcher noticed the following bins and books: in the "A" bin was a book entitled *The Balloons*; in the "B" bin was *Have You Seen My Cat*; in the "C" bin was *The Magic Machine*; the "D" bin held *The Sky Diver*; the "E" bin held *Greedy Cat's Breakfast*; and the "F" bin held a book entitled *The Grump*.

There was a blue sofa next to the bookshelves and in front of Mrs. Smith's desk was a brown, remnant carpet. A cork board panel separated this part of the room from the rest. On the panel were self stick numbers and pictures that the students matched together. Students frequently came to the rug and sofa to do their work.

In this first grade classroom, there were four Dell PC computers. The desktops had many different types of educational software that the students used during center time, indoor recess or free time including Living Books, Inspiration, Graph Club, Math Shop, and Literacy Launcher. Next to each computer was a cradle. The students were each given a number one through four for one of the four computers. A piece of paper next to the computers had their numbers. Each student would go to the assigned computer and put their handheld computing device on the cradle to perform a HotSync operation. The cradles were connected to the computers and when the students pushed a button on the cradle, a mirror image of the data was created on both computers.

The Students' Handheld Computing Devices

Each student had their own handheld computing device (see Figure 2) that they stored in a padded mailing envelope with their name and number (1-23) on the back of it.

Figure 2 - Photo of the Palm™ m100 Copyright palmOne, Inc. Used with permission.

Parents/Guardians were asked to sign the “Handheld Contract and Permission Form” (Appendix O). This form described how the students used the handheld computers and told the parents/guardians how their child was expected to take care of the computer when they took it home. The permission form stated that if the student’s handheld was damaged or lost due to negligence on his/her part, then he/she will no longer be able to take the computer home. The student will be allowed to use it only in the classroom. After the parent/guardian signed the permission form, the students were asked to sign the “Handheld Contract Between Student and School” (Appendix P). The contract stipulated that the students promised to take good care of the handheld computer. At first, everyone

signed the permission slip that said the students could take them home. However, one student's handheld computer was stolen at after school daycare. It was retrieved but the parents did not want to be responsible for it being stolen again (even though they would not be held accountable for it). Therefore, this student could not take his home. A second student broke the screen on his handheld computer when he first got it. Therefore he could not take his home either. When the students were assigned homework to do on their handheld computer, these two students did the work on paper.

When the students were assigned homework on their handheld computer, they were held to the agreements on the contract they signed with their parents. They were also told that if they were at home and they could not finish their assignment on the handheld computer because the battery was dead or the device was not working correctly, they were still responsible for completing the assignment on paper. They were given a paper for each assignment which explained the assignment, showed them which program to complete it in, which icon to press, and what to do if their computer did not work.

Each student got a brown padded bubble wrap envelope with their name on it. When they were not using their handheld computing device, it had to be stored in the padded envelope so that it was protected. A few devices fell off of the students' desks but were not harmed because they were in the padded envelope.

Getting Started

When the researcher arrived, the students already knew the basics of how to use the handheld computer and how to do Graffiti characters. The class used the handheld computers during several lessons each day. The computers were used as a tool to do work much like a pencil and paper or other computer would be used to do work. Each lesson

began on the rug in the front of the room as a whole group. Even though Mrs. Smith taught the students how to use the handheld computer before the researcher arrived, during the first few lessons that the researcher observed, she reminded the students how to get started.

During interviews with Mrs. Smith, the researcher asked her to explain how she taught the students to use the handheld computing devices to do their work. Her explanations are illustrated in the next few paragraphs.

During each lesson, the students sat on the rug as a large group. They held their computer in their hand and watched as Mrs. Smith showed them what to do on her handheld computing device. They constantly looked at each other to reassure themselves of what they were doing. Mrs. Smith frequently drew a picture on the board of what they should tap on the screen or which button they should push. It would have been very helpful for Mrs. Smith to have the MARGI Presenter-to-Go so that she could put her handheld computing device on the overhead projector and show the students exactly what to do. The MARGI device enables the handheld's screen to be viewed on a screen through a projector (MARGI Systems, n.d.).

The first time the students were given the handheld computers, Mrs. Smith showed them how to do the following: turn it on and off, push the six buttons at the bottom of the computer, hold the computer, and use the stylus. In order to teach the students how to use the stylus, she taught them to use a feather-like tap on the screen with the stylus. Mrs. Smith told the students to use the pointer finger on their right hand and tickle their left arm. This is the type of touch she told them to use on their handheld computer screen.

The second thing that Mrs. Smith taught the students was probably one of the most important. She taught the students how to tell if their handheld computer needed to be charged. She explained to them that they needed to check the battery icon each time they used the handheld computer. If the battery was low, they should put it on the charger in the back of the room. She took them to the back of the room and demonstrated for them how to put the handheld computer on the charger. She showed them how to push it onto the charger and listen for a beep which indicated that it was on correctly.

Next, Mrs. Smith taught the students how to open a software program on their computer. She showed them how to use the stylus to scroll down on the right hand side of the screen to see all of the icons. She told them to tap on the Memo Pad program which started with an “M”.

In Memo Pad, Mrs. Smith taught the children how to do the letters of the alphabet using Graffiti characters. She already taught them how to print all of the letters of the alphabet on paper so she felt they were ready to do Graffiti characters and it would not interfere with their writing on paper. Each student also had a sticker on the lid of their handheld computing device which showed them how to write the entire alphabet using Graffiti characters.

Mrs. Smith showed the students on the board how to do the first half of the alphabet, one letter at a time. They followed her and wrote the letters on their handheld computer as she did on the board. In the process, she showed them how to do a backspace to erase a mistake. After she showed them how to do the first half of the alphabet, some students went ahead and wrote the rest of the Graffiti® characters. At this point, she sent them back to their seats to do the rest of the alphabet on their own. She told the

researcher that the students collaborated with their group members and showed each other as they wrote the letters.

Several students finished writing the alphabet early so Mrs. Smith showed them how to use the program Giraffe. This program helped them practice writing Graffiti characters. It required the students to write the letters that popped up on the screen. They earned points by writing the letters correctly. This was one of the only times they used this software to practice writing Graffiti characters. Students learned how to write their letters correctly mostly by doing their work on the handheld computer. Mrs. Smith explained that learning how to do all of the above things on their computer was progressive. The students continued to practice each of these skills with every learning experience they completed. In this case, practice makes perfect and each time they used Graffiti characters, they got better and better at it.

When the researcher first began observing this class, they were using their handheld computers to do simple learning experiences using Memo Pad and Note Pad. This helped them become familiar with using the computer and practicing Graffiti characters. During the first observation, the researcher could tell they were still new to beaming. When they beamed their spelling words in Memo Pad to a partner they were very precise with how they did it. They put their handheld computers on flat surface where they were working and very carefully lined them up so that the infrared beam hit the correct spot on the other computer. They put one of their hands in between their handheld computing devices to make sure they were the proper distance apart and then tapped the correct icon to beam. Students waited patiently to hear the beep signaling that

the beam had occurred and then looked at each other's screen just to make sure. They each tapped the correct button on their computer to accept the beam.

During the first two weeks of the researcher's observations, while the students used the handheld computers, they were still being introduced to new programs and new features of the handheld computer. During every lesson, they learned a new feature from Mrs. Smith because she integrated skills into each lesson. Then while they worked, the students discovered new things and shared with each other. The students constantly asked the researcher, Mrs. Smith, and their neighbor(s) questions. Asking the researcher and Mrs. Smith questions gradually tapered off and they either asked their neighbor, the student expert (established by Mrs. Smith), or discovered the answers on their own.

There was a point about half way through the study when the researcher noticed that several students were having difficulty with their handheld computers. Mrs. Smith and the researcher took a closer look at the screens on the some of the students' handheld computers and noticed that they were dirty. One student's handheld computer looked like it had pieces of food on it. Mrs. Smith reviewed with them the importance of not eating or drinking while using the computer because it could get dirty and not work correctly. Specifically, the students were having so much difficulty writing on their handheld computer because the part of the screen where they write needed to be clean and smooth so that it could recognize the stylus. They cleaned the screens with a mild cleanser and a soft cloth. The next day when the researcher returned she noticed a significant decrease in the number of students who were having difficulty writing on their handheld computer.

Some of the screens were also scratched. The researcher noticed that the students pressed very hard on the screen when using Graffiti characters or selecting something on

the screen. Most of the students whose screens were scratched had the same area that was affected. The affected area was right where the students wrote their letters. The researcher told the students that they had to write like a feather and write in an area that was not scratched.

At several points throughout the study, the researcher also noticed that some students had technical difficulties with their handheld computers. During her interviews with Mrs. Smith, the researcher asked her about the problems she noticed the most with the handheld computers and she mentioned exactly what the researcher observed. Mrs. Smith also said that she has been using the handheld computers in this program with her students for three years and this is the first year she had any problems. Most of the problems had to do with the handheld computer not recognizing the students' writing. The wrong feature was activated when they tapped the device's screen or the cursor was inserted in the wrong place when they tapped on editable text. All of these errors indicated that the screen was not calibrated correctly.

Calibration meant that the computer recognized the touch of the stylus in the appropriate spot on the screen. According to the palmOne™ website, "With use over time, calibration of the touch-sensitive LCD screen can be less accurate, making your taps on the screen less accurate" (palmOne, Inc., para. 3). The students used the handheld computers a lot so that would explain this problem.

In order to correct this problem, the students calibrated the digitizer by opening the program and tapping a target with the stylus. This aligned the screen digitizer. They had to be very accurate when they tapped the targets to ensure accuracy of the screen. Occasionally, when tapping the targets, the computer would not advance to the next

screen and would continue to show targets on the screen. According to the palmOne frequently asked question (FAQ) website, this is called looping and there may be a physical problem with the handheld computer screen. In the cases where students had this problem, it seemed as though they had deep scratches to their screen, "…which can cause permanent damage" (palmOne, Inc., para. 6). Other students who had problems with their handheld computing device being sensitive to their tap calibrated the digitizer and then their handheld computer started working again. Throughout the study about six handheld computers were sent to the Information Technology Department and replacements were sent to Mrs. Smith's classroom.

When students weren't successful using their handheld computing device, they knew that they were supposed to put their handheld computer away in the bubble wrap envelope and get out their white boards and do the activity on their white board. The white board was about 10 inches by 13 inches and fit in their desk. They used dry erase markers to write on it. Students didn't complain that they had to put their handheld computer away. They did look disappointed but got right to work on their white board.

Mrs. Smith also mentioned that in a few cases, the handheld computer froze and stopped working properly. She always tried to troubleshoot the problem and if she could not fix the device, she sent it to the Information Technology Department for repair. She told me the following steps she used to troubleshoot problems:

1. Perform a soft reset. A soft reset is very similar to restarting a desktop computer. She took a paperclip out of her desk, straightened it out and pushed a button on the back of the device. In most cases, this restarted the computer and it worked fine.

2. If a soft reset didn't work, she performed a hard reset. A hard reset erases everything on the device. She took out her paperclip and pressed the button on the back of the device while she held the on/off button. This function reset the handheld computer back to the factory settings. Mrs. Smith had to load the software on it again for the student.

Mrs. Smith said that performing a soft or hard reset didn't take much time. It took about two to three minutes at the most and it did not happen often so the students didn't get frustrated. They gave their handheld computer to her to try to fix and they completed their work on their white board. Most of the time, Mrs. Smith said that performing one or both of these operations got the computer working again. If the operations didn't work, the students were given a spare handheld computer to use or they used their white board.

How Did the Use of Handheld Computing Devices to Collaborate Impact Students' Learning Outcomes?

Students Used Handheld Computers to Learn

Students used handheld computers to do math, writing, spelling, science, and social studies. During each lesson that the researcher observed students using handheld computers as a tool during the learning process, she asked them questions. She interviewed students randomly and interviewed each student three times. Each time the researcher interviewed a student or several students together, the first question she asked them was, "Did your handheld computer help you learn?" Overwhelmingly, they answered "yes" (see Figure 3).

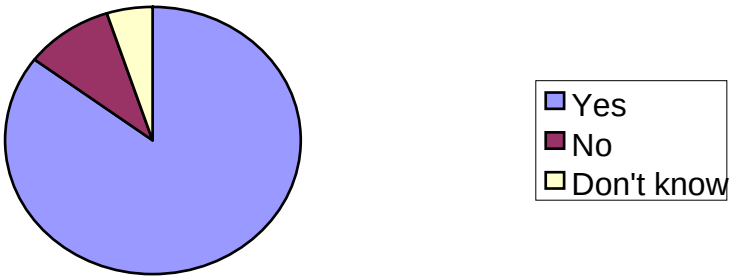


Figure 3 - Student Answers to the Question “Did your handheld computer help you learn?”

When asked this question, 85% of the students said that their handheld computer did help them learn. In most cases, students answered with a simple yes or no answer. However, a few students expanded their answer. Steven said, “Yes because I can use my friend’s words” and Maggie said, “Yes, because we wrote the words first in our palm” after she used her handheld computer to brainstorm words in a PiCoMap and then wrote sentences with her words in the map (the students called their handheld computers “palms”). Only 10% said their handheld computer did not help them learn. Specifically, when Josh used his handheld computer to learn place value, he answered, “Nope, our teacher taught us”. In another case, Seth used his handheld computer to beam math facts back and forth with a partner. He responded to the researcher’s question by saying, “I’m not using my palm to help me learn. I’m using my fingers.” About 5% told the researcher that they did not know if their handheld computer helped them learn.

After asking students if their handheld computing device helped them learn, the researcher asked them what they learned. Two themes emerged from this question. Students answered questions with a “content” focus or a “technical” focus (see Figure 4).

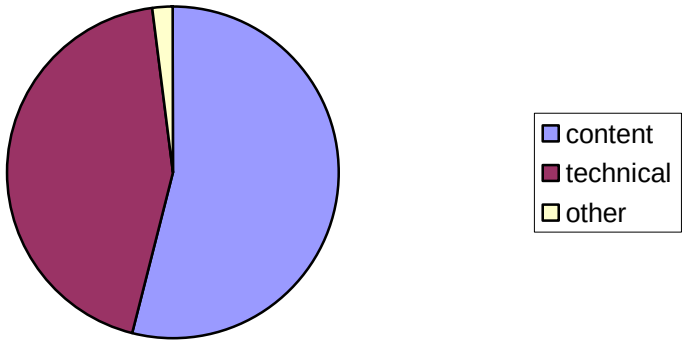


Figure 4 - Student Answers to the Question “What did you learn?”

More than half (54%) of the responses to the question “what did you learn?” were content oriented. When beaming math problems back and forth with a partner, Rose responded to the researcher’s question by saying, “I learned that 2 plus 4 is 6”. Ann said that when writing r-blends (a consonant and then the letter “r”) on her PiCoMap, she learned “to write bigger words and spell them”. John said he learned “how to spell brown and grass because they are r-blends”. About 44% of the answers to this question were technical. Students said that they learned how to do something on their handheld computer. This theme is discussed in depth in another section.

Student work was assessed. Each week, one lesson was randomly chosen and student work that students completed during that lesson was assessed. During the first week of observations, students used PiCoMap to organize their ideas before writing a

story about the pilgrims. Mrs. Smith asked the students to come to the rug. She asked them, “Who remembers what we read about yesterday in this book?” She held the book *If You Sailed on the Mayflower in 1620* in the air. The students’ hands flew into the air in excitement. One student responded, “Pilgrims” and another said, “the Mayflower”. After discussing what they read the day before, Mrs. Smith read the rest of the story aloud to the students. After the story was finished, Mrs. Smith told the students that they were going to write a story about the pilgrims. She asked the students what happened to the Pilgrims. She took out her handheld computer and began to show them how they were going to use PiCoMap to do their prewriting activity to organize their thoughts.

She told them to use words from the book they had just read to make a list of words they could include in their story about the Pilgrims. She told them to put at least four facts on their map to get a three, which meant that they met the standard. They were instructed to only put key facts on their map. She gave them directions to follow when they got back to their seats: open PiCoMap, start a new map, make a list of words to include in their story, and begin to write their story. She sent the boys back to their seats and then the girls.

They immediately took their handheld computers out of the bubble wrap envelopes on their desks. Six students’ handheld computers were either on the chargers or not working so they used their whiteboard to write the words with dry erase markers.

Mrs. Smith walked around the room to make sure they were comfortable getting started with PiCoMap. Several students already began writing words and she announced, “Boys and girls write words that you might use in your story”. Some students looked down at their computer and erased words.

Mrs. Smith walked around the room while they worked and handed out two pieces of paper. One was a Pilgrim story and the other had lines half way up the paper for students to write their story and a blank space at the top for a picture. Key words were circled in the Pilgrim story for them to refer to as they completed their PiCoMap. They referred to the paper to see how to spell words they wanted to use. One by one, the students finished their maps and began writing their story on the paper Mrs. Smith handed out. Students kept their handheld computer next to the paper they were writing on and looked back and forth between the paper and computer for words to use in their story. The researcher observed several students looking at their neighbor's handheld computer for words to use in their story.

The students' maps were assessed according to the criteria that Mrs. Smith established. Mrs. Smith told the students they had to include at least four words on their map to get a three or meet the standard.

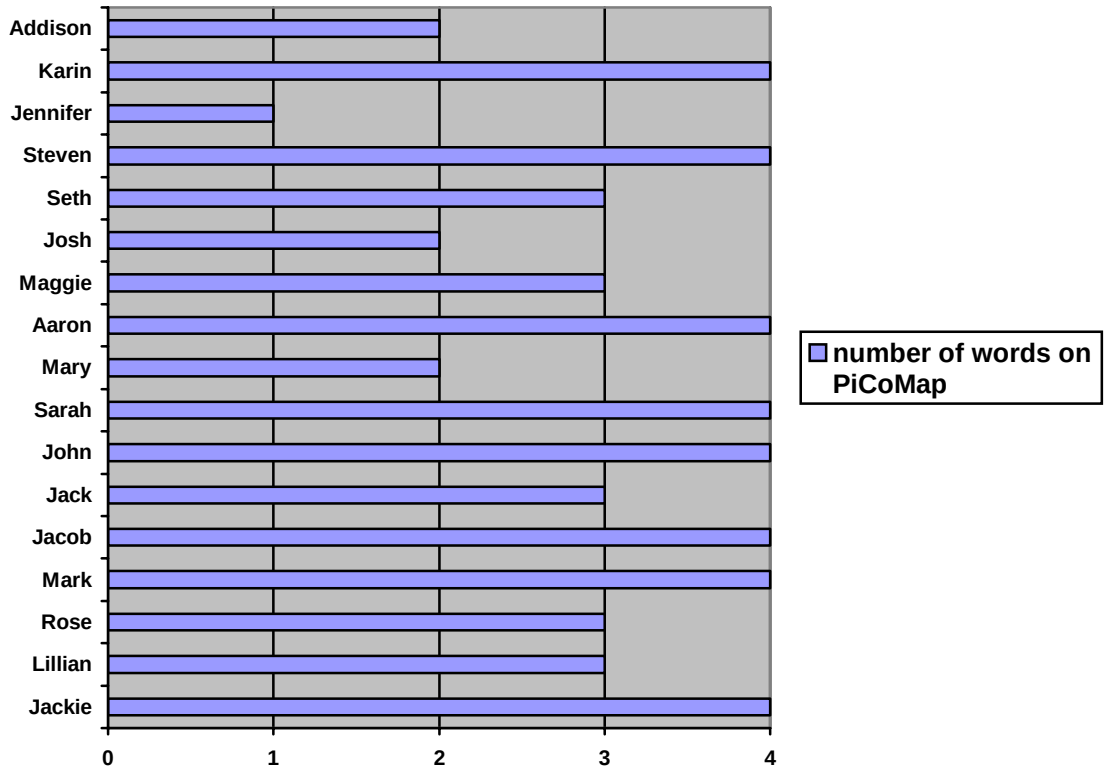


Figure 5 - Number of Words Students Had on Their PiCoMap™

Almost half (47%) of the students wrote more than four words and got a score of four or exceeded the standard. 29% of the students met the standard, 18% of the students scored below the standard and 6% of the students showed little evidence of meeting the standard.

The researcher also randomly chose eight students' stories to assess by content, conventions, and whether or not they used the words from their PiCoMap in their story (see Figure 6).

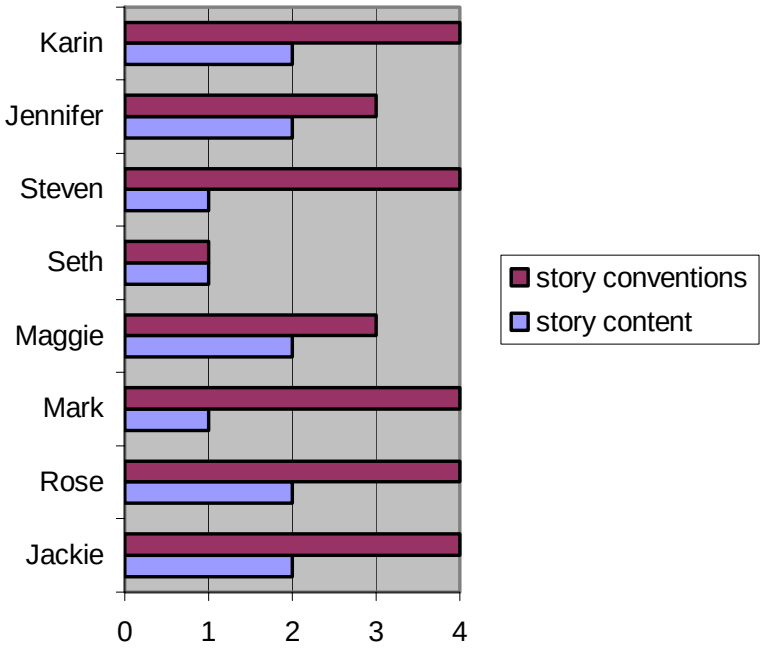
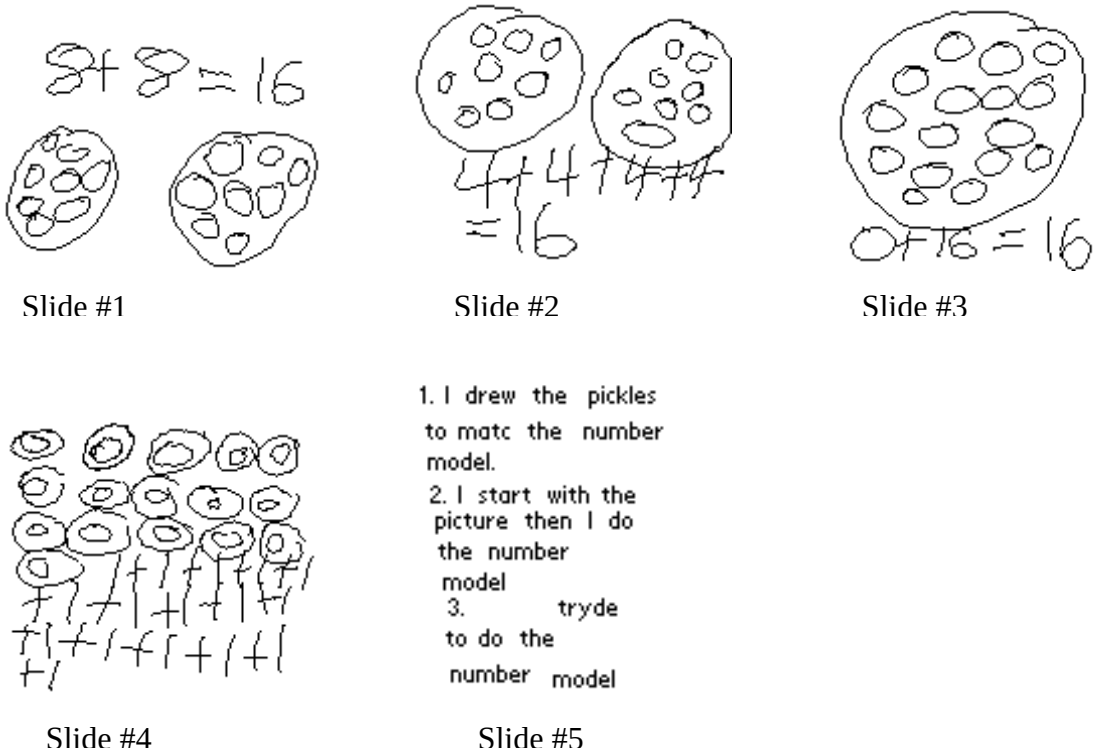


Figure 6 - Assessment of Students' Stories

The stories were assessed according to a rubric (Appendix Q) for content and conventions. More than half (63%) of the students used one word from their PiCoMap in their story, 13% of the students used two words and 25% of the students did not use any words from their PiCoMap. For content, 63% of the students scored a two and were below the standard and 38% of the students got a score of one and showed little evidence of meeting the standard. For conventions, 63% of the students scored a four and exceeded the standard, 25% of the students met the standard and 13% of the students showed little evidence of meeting the standard.

Students also used their handheld computing devices to complete a math performance task. When the researcher arrived for this observation, students were on the

rug in a large group. Mrs. Smith explained to them that they were going to do a performance task in math. She gave them a sample task on the board to do as a group. She wrote the following on the board: 8 beans in a jar. Mrs. Smith explained to the students that they had to draw a picture that showed the same number of beans in each jar, write a number sentence that matched their picture, and explain how they solved the problem. She told them in order to get a three (meet the standard); they had to use their math words. As she explained the three steps they had to complete, she pointed to the steps on the board for the students to follow. Next, Mrs. Smith told the students they were going to use Sketchy to complete the task and use a different slide for each solution they came up with. On the last slide they had to explain their work. Maggie's slide number five (see Figure 7) shows her authentic writing. In first grade, students were encouraged to use inventive spelling which means that they sounded out the words to the best of their ability. For this assignment, Mrs. Smith emphasized to the students that using their math words was more important than spelling them correctly.



Slide #1 Slide #2 Slide #3

Slide #4 Slide #5

Figure 7 - Maggie's Math Performance Task– Different Ways to Show 16 Using Pictures, Number Sentences and Math Words

Five students' handheld computing devices were on the charger so they used paper. After she sent the students back to their seats, she took four handheld computers off of her desk. She handed them out to four students whose handheld computers were not working the previous week. They looked very excited to have a new handheld computer. They instantly got to work on their math problem.

A few students went to Mrs. Smith to ask her questions about using Sketchy. She answered their questions and then made an announcement to the group. "Boys and girls, if you have a question about how to use Sketchy, I want you to ask our classroom

experts. John, Jacob, Maggie, and Karin will be our experts". Mrs. Smith chose the same Sketchy™ experts as the previous day. The students went to the experts if they needed help with the program. After Mrs. Smith made the announcement, Sarah and Lillian asked Karin how to open a new slide. Several students struggled to fit their drawing and number sentence on the slide but eventually got the hang of it. Students discovered by erasing their work over and over again that they needed to draw small to fit everything on the slide. They all got at least one solution finished. They completed the problem the next day.

The rubric used to assess the math performance task used communication, application, and computation to evaluate the students' work (see Appendix R). Figure 8 shows the students' scores on their math performance task. For communication, the students had to represent their mathematical thinking. They had to explain how they solved the problem using math words such as add, groups, sets, each, more, greater, fewer, total, etc. For application, the students had to draw correct pictures to solve the problem. For computation, the students had to write correct number sentences to represent their pictures. Only 17 students' work was scored. One student was absent and five students completed their work on paper because their handheld computers were not working.

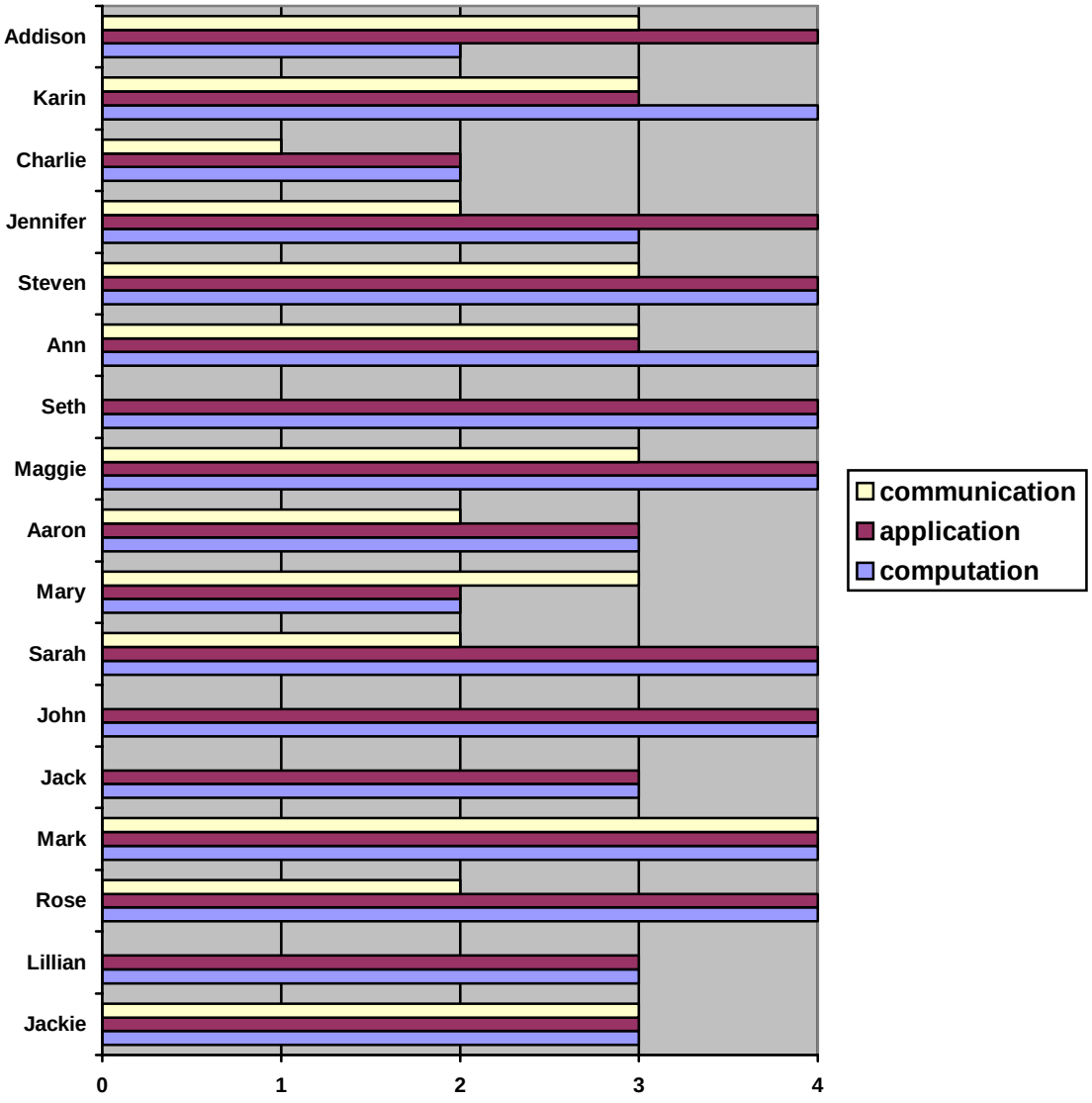


Figure 8 - Students' Scores From the Math Performance Task

The following is a summary of the students' scores:

- Communication: 8% of the students exceeded the standard, 41% of the students met the standard, 24% scored below the standard, 8% showed little

evidence of meeting the standard (number one on the chart), and 24% of the students didn't complete the communication section (zero on the chart).

- Application: more than half (53%) of the students exceeded the standard, 35% of the students met the standard, and 12% of the students scored below the standard.
- Computation: more than half (53%) of the students exceeded the standard, 29% of the students met the standard, and 18% of the students scored below the standard.

Several students had difficulty using their math words to explain how they solved the problem. Mrs. Smith explained to the researcher that communication is always the most difficult part of the math problem for the students. She did not seem discouraged, however because it was still only the second quarter of the school year and they will continue to practice this skill.

Handheld Computers Enhanced the Students' Ability to Learn Content Through Collaboration

Throughout the study, students used their handheld computing devices to learn content in collaboration with their peers. When the students first began using the handheld computers to learn, they primarily used them for writing their spelling words and beaming them to a partner. Each week, students wrote their spelling words several times for practice (see Figure 9). Occasionally, this was a homework assignment.

ln in ln in in
is is ls is ls
you you you you you
that that that that that
it it it it it
a a a a a
the the the the the
of of of of of
and and and and and
to to to to to

Figure 9 - Jennifer's Spelling Words Using Memo Pad

After students wrote their spelling words in Memo Pad or Note Pad (see Figure 10), they beamed their work to a partner who checked their work.

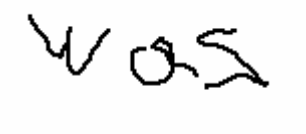


Figure 10 - Charlie's Spelling of the Word "Was" Using Note Pad

The partner had the responsibility of making sure each word was spelled correctly. He/she beamed a note back to his/her partner and told each other if they needed to make corrections. The note either had a happy/sad face in Note Pad or said correct/wrong in Memo Pad. They worked together to fix the misspelled word(s). Students had no problem sharing their work with one another through beaming. They beamed one at a time to each other and then checked their work and talked about how to fix any misspellings.

Sometimes, when they had extra time, they beamed each other more difficult words to spell correctly. The researcher didn't see any negative reactions to the students telling their partner that a word(s) was misspelled. However, she did see excitement when they received a "perfect" note or happy face through a beam from their partner. Students were very proud of their work. As the researcher watched the students go through this process, they did it flawlessly as if it was just another part of their day. Since the students were so good at working with a partner to practice their spelling words, they did this during free time throughout the day.

As students progressed with their knowledge of how to use the handheld computer, the students began to use different software programs to do their work. Students used PiCoMap to organize their thoughts, enhance their writing, and do word building. The beauty of this software is that it promoted collaborative learning. Students created their own maps and then exchanged their map with a partner(s) using the beam function. After beaming, their map went to the receiving handheld computer and they received their partner's map on their computer.

During one lesson, students used PiCoMap to make a list of words that began with r-blends (a consonant and then the letter "r"). Mrs. Smith gave them instructions to put r-blends in the center circle and then put at least five words in the outer circles that begin with r-blends. After they wrote five words on their own, they beamed their map to each other. Beaming maps resulted in an exchange which put the students' words on each other's maps (See Figure 11).

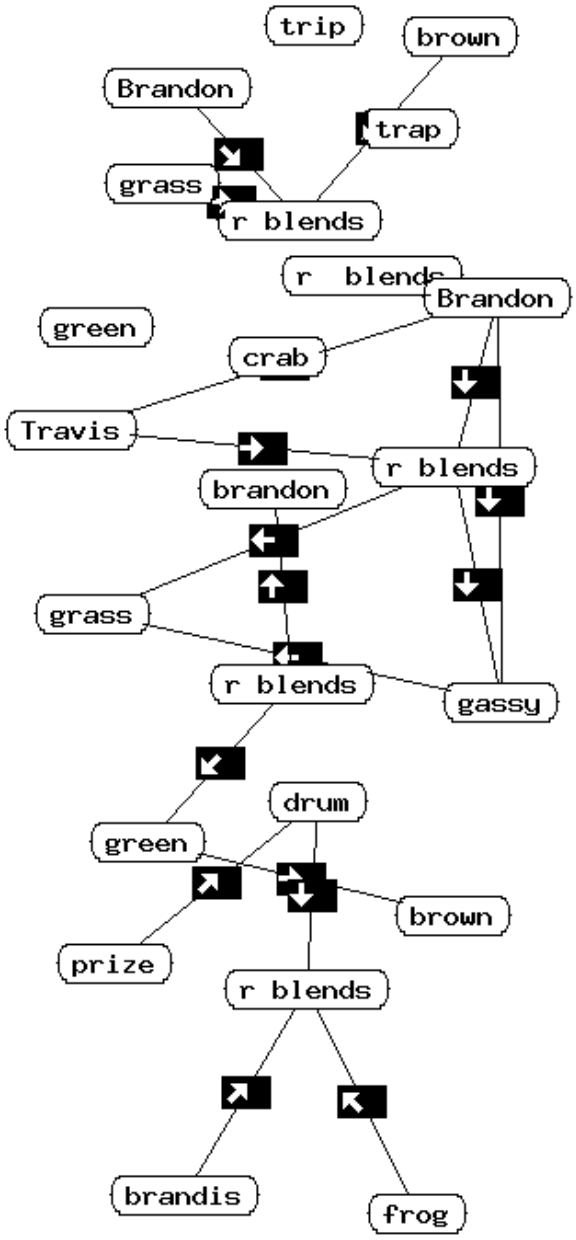


Figure 11 - Jacob's R-blend Map That Was Exchanged With Three Partners.

Jacob's map had four different circles that contained "r-blends". One of them was the map he started with. The other three appeared on his map when he beamed with three

other students. Not all of the words were spelled correctly; however, Mrs. Smith explained that they were supposed to use their inventive spelling.

To begin the lesson, Mrs. Smith instructed the students to begin a new PiCoMap and put the word r-blends in the center circle. Their assignment was to add five words that began with a r-blend to their map. When they finished, they looked for other students that were finished and they beamed their map to one another. As students paired up, they went together to the front of the room or the back of the room to work on the rug. Several students also worked at the round table in the center of the room. Students were all fully engaged in beaming their maps to their partner(s). They put their handheld computing devices on the rug or the table between them, made sure they were lined up so the infrared beam would hit the right spot on the computer, and then put one hand between the two computers to make sure they were one hand space apart.

After the computers were lined up, one of the students in each group used the stylus to carefully select the beam function. Students did not take their eyes off of their handheld computers and when they got the signal on the receiving computer that the beam actually took place, they sat next to each other and looked at that device to make sure they selected the correct option. Students selected “exchange” so that their maps would both be beamed to each other’s computer. The first time they actually beamed their maps to a partner; there was excitement throughout the room. The researcher heard many students exclaim, “Wow, my map’s huge now” and “Oh my gosh, look at this map!”

As the students worked, the researcher asked them questions about beaming. She asked several students what they liked about beaming. Rose responded by saying, "[We]

get bigger maps and you learn more words". Mark said, "My map is huge now because Steven and Rose beamed me. It makes a bigger map". Mark also told the researcher that he learned how to spell words by beaming to Steven and Rose. Jacob thought it was cool that his partner's map appeared on his handheld computer after beaming and Sarah asked her partner Jennifer what a word was that she received from their beam. They worked together to spell the words correctly. When the researcher asked Aaron what he liked about beaming, he said that he "...got more words 5 + 6 = 11". She asked Steven why he exchanged maps with his partner and he said, "If I need any words, I can get them from his (his partner's) map". He also said, "One of the words that I didn't know of that I needed would be on my palm from my friend". Jennifer said that she liked beaming because "you get other people's list of words".

After beaming, students looked at their own handheld computer and their new map individually. The neatest part about watching the students beam their maps to one another was seeing how they read through each of the words and made sure they made sense. Students frequently asked each other questions about information that they received from their partner's handheld computer. Karin asked Jackie, "What is this word you beamed to me?" Jackie responded by telling her that the word was "grassy" but it was spelled with one "s" instead of two. Karin said, "That is not a word". They both looked at the word and decided it should be spelled "grassy" then they worked together to get it spelled correctly on both of their handheld computers.

The same situation happened between Sarah and Jennifer. Sarah read the words that Jennifer beamed to her and replied, "I don't know what this word is". Sarah and Jennifer worked together to correct the word on both of their handheld computers.

When they collaborated to do work using their handheld computers, the students got very close to one another. They put their computers together and looked carefully to compare the information on their screens. It was amazing to see them problem solve to get their words corrected on their screens.

After students exchanged maps with several other students, they made a good copy list of the words with r-blends. They took their handheld computers to their desks individually and looked at the words on their computer and copied them onto paper to hand in to Mrs. Smith. The researcher collected their papers and assessed them and their PiCoMap file from PAAM (see Figure 12). The students were required to write at least five words that contained an r-blend in the beginning of the word. Mrs. Smith told the students to use their inventive spelling.

Mrs. Smith used the following scale for scoring their work: A score of four exceeded the standard which meant the student wrote six or more r-blends, a score of three met the standard which meant the student wrote five words, a score of two was below the standard and meant the student wrote three or four r-blends, a score of one showed little evidence of meeting the standard and meant the student wrote one or two words, and a score of zero indicated that the student did not write any words.

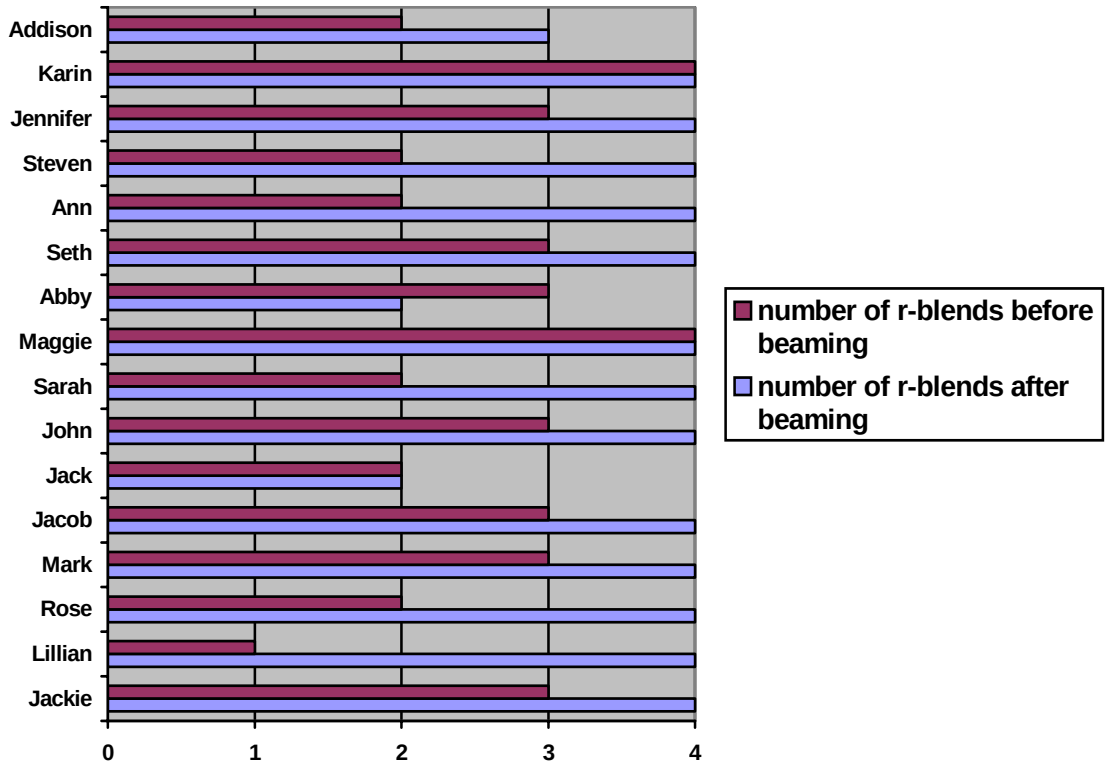


Figure 12 - Assessment of R-blends Activity

The researcher looked at students' work before they beamed to a partner and after they beamed. Both documents were assessed according to the above scale. Overall, 75% of the students' scores improved after exchanging words with their partner. 81% of the students either scored below the standard (six words) or met the standard (seven or more words) with the number of words on their map before they exchanged maps with a partner. The following is a list of the scores of those students who scored below the standard or met the standard before beaming:

- 38% of the students, who met the standard before exchanging, exceeded the standard after beaming with their partner.

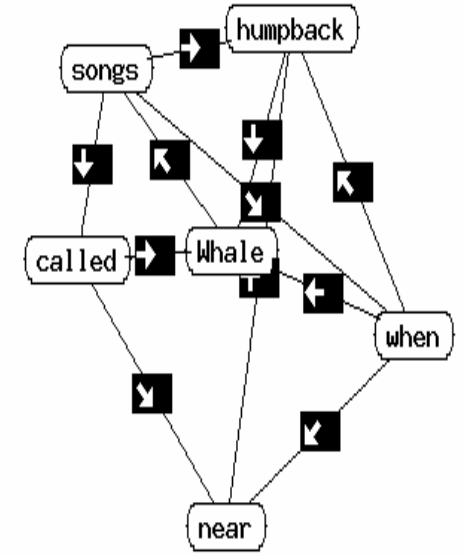
- 6% of the students who met the standard before beaming did not meet the standard after beaming.
- 25% of the students who were below the standard exceeded the standard after exchanging.
- 6% of the students who were below the standard met the standard after exchanging.
- 6% of the students' scores didn't change.

Seven of the students' work isn't represented above; three students didn't participate in this activity and four students didn't complete both activities.

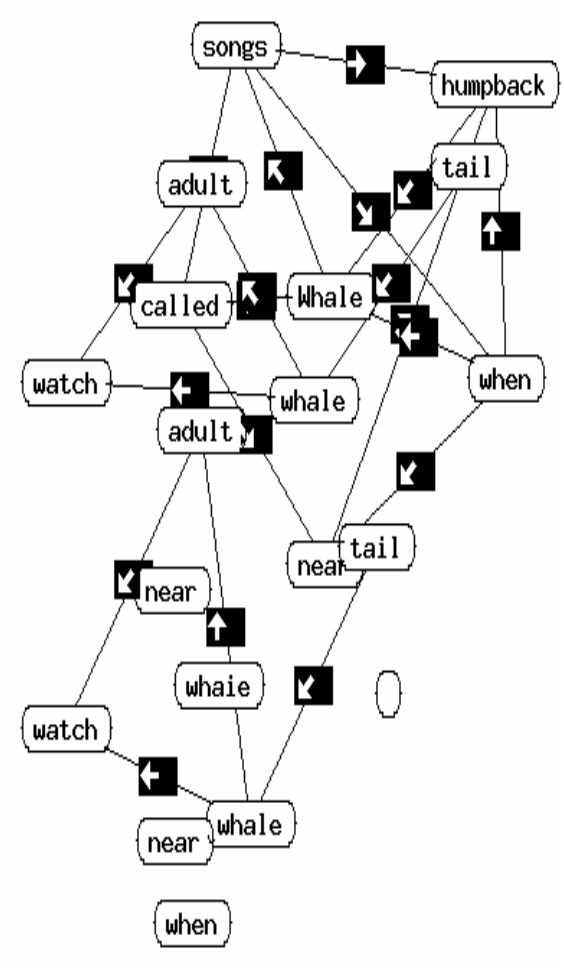
During a writing lesson, students used PiCoMap to revise stories they wrote about whales. This lesson occurred toward the end of the study so the students had been using the handheld computing devices for about two months. Mrs. Smith called the boys then the girls to the rug and told them that, "…you do not have enough descriptive words that you learned through your reading in your stories". The students wrote stories about whales. In their story, they were supposed to include important words that they learned while reading about whales. Mrs. Smith drew a circle on the board and wrote "whale" in that circle. "What words did we learn about whales through our stories?" she asked. "Humpback" said one boy, "spyhopping" said another. She wrote those two words in circles on the board and told the students that they needed to brainstorm at least four more words to put in a PiCoMap on their handheld computer. She told the students to look around the room at books about whales, in their notebook, and exchange beam with a partner to get more words.

Mrs. Smith called each student's name to come to the board to get their story from her. They immediately went to their seats, read their story, and then got out their handheld computer and began a new PiCoMap. One student called out to Mrs. Smith, "What should we call this map?" and she answered, "Whale". Some of the students used their white boards because their handheld computers were being charged. A few other students' handheld computers were not working so they also made a map on a whiteboard at their seats. Some of the students walked around the room and looked at books they read about whales and others stayed at their seats and read through their notes on whales. After students had four words on their PiCoMap, they walked around the room and looked for a partner to beam their map to.

Mrs. Smith made an announcement, "You are now going to collaborate and beam your maps to each other to get more ideas from others. This way, you will get more correct spellings and ideas so when you go to revise your stories, you will have more words. Exchange beam your PiCoMap to two people". Rose and Mark quickly rushed to the rug to beam to each other. Maggie and Josh stayed at their seats and beamed to each other at their desks. Sarah (see Figure 13) walked toward another group of desks to see if anyone wanted to beam with her and Steven went to the rug to join Maggie and Josh.



Before beaming with a partner



After beaming with a partner

Figure 13 - Sarah's PiCoMap™ Before and After Beaming With Partner

As the students worked to exchange maps with their partner through beaming, the researcher asked them some questions. She asked them to tell her what they learned and how their handheld computer helped them learn. Rose responded by saying, "I beamed to three people so far. I learned some new words but I want to add another that I just thought of. My palm helped me to write my sentences by beaming to others and learning

new words". Mark agreed and said, "Yes, I used my palm and it helped me to copy the words for my story and I learned more words from other people beaming".

Abby told me, "Yes, I'm using my palm to collaborate and help me find words and spell words correctly" however, her handheld computer started giving her problems. The screen was very dirty and it wasn't recognizing her writing. She got frustrated because she wasn't able to continue writing on her device. She changed her mind and told the researcher that "…my palm isn't very helpful anymore". Abby took her handheld computer to her desk, put it in the bubble wrap envelope and began a new map on her whiteboard.

The excitement in the room was more and more evident as students beamed their maps to each other. Mrs. Smith encouraged them to go back to their seats quietly and use their new map to revise their story. Rose held her handheld computing device in her left hand with her elbows on her desk and scrolled down through her new map with the stylus in her right hand. She came across a word and put her computer down and wrote a sentence on her paper that included that word. The researcher could still feel the energy in the room as the students looked back and forth between their handheld computer and their paper; however it was much quieter once the students were working on their stories individually.

One by one, Mrs. Smith collected the students' work after they finished. The researcher looked at the work from students who used their handheld computer to collaborate and revise their whale story. The researcher collected their PiCoMap documents from PAAM and counted how many words were on their map. Then, she

compared their PiCoMap with their story and counted how many words they used (see Table 6).

Table 6 - Chart Showing Number of Words on Students' Map and in Story

	Words used from map in story	Words on map after beaming
Lillian	2	5
Jack	1	4
Rose	3	8
Maggie	2	4
John	3	5
Aaron	2	4
Jacob	4	10
Jackie	0	9
Mark	3	8
Sarah	3	10
Steven	2	4

Mrs. Smith and the researcher also used a writing rubric (see Appendix Q) to assess their writing after they completed their revisions. They graded their work based on content: their response made sense, they used four or more details from their PiCoMap, and their illustration was neat, detailed and clear. They also graded the students' work on

conventions: their sentences begin with an upper case letter and ended with punctuation, they had spaces between their words and their letters were neatly written. The students' scores (see Figure 14) according to the SCSD Writing Standards, a score of four would exceed the standard, three would meet the standard, two would be below the standard and one would show little evidence of meeting the standard.

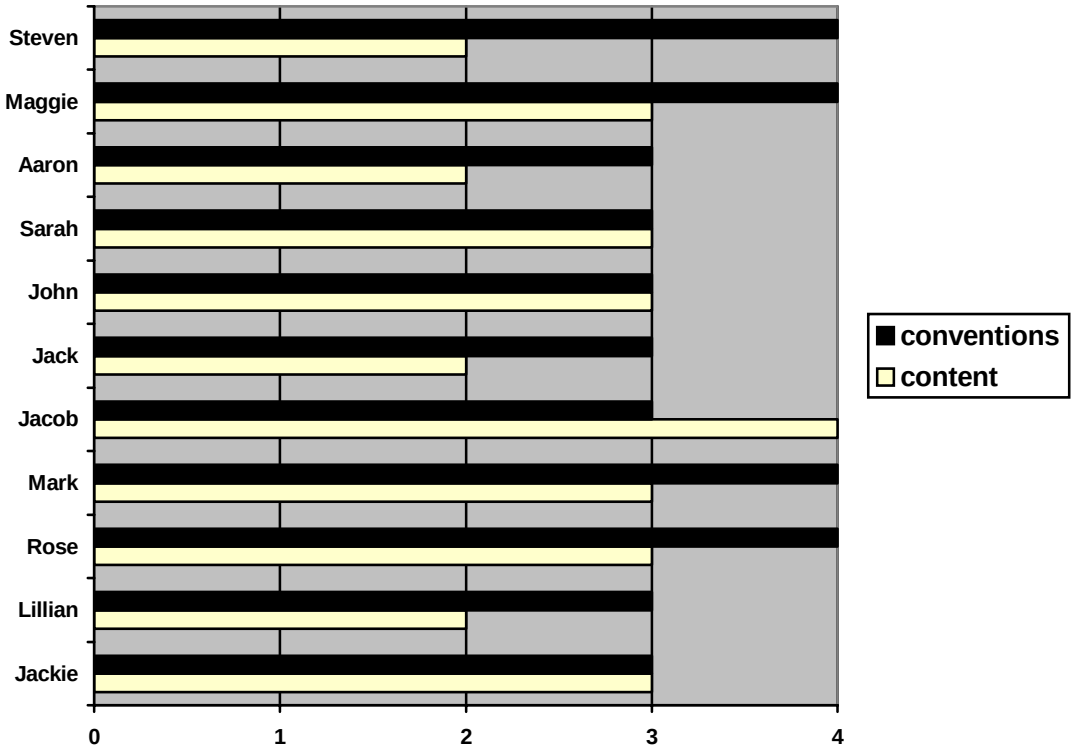


Figure 14 - Students' Scores for Whale Story

For content, 9% of the students exceeded the standard, 55% of the students met the standard, and 36% of the students nearly met the standard. For conventions, 36% of the students exceeded the standard and 64% of the students met the standard.

Students' Thoughts About Using the Handheld Computer to Learn Collaboratively

When asked a series of four questions, overall students noted that they did learn from collaborating with their peers through the use of the handheld computer. Students were asked the questions during several lessons while they used their handheld computer to learn content collaboratively.

The first question (see Figure 15) the researcher asked students while they worked on their handheld computer with a partner/group was, "What did you use the handheld computer for?"

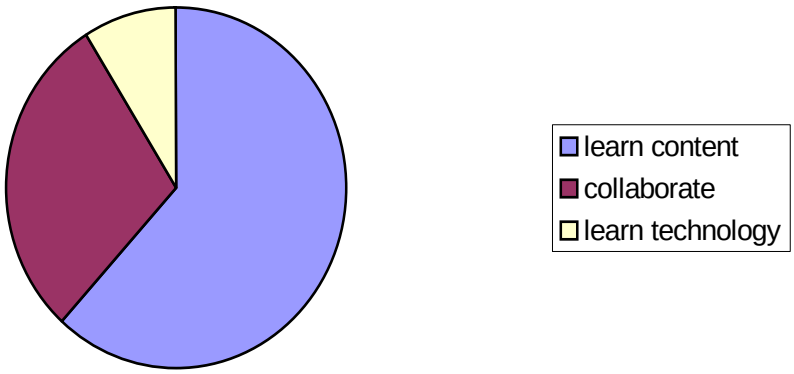


Figure 15 - Interview Results for "What did you use the handheld computer for?"

Most students (62%) told the researcher that they learned how to spell words, how to do a math problem, or they learned other content area information. Specifically, Steven told the researcher that he used the handheld computer to "…learn plusses and equals" during a math lesson when he used Note Pad to beam addition problems back and forth to a partner. About 29% of the students' told the researcher that they used the handheld computers to collaborate. Mark told the researcher that he used the handheld computer "…to learn how to write words and to scramble up the words and then beam to Sue and see if she could unscramble it and spell it correctly". Steven told the researcher that he used the handheld computer to get his partner's words. Sandy answered the question by saying, "I wrote the word backwards and she fixed it".

Less than 10% of the answers were technology related. Rose said she used the handheld computer to "…beam and to write and to play games" and Charlie said he used the computer "to learn how to do things like PiCoMap". Karin told the researcher that she used the handheld computer to "practice Graffiti".

When the students used their handheld computer to collaborate with a partner(s), the researcher also asked them if a friend helped them get their information. Students overwhelmingly replied, "Yes".

The third question the researcher asked the students was, "How did your friend get the information to you?" Initially after asking the question, some students had difficulty answering. They looked at her with confusion but she continued to talk with them and ask the question in a different way, "How did you get those spelling words from your friend?" The researcher used specific words when she asked the question the

second time and then the student(s) who were confused told the researcher that their friend beamed the information to them.

The final question (see Figure 16) the researcher asked the students was, “What did you learn from your friend?”

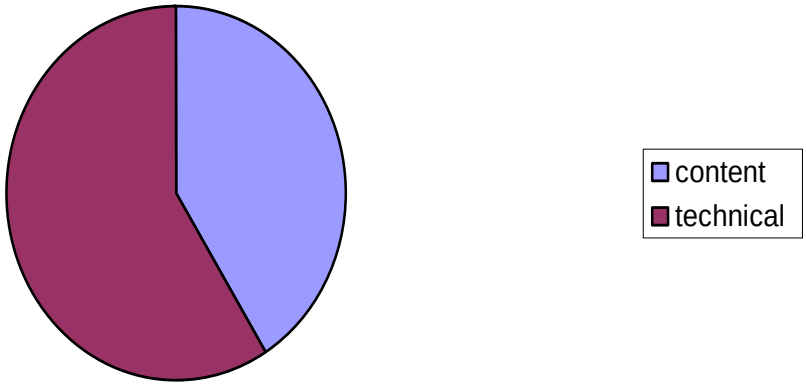


Figure 16 - Interview Results for “What did you learn from your friend(s)?”

When students were asked what they learned from their friend, about 41% of their answers were content related. Mary told the researcher that her friends “…helped [her] learn different kinds of words and [her] words helped them make new words”. Steven said that his friend taught him “how [he] can use his [friend’s] words”. More than half (59%) of the students stated technical answers. Charlie told the researcher that his friend “helped [him] do Graffiti” and Maggie, Joe, and Jacob told her that their friend told them “how to beam”.

How Does Collaborative Learning Through the Use of Handheld Computers Relate to Technology Standards?

Students Met Technology Standards

Prior to the completion of second grade, all students must meet the following technology performance indicators (ISTE, n.d.):

1. Use input devices (e.g., mouse, keyboard, remote control) and output devices (e.g., monitor, printer) to successfully operate computers, VCRs, audiotapes, and other technologies.
2. Use a variety of media and technology resources for directed and independent learning activities.
3. Communicate about technology using developmentally appropriate and accurate terminology.
4. Use developmentally appropriate multimedia resources (e.g., interactive books, educational software, elementary multimedia encyclopedias) to support learning.
5. Work cooperatively and collaboratively with peers, family members, and others when using technology in the classroom.
6. Demonstrate positive social and ethical behaviors when using technology
7. Practice responsible use of technology systems and software.
8. Create developmentally appropriate multimedia products with support from teachers, family members, or student partners.
9. Use technology resources (e.g., puzzles, logical thinking programs, writing tools, digital cameras, drawing tools) for problem solving, communication, and illustration of thoughts, ideas, and stories.
10. Gather information and communicate with others using telecommunications, with support from teachers, family members, or student partners (para 1).

One lesson from each of the six weeks was randomly chosen (See Table 7 Performance Indicators Met in Six Different Lessons). The students' use of technology during those lessons was examined to assess if they could work toward meeting the technology standards in those particular lessons.

Table 7 - Performance Indicators Met in Six Different Lessons

Performance Indicators	11/18 PiCoMap writing	12/3 Sketchy writing/science	12/7 PiCoMap writing	12/15 Memo Pad spelling	1/5 PiCoMap writing	1/12 Sketchy math
1	X	X	X	X	X	X
2	X	X	X	X	X	X
3	X	X	X	X	X	X
4						
5	X	X	X	X	X	X
6	X	X	X	X	X	X
7	X	X	X	X	X	X
8						
9	X	X	X	X	X	X
10						

Performance indicator number one indicates that students must be able to use input devices to successfully operate computers. During every lesson that the students used the handheld computer, they were required to use the stylus to enter information. In the six lessons that the researcher assessed, students wrote words, pictures, a story and number sentences for math problems on their handheld computer. Every student was successful in using the stylus to enter information into their handheld computing device for those lessons.

In addition to using the PC computers in the back of the classroom during center time and also the wireless laptop computers during instructional times, students used the handheld computing devices to do their work. It is rare that a first grader uses such a wide variety of computing devices to do their work. Every student in Mrs. Smith's classroom used a handheld computer to do their work during the six lessons that were examined. However, during three of the lessons some students' handheld computers were not working so they completed their work on paper or their individual whiteboard. During the math lesson, five students' handheld computers were on the charger so those students did their assignment on paper.

During a writing lesson, three students' handheld computing devices were on the charger because they took them home for homework the previous night and the computers needed to be charged. They used their whiteboards to do their work. During a spelling lesson, six students' handheld computers weren't working properly. Students had difficulty erasing words, highlighting words, and rewriting words. Mrs. Smith looked closely at the screens and noticed that the screens were dirty and scratched. This prevented them from working efficiently. She showed those students how to carefully clean their screen and they did that together. After cleaning the screens, the computers worked a little better. One student actually had a big scratch right where he wrote his letters. Mrs. Smith told him to write in another area away from the scratch and that helped him write better.

The students used the handheld computer to do various directed and independent learning activities. Because they used the handheld computers in addition to the other

computers, it can be stated that they used a variety of media to complete their work which meets standard number two.

Performance indicator three states that the students should be able to communicate about technology using developmentally appropriate and accurate terminology. During interviews and observations, the researcher constantly heard students using technical words to refer to the work they did on their handheld computer. When referring to the spelling lesson where the student had to scramble words, beam them to their partner and then fix them and beam them back, Sandy described the learning experience like this: “We are beaming words that have wrong spellings and we have to fix them”. Similarly, when working on the r-blends lesson in PiCoMap, Karin asked Jackie, “What is this word you beamed to me, grassy?” Karin noticed the word “grassy” was spelled incorrectly on the map that Jackie beamed to her. The researcher asked Sarah and Mark to tell her what they were doing during this lesson and they responded by saying respectively, “…working in PiCoMap, writing blend words for tree…” and “…writing r-blends and beaming them so we can get more words”. Jackie also said that she learned more Graffiti while working on her PiCoMap. The researcher asked Rose, Jacob, and Steven to tell her how their friend got the information to them and each one of them responded by saying that their friend beamed it to them. In addition, John said that he and his friend used the exchange beam to share the words on their map. When students beamed their maps to one another, they chose the exchange beam option so that they not only got their partner’s map but their map also went to their partner’s computer. In addition, throughout the study, when Mrs. Smith talked to the students, she

used words such as icon, etc. and the students didn't question that. They knew exactly what she was talking about.

Performance indicators four and eight require the students to use technology to create multimedia products and use multimedia resources to support their learning. Although the students did not work with multimedia during any of the lessons that were observed throughout this study, they did have the opportunity to work toward this standard while using the PC computers in the back of the room and also the wireless laptop computers at other times.

For performance indicator number five, students are required to work collaboratively with others when using technology in the classroom. The researcher saw two different types of collaboration in the six lessons that were assessed. First, students collaborated with their peers to help learn more about using the handheld computer and the software. During every lesson, Mrs. Smith encouraged the students to work with one another to learn how to use their computer and the software. During the lesson when students used Sketchy to make an animation of a seed growing, students showed each other how to use the eraser, change the size of the lines on the screen, add color, add text boxes, add a new slide, delete a slide, and show the animation. As they worked on their slides, they discovered how to do new things in Sketchy and shared that with other students. Mrs. Smith also established student experts during several lessons so the students knew who to go to if they had a question while working on their handheld computer.

Second, students collaborated to learn content by using the beam feature. During the lesson when students used PiCoMap to list words that contained r-blends, after

students made their own map with five words, they beamed their map to a partner. Beaming resulted in the students having their partner's r-blend words on their map, too. The researcher asked Mark what he was using his handheld computer to learn and he replied, "Writing r-blends and beaming them so I can get more words". She observed several students talking with one another about words they beamed to each other. They were reading through the new words on their computer and talking with their partner about their words to make sure they were spelled correctly.

Performance indicators six and seven are items that Mrs. Smith taught the students about when they were first given the handheld computing devices. Students need to practice positive social and ethical behaviors when using technology and practice responsible use of technology systems and software. Working toward meeting these two performance indicators, every student and their parent/guardian had to sign an agreement that reminded them how to treat the handheld computer as they have been taught in class, leave the computer in its protective case when not in use, and not allow other students to play with their handheld computer. Every student signed the contract between the student and SCSD (Appendix P) however; all but two parents/guardians signed the contract and permission form (Appendix O). This meant that all students could use the handheld computers in school and all of the students except two of them could take the device home to do their homework. The students who were not allowed to take them home did their homework on paper.

The ninth performance indicator, use technology resources for problem solving, communication, and illustration of thoughts, ideas, and stories was constantly something that the students worked toward. Students continually solved problems when they had

questions about how to use the handheld computers or the software. They communicated with their peers to solve the problems and learned more about using the device. Students also used the handheld computers for math problem solving assignments. They completed a performance task using Sketchy to illustrate different ways to write math problems. Students used the computers to beam spelling words, word building activities, and math problems back and forth. They worked with each other to correct mistakes and solve the problems. Using PiCoMap and iKWL, students organized and illustrated their ideas about different words and topics. Students illustrated their stories using Sketchy. They used the different slides for text and pictures like pages in a book.

Lastly, according to performance indicator ten, students need to gather information and communicate with others using telecommunications, with support from teachers, family members, or student partners. With the proper technology, handheld computing devices can be used as telecommunication devices; however, this technology was not available to the class during this study.

Individual Discovery of Technology Skill and Collaboration

Mrs. Smith introduced the students to different pieces of software on the handheld computer gradually. She integrated the learning of the software into the content area learning by looking at her lesson plans and deciding which piece of software would enhance the lesson for the students. They used the simpler pieces of software first then gradually began to use more difficult programs. During each lesson, Mrs. Smith encouraged the students to discover how to use different features on their handheld computer. Students were self-directed in learning how to use many of the features in the software programs.

Memo Pad and Note Pad

When the students first learned how to use the handheld computers, they did a lot of work in Memo Pad and Note Pad because they were easy programs to use.

In Memo Pad, students used Graffiti characters to write text. The Memo Pad screen looked like a piece of lined paper (see Figure 17).

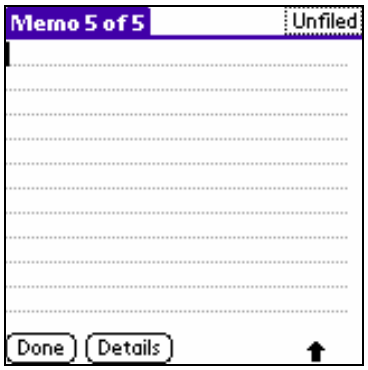


Figure 17 - Memo Pad Screen

In the beginning, the class used Memo Pad to write their vocabulary words and spelling words and even write stories when they got more advanced. Students frequently beamed memos back and forth to one another to share data

The class also used Note Pad to do work in writing. Note Pad is another simple program that allowed the students to write freehand on their handheld computer. It did

not require them to use Graffiti characters. When they wrote on the screen, their handwriting appeared (see Figure 18).

Figure 18 - Maggie's Note Pad Screen - Practicing the Spelling of "That"

The screen in this program looked like a regular note pad that could be written on with a pencil or pen. The class used Note Pad to write spelling words, vocabulary words and math problems, all of which they beamed to a partner to figure out. The real reward for the student was when they beamed to their partner, they could draw a star or a happy face or sad face and beam that back to their partner to signal to the student that their answer was correct or incorrect. In Figure 18, Maggie wrote the spelling word "that" and beamed it to her partner. Her partner drew a happy face on the screen and then beamed that back to Maggie.

During the first lesson that the researcher observed, the students worked individually at their seats. After the students worked for about five minutes, Mrs. Smith made an announcement. "Boys and girls, can I have your attention please? When you finish your work, please take your handheld computer to the rug quietly and write ten of your vocabulary words in either Memo Pad or Note Pad. You have to write ten words to

meet the standard and do more to go beyond the standard. You should take your book to the rug with you so you know what the words are or you can use the words on the board".

The children looked at one another and smiled. The researcher heard a wave of chatter across the room as students were excited to use their handheld computers. They quickly looked at their papers on their desks and continued working. Soon after that announcement, one by one, as they completed their work, students quietly reached into their desks, took their handheld computer out of the bubble wrap envelope and took it to the rug with their reading book.

Several students finished their work, got to the rug, turned on their handheld computers and experimented first. Two students sat next to each other and put their handheld computers side by side and compared what programs they each had on their screens. Since they just began using the handheld computer the previous week, they were still very excited and curious about the computers.

Two other students came to the rug and began to play a game called Bubblet on their handheld computers. Bubblet is a puzzle game in which the students matched similar patterned bubbles together in order to burst them from the screen. The more bubbles they burst at once, the more points they received. Another student came to the rug when he was finished his work and noticed that Jacob and Charlie were playing a game. He said that he didn't have this program on his computer so Jacob beamed it to him. Before they could get started playing Bubblet again, Mrs. Smith was heard in the background, "Boys and girls, if you are on the rug working you should be writing your vocabulary words in either Note Pad or Memo Pad. You should have at least three words written down by now". She must have seen the excitement on the students' faces and the

beaming which indicated that they were off task. Students immediately closed the game program and began their work.

Students chose which program they wanted to use to write their vocabulary words. There was not any discussion between the students. They simply began to work. Jacob used Note Pad and looked frustrated as he wrote his words. The researcher got a little closer and looked over his shoulder. He had a difficult time fitting the word animal on the screen. He erased it several times and rewrote it smaller and smaller until it fit. Then, he moved on to write the next word and wrote it as small as he wrote animal. Jennifer used Graffiti characters to write her words in Memo Pad. She erased letters over and over again to get the spelling correct. As the researcher observed all of the students on the rug, she noticed that no matter which program they were using, they wrote their words with ease.

Whenever the students got something wrong, they worked together to fix it. Students who used Note Pad discovered how to change the thickness of the pen and how to make their writing bigger. Their newly learned knowledge was then shared with a neighbor and spread quickly throughout the room with excitement. In one instance, Karin saw Jacob using Note Pad to write his spelling words and tried to convince him to use Memo Pad instead of Note Pad because she said Memo Pad looked neater. Memo Pad uses Graffiti characters so it looked like it was typed instead of handwritten.

Students who worked on the rug finished writing their words at the same time. As they finished, they still had some time so they beamed their words to each other to check each others' spelling. Two students placed their handheld computers on the floor between them. One of the students put her hand between the computers to make sure they were the

correct distance apart. She pressed a button on her palm and her Memo Pad was beamed to the other student's computer.

During the lesson, some of the students' batteries wore out. They walked to the back of the room, placed their handheld on the charger, put their ear close to the charger and listened for the "beep" to signal it was charging. Then they went back to their seat and worked on their white board. The students did not complain. It seemed like a normal thing they were expected to do when their handheld computer was not working or charged.

At recess time, Mrs. Smith got their attention and asked the children to put their handheld computers away. The researcher heard several students say, "I'm going to see if my palm needs to be charged". One by one, students spread the news that they were checking to see if their handheld computers needed to be charged. Several students rushed to the back of the room and put their computer on the charger. If they did not need to be charged, they put their computer in the bubble wrap envelope on their desk. Jackie opened her handheld computer to see what time it was. She announced to the class what time it was and said that she used her handheld computer to find that out.

During one lesson using Memo Pad, Mrs. Smith asked the students to see if they could figure out how to do a return stroke to write their words on different lines and also how to do a capital letter. Students worked at their seats to write their spelling words in Memo Pad. Students who did not know how to do a return stroke simply put a space between the words. Others tried to figure out how to do a return stroke. Some figured it out and then shared with their peers in their group. Aaron was excited that he figured out how to do a return stroke and also how to erase the letter and retype it. He told his group

in a loud whisper that, “I figured it out!” and then showed them how to do it. For closure to this lesson, Mrs. Smith brought the students to the rug. She reviewed the spelling words with them and also how to do a return stroke and capital letter. She drew the stroke marks on the board and the students tried them on their handheld computers.

PiCoMap

After mastering the easier programs on their handheld computer, Mrs. Smith introduced the students to other more complex software. Students learned how to use a tool called PiCoMap to organize their ideas. Mrs. Smith introduced the students to PiCoMap on the rug as a large group. PiCoMap is a concept mapping tool that allowed the students to create and share documents with one another. Concept maps were in the shape of a web (see Figure 19) and were used for brainstorming ideas and organizing their thoughts. Students drew a main circle in the middle of their screen and put their main idea in it. Then, they drew other circles to put ideas that supported their main idea. They drew lines to connect the circles. Students beamed their concept maps to one another, and their ideas became integrated on each other’s screen.

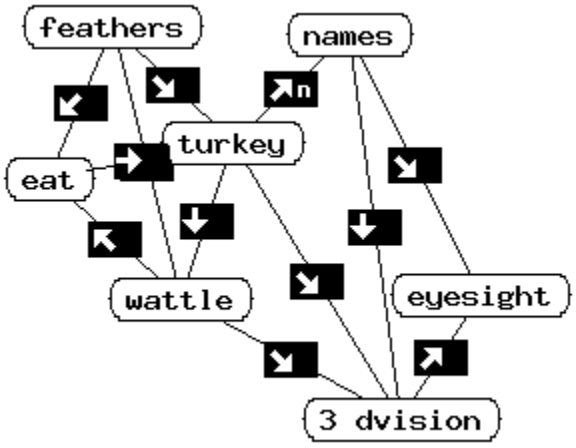


Figure 19 - Jackie's Turkey Concept Map

For their first learning experience using this software, Mrs. Smith instructed the students to do a web about turkey with four facts. They worked together on the rug to open a new map, drew the first circle and put the word turkey in it. Mrs. Smith sent the students back to their seats and they began working by themselves and then gradually shared information with one another. As they worked, they discovered how to do different things in PiCoMap and shared that with their neighbors.

At a later date, students used PiCoMap to brainstorm and organize their ideas about Pilgrims. Students worked on the rug and at their seats, and discussed their ideas with peers throughout the learning experience. While they worked, the researcher observed them talking about what they learned how to do on their handheld computer. Throughout the time that the students were working on their computers, they frequently glanced at other students' handheld computer screens. It seemed as if they wanted to see if there was anything that person knew how to do and could show them. The researcher

heard several different students ask, “How did you do that?” (draw a line from circle to circle to show the relationship between the ideas) and their partner responded by showing them how to draw the lines on their handheld computing device.

Sketchy

As shown in Figure 20, students learned how to use a program called Sketchy to create an animation of a seed growing. Sketchy is a tool that allowed the students to draw and animate objects. It consisted of slides that the students drew on and the slides played as a slide show. Specifically, students used Sketchy to create an animation of a seed growing.

Figure 20 - John’s Four Slides Showing a Seed Growing

Since this was the first time using Sketchy, Mrs. Smith brought the students to the rug for a whole group lesson on how to begin using the program. The students rushed to the rug with their handheld computing devices. Mrs. Smith drew four squares on the board. She explained to the students that they were going to use four slides in Sketchy to

show how a seed grows. Under each square on the board, the students helped Mrs. Smith brainstorm and write what they could draw on the slide to show a seed growing. They said the following words: seed, plant, growth, watering can, flower, apple, and tree. Then, Mrs. Smith told the students to turn their handheld computers on and tap on the Sketchy icon. She told them it was the one that started with an “s” and ended with a “y”. They all found it and compared their screen with their neighbor to make sure they had the correct application open. Mrs. Smith asked the boys and girls, “Look at your screen, what do think you should tap on now?” The students responded by saying, “New”. They responded with excitement because the other programs began the same way. They knew exactly what to do. After they tapped “new”, the students continued to look down at their screens and write the title of their document and their name.

They did this several times before in other programs. On the board, Mrs. Smith drew a picture of what the Sketchy screen looked like. She told them to tap on the four buttons on the bottom of the screen to change the pencil size, color, and pattern. She also told them to tap the arrow to make a new slide. After telling the students those two instructions and allowing them to experiment with it for a few minutes on the rug, she sent them back to their seats. Mrs. Smith encouraged the students to work on their own and with each other to "discover" the other features of Sketchy.

Students began to work on their own to create their slides. Every now and then, one of them got excited after discovering how to do something new in the program. Throughout the time the students worked on their own, they worked with one another to show each other how to use the program. As they began to feel more confident about what they were doing, they talked to each other about what they were drawing and what

other things they learned about the program. They were excited and acted like little bees buzzing around the room! One student discovered how to use the eraser and also how to change the size of the lines to draw with. She showed others and soon everyone in the class knew how to do it. One student discovered how to change/add color in Sketchy. He showed other students and then four students collaborated and learned from those students how to change color. Specifically, after finishing his drawing on each of the four slides, John wanted to add text to his seed animation. He used the buttons on the bottom of the screen and tapped on each one until he figured out which one would help him write text on the slide. Soon after he added text to his slides, the rest of the class wanted to know how to do this and he began to show other students. It looked like a chain reaction. One student showed another and so on. Before Mrs. Smith knew it, several of the students were adding text boxes. Students worked together to help each other discover and learn new features of the program.

After finishing their slides, the students animated their stories and began to show each other and the teacher. Students talked about more ways to change their animation or add other items to grow such as a tree. The researcher observed students figuring out how to make their line thicker, change the color, add text, and erase objects on their slide.

At another point during the study, the class used Sketchy to write stories. By this time, they had already used Sketchy a number of times so they were familiar with how to use it. Students discovered features of using Sketchy as they had a purpose for using them. They began to experiment and do more difficult tasks. One boy used the shape tool to make his picture instead of using freehand to draw (see Figure 21).

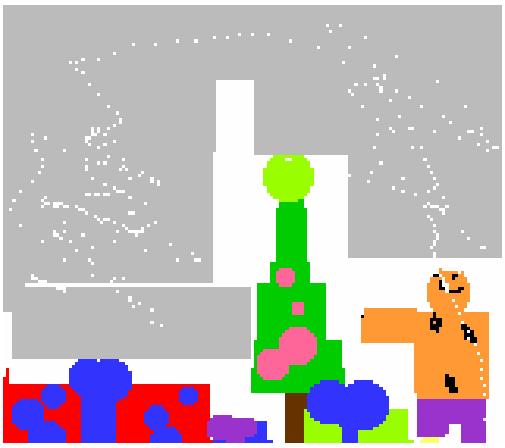


Figure 21 - John's Sketchy™ Picture

He used squares to make presents and circles to make the bows. He proceeded to show his neighbors how to do this and explained to them that it was easier and looked better instead of drawing.

Using the printer to publish stories

One of the most exciting moments for all of the students and Mrs. Smith was when Karin used the wireless printer to print a copy of her story. They used Memo Pad to write their first story on their handheld computer. Earlier that week, the class received a new printer to use with the handheld computers. The students were very excited to finish their story and use the new printer. Karin was the first student finished her story so she beamed her work to the printer. Mrs. Smith showed Karin how to hold her handheld computer so that the infrared light on the computer met the infrared on the printer. There was excitement as Karin pushed the button on her handheld computing device and her story immediately began to print. She showed other students how to do this. The class

was amazed at how something without wires could print their story. Students gradually finished their stories and printed them. Karin was the expert in printing so she helped others.

As the software became more difficult, the students discovered more difficult things on their own and shared with a peer. The learning of the software was integrated with their content area learning and as the students needed to perform a function on the handheld computer, they tried to figure it out on their own.

Student Had a Question and Collaborated With a Peer to Find the Answer

Throughout the researcher's observations and interviews with students she also saw another kind of collaboration. Students frequently had questions about how to do something on the handheld computer. Although the students had many questions in the beginning, as time went on, their questions tapered off. Towards the end, they either knew how to figure out the answers to their own questions or they just simply knew how to perform the task. The children immediately went to their peers to ask questions about the use of their handheld computer. The student who was asked for help either knew how to help his/her peer or they worked together to figure out how to solve the problem. Mrs. Smith facilitated the kind of environment in her classroom that encouraged her students to ask each other questions which in turn encouraged collaboration.

In the beginning of the study, as soon as students were given a task, they did a lot of talking, showed each other their screens, and asked each other many questions. This "chatter" while students worked gradually decreased as the students became more familiar with how to use the handheld computing device, to the point where there was almost no talk when the students were sent to complete a task.

Memo Pad and Note Pad

In the beginning of the observations, students used Memo Pad and Note Pad to work with spelling and vocabulary. They all talked as they wrote their spelling words and asked each other questions. During one lesson, the researcher observed students asking each other how to perform the following functions: erase letters, insert capital letters, correct mistakes, write bigger or smaller, go to the next line, and save their work. Students who used Memo Pad had many questions about how to write certain letters using Graffiti characters. They did not hesitate to ask each other for help or use the cheat sheet on the back of their computer.

PiCoMap

During one lesson, students used PiCoMap, which they hadn't used for a few days. Mrs. Smith brought the students to the rug and told them to open the PiCoMap program on their handheld computer and start a new map. She said, "It's the icon that begins with the letter 'P'". Most students tapped the PiCoMap icon and entered the title of their project (-ing) and their name. She reminded the students how to begin their map by drawing a circle on the board. She wrote –ing in the center of the circle. Students followed by doing the same on their handheld computer. As they finished, they showed each other their computers to make sure they all did the same thing. Mrs. Smith told them they had to put at least five words in outer circles that have the –ing ending. After they were finished, they could see if anyone else was finished and then beam their map to each other so they could get other people's words on their own map. Students got excited on the rug in the large group and immediately rushed to their seats and independently began their maps.

They all calmed down within one minute and got working quietly and quickly. After students went back to their seats to begin working, some students forgot how to begin PiCoMap and asked their neighbor. Several students collaborated on getting started with their web. They were excited to use this program again and talked with each other and helped each other remember how to open and start PiCoMap™. After searching for PiCoMap™ on her handheld computer, Abby said in a concerned voice, “I don’t have PiCoMap™”. Jackie immediately jumped up with a smile and exclaimed, “I can beam it to her!” Jackie beamed the PiCoMap program to Kelly.

Through this observation, the researcher could tell the students had used PiCoMap several times before. They were working quietly and by themselves. At one point while the students were working quietly, two students began to talk. Sarah whispered under her breath, “I got a line!” Later during the work period, Jennifer tried to put a line on her computer and could not. She asked Sarah, “How did you do that?” Sarah showed Shannon how to get a line to connect her circles.

At the end of the lesson, Mrs. Smith asked the students to stop working. She told them that they should have at least five words on their map at this point. She told the students to get with a partner and beam their maps to one another. They rushed to find a partner and beamed their maps. Steven helped John beam because he did not remember how to do it.

The next day, the class used PiCoMap again to list words that began with an r-blend (a consonant and then the letter “r”). The students were more comfortable using PiCoMap. Not as many students asked technical questions about how use the program.

iKWL

During another observation, Mrs. Smith introduced the students to a new program called iKWL. This program guided the students through listing what they know about a topic, what they want to learn, and what they learned. Students were at their desks with their handheld computers on their desks. Some of them went to the chargers to get their handheld computers. Mrs. Smith asked the girls to quietly come to the rug and then the boys. She wrote the word iKWL on the board so they could see what it looked like. She also printed out pictures of what the students should see on their screens and what the iKWL icon looked like, blew these pictures up and attached them to the board for the students to see.

Mrs. Smith told them that this program will help them learn about different topics. She asked the students what they knew about the Titanic. As a large group, they discussed what they knew and Mrs. Smith wrote key words from their discussion on chart paper. Several students raised their hand to tell everyone what they knew about the Titanic.

Mrs. Smith instructed the students to go to their seats and get their handheld computers out of the bubble wrap envelope. The students went back to their seats and acted very excited about this new program. She instructed them to open iKWL and then told them that they would do the next part step by step together. They talked with one another and showed each other how to find the iKWL icon and tap on it. They all compared what each other's screen looked like to make sure they were at the right spot. Students looked down at their handheld computers and tapped on the scrolling bar to the

right hand side of the screen to look for the icon. As they found it, several of them said aloud, “We got it!”

Mrs. Smith told the students to tap the new button and begin a new iKWL chart. They wrote their name and title. The students frequently checked each other’s screen to make sure they were at the same spot. They knew instantly to write their name and title because they did this every time they began a new PiCoMap.

Sandy finished quickly and helped other students. She told the researcher that she felt good about finishing her iKWL chart first because then she could help others. Sandy usually doesn’t get any work done; however today, she told the researcher she was interested in the topic and had a new handheld computer that worked a little better. Charlie could not complete any work because his screen would not recognize his Graffiti characters. The researcher showed him how to use the keyboard.

Throughout this lesson, students constantly collaborated to help each other use the handheld computer and the new program they learned, iKWL. Sue came in late and asked the other students at her table to help her get started with her iKWL chart. The teacher did not have to help at all. With the help of another student, Sue learned what to do and completed her chart. John showed Jack how to delete a space in between letters in his title. Karin and Abby showed each other their screens to see if they were the same. Abby asked Marcus what she was supposed to do next. Addison and Karin showed others their screens. Jennifer checked her screen with Sarah. Mary helped Lillian get back to the right place on her iKWL screen. Jackie helped Mary get to the right place on her iKWL screen. Joe told Abby she was not supposed to use the keyboard. Jacob and Josh worked together to open their files. Ann told Jackie, “Don’t go helping people if you’re not finished”.

Jackie helped Lillian get to the beginning of her sentence. Rose helped Sandy re-open her document and start a new idea.

Sketchy

In two instances, students used Sketchy which was a program that they were not very familiar with. To eliminate confusion and students getting "stuck" while they worked, Mrs. Smith assigned four students the responsibility of being class experts. John, Karin, Jacob, and Maggie were knowledgeable in using Sketchy so Mrs. Smith appointed them the experts. When students had a question, they went to one of those four students. The next day, Mrs. Smith gave the students an assignment to take the rough copy of their story and write the good copy in Sketchy. They were instructed to write one or two sentences in the text box on each slide and then draw a picture to match their text. Throughout the morning, students asked the experts how to do things on their handheld computer. The experts were busy helping the other students but not too busy that they could not get their own work done. Specifically, Lillian asked the researcher how to do an apostrophe on her handheld computer. That was a skill they learned the previous day. Lillian's neighbor overheard her asking the researcher and she was an expert, she showed Lillian how to make the apostrophe using Graffiti characters. A second student also asked how to do an apostrophe and his neighbor showed him.

Because the learning of how to use the handheld computing devices and software programs was integrated in their learning, the students did a better job of remembering how to use the program. This was shown in how easily they helped their peers. The learning of the software was integrated with the content area learning and as the students needed to perform a function on the handheld computer, they figured it out on their own

or asked a neighbor. As the software programs got more difficult to use, the students discovered how to perform more detailed functions, for example: how to make the lines thicker when drawing in Sketchy, how to draw lines to make the circles connect in PiCoMap, how to make the slides animate in Sketchy, and how to change the color of text and lines in Sketchy.

Summary of Results

Throughout this study, first grade students used handheld computers to learn in all content areas. The handheld computing devices enhanced the students' ability to learn content through collaboration. They used the beam feature on the device to share their work with each other. Students told the researcher that they learned content and technology while using the handheld computer. Specifically, they said they learned both content and technical information from a friend. The use of the handheld computers to collaborate enhanced the students' ability to achieve learning outcomes.

Students also met technology standards while using the handheld computing devices. The teacher facilitated the students' learning how to use the devices. She gave them basic instructions then sent them on their own to discover the rest. As they discovered new features on their own, they collaborated with peers to share their new information. When students had questions about using the handheld computer, they worked with their classmates to figure out the answer.

Chapter 5: Summary and Discussion

This last chapter provides a summary statement of the research problem, the research methods used during the study, and the results. The final sections of this chapter state the researcher's conclusions, explain the significance of this study, and discuss implications for research and practice.

As shown in Chapter 1, students need to have access to technology throughout their learning experiences to be able to achieve learning outcomes and meet technology standards. Technology should be available to students so that it can be used as a tool to enhance the learning process anywhere and anytime. Handheld computers provide students with less expensive, anytime, anywhere access so that technology can be used throughout the learning process. This study examined the following questions:

1) In what ways do first grade students use handheld computing devices to learn in collaboration with others throughout the learning process?

    a) How does the use of handheld computing devices to collaborate impact students' learning outcomes?

    b) How does collaborative learning through the use of handheld computing devices relate to technology standards?

This study was an ethnography of a first grade classroom in a suburban elementary school. The students in this classroom used handheld computers to collaborate throughout the learning process. The methods used by the researcher were mainly qualitative. Rich descriptions explained how students learned how to use the handheld computers, how they used their handheld computing devices to learn content in

collaboration with their peers, their thoughts about using the handheld computers, and how their use of the devices impacted learning outcomes and technology standards.

The researcher observed students, conducted informal group interviews, and collected student artifacts while they used handheld computing devices to learn. The study took place during November, 2004 and December, 2004 and lasted six weeks. Standards-based content rubrics were used to evaluate student work that was created as a result of using the handheld computer to learn.

First, results showed that first grade students who used handheld computers throughout the learning process achieved learning outcomes. Through interviews 85% of the students told the researcher that they did use handheld computers to learn. And, 54% said they learned the content - math, writing, spelling, and science. The rest said they learned how to do something new on the handheld computer.

This result was shown through analysis of learning activities that were randomly chosen and assessed. The writing included a PiCoMap and a story completed by the students. The map, content and conventions were assessed. Over half (76%) of the students met or exceeded the standard on their PiCoMap. Also, over half (88%) of the students met or exceeded the standard in story conventions. However, for content students did not use many “Pilgrim” words from their PiCoMap in their story. As a result, 63% of the students scored below the standard and 38% showed little evidence of meeting the standard.

The students also used their computers to complete a math performance task. This task was assessed based on their computation, application of strategies, and how well they communicated their problem solving skills. Over half of the students either exceeded

or met the standard for application (88%) and computation (82%). For communication, 49% of the students exceeded or met the standard. Mrs. Smith noted that communication of math ideas is the most difficult part of problem solving for the students.

Second, students used handheld computers to learn content through collaboration with others. The researcher compared student documents from PAAM before beaming and after beaming and found that 75% of the students' scores improved after exchanging words with their partner. 88% of the students either met or exceeded the standard after beaming with their partner. During a spelling lesson, 90% of the students either met the standard or exceeded the standard after working with their partner (using the beam function) to make sure their words were spelled correctly. Students were also scored based on content and conventions in a whale story that they used the handheld computers to share words with a partner. Over half (55%) of the students met the standard, and 9% exceeded the standard for content. For conventions, 64% met the standard and the 36% exceeded the standard. During all of the activities that were observed and artifacts collected, the majority of the students improved their score.

Third, collaborative learning through the use of handheld computing devices assisted students in meeting technology standards in two different ways. They learned how to use the new technology by discovering different features of the device on their own. They collaborated with peers to teach them how to do what they learned. They also learned new technology skills by asking other students questions and collaborating with a peer to find the answer.

During each lesson, Mrs. Smith encouraged the students to discover on their own how to use different features on their handheld computer. After discovering new skills on

their own, they rushed to share their new knowledge with other students. For example, while using Sketchy to create an animation of a seed growing, students were taught in a large group lesson on the rug how to open the program and draw their pictures on slides. Then, Mrs. Smith sent the students back to their seats and told them to work on their own to create their animations and discover with a peer the other features of Sketchy. Students worked on their own to create their slides. Every now and then, one of the students got excited about discovering something new in the program. One student discovered how to use the eraser and how to change the size of the lines to draw with. Another student figured out how to write text on the slide next to the drawing. Those students showed other students how to do what they discovered. Many students collaborated; one student showed another and so on. Students were excited to teach each other what they learned.

Throughout the researcher's observations and interviews with students she also saw another kind of collaboration. The children collaborated immediately by going to their peers to ask questions about how to use certain features on their handheld computer. The student who was asked for help either knew how to help his/her peer or they worked together to figure out how to solve the problem. Mrs. Smith facilitated the kind of environment in her classroom that encouraged her students to ask each other questions which in turn encouraged collaboration.

During several lessons, Mrs. Smith appointed three students to be experts. When students had a question while they worked on their handheld computer, they asked one of the experts for help. Specifically, while using iKWL to learn more about the Titanic, since students were new to this program, they asked each other a lot of questions. Students showed each other how to delete letters, go to the beginning of the sentence, and

save their document. They constantly showed each other their screens to make sure they were on the right track.

Collaborative learning through the use of handheld computing devices relates to technology standards. The ISTE established ten performance indicators that students must be able to complete by the end of second grade. Of those ten, students had opportunities to demonstrate seven performance indicators while they used handheld computers to learn collaboratively.

Discussion

1) The first conclusion of this study is that the handheld computers facilitated collaborative learning which in turn helped the students learn content. Students learned spelling words by beaming words back and forth and helping each other correct mistakes. Students also learned words through collaboration using PiCoMap on their handheld computer. Students created their own word maps and then exchanged their map with a partner(s) using the beam function. Beaming maps resulted in an exchange which put the students' words on each other's maps. Students responded after beaming with a partner by saying, "[We] get bigger maps and you learn more words" and "if I need any words, I can get them from his (his partner's) map". After receiving their partner's words, they immediately read through them and a few asked, "What is this word you beamed to me"? They worked together to make sure the word was correct on both computers.

Assessment of a word building activity that the students completed using PiCoMap also supported this conclusion. Overall, 75% of the students' scores improved after exchanging words with their partner. Before beaming their individual map of words that contained r-blends to a partner, 13% exceeded the standard and 44% of the students

met the standard. After exchanging maps with a partner through beaming, 81% exceeded the standard and 6% of the students met the standard. The number of students who were below the standard (13%) was significantly reduced (from 38% before beaming) and zero students fell into the "little evidence of meeting the standard" category after beaming.

This data supports the conclusion that handheld computers facilitated collaborative learning which in turn helped the students learn content. Students used the beam function on their handheld computer to exchange information with a partner(s). Students discussed the new data that appeared on their device. They discussed the accuracy of spelling words, math facts, or new data to add to their handheld computer. Students learned content as a result of this collaboration.

2) The second conclusion of this study is that the students themselves said that the handheld computers helped them learn content and technology. Students said that the handheld computers helped them learn "…that 2 plus 4 is 6", "to write bigger words and spell them", and "to learn how to do things like PiCoMap". Most students (85%) stated that their handheld computer helped them learn. Only 10% said that their computer did not help them learn. When asked what they learned, students (54%) told the researcher that they learned content and (44%) how to do things on the handheld computing device.

Students were also asked what they used the handheld computer for and they (62%) told me that they learned how to spell words, how to do a math problem or they learned other content area information. About 29% told the researcher that they used the computer to collaborate with a peer. Some students' (10%) answers were technology related.

Students also told the researcher what they learned from a friend while they used the handheld computer. About 41% of their answers were content related and 59% stated technical answers. Mary told the researcher that her friends taught her different kinds of words and how to make new words. Several students also stated that they learned how to beam and do Graffiti.

The students' awareness of this technology was also shown in the language they used to talk about the handheld computers. They constantly used technical terms to refer to the devices. "It's not beaming because we're too far away," said Ann to Maggie when they tried to beam spelling words to each other. Maggie told the researcher that "Rose is helping me learn by giving me smiley faces by using the stylus and drawing it on her screen and then beaming it to me". At the end of one lesson, Jackie announced to the class that she was going to "…open her palm to see what time it was". At that time she also noticed that her battery was low so she told her neighbors that she was going to put it on the charger.

When Mrs. Smith talked to the students in the beginning of each lesson about new features that she wanted them to discover, she used the proper terms for the words such as icon, stylus, return stroke, exchange beam, Notepad, Memopad, PiCoMap, Sketchy, and Graffiti. Because Mrs. Smith modeled the use of these terms, the students used them in their everyday vocabulary.

After each lesson, Mrs. Smith brought the students to the rug for closure. In addition to discussing what they learned and reinforcing key concepts about the content from the lesson, Mrs. Smith asked the students questions about their use of the handheld computers. She asked them how they used them to do their work, what new features they

learned about the computers, and if they used them to collaborate with anyone. The students developed an awareness of use of the handheld computer as a tool at an early age.

3) The third conclusion of this study is that students can use the handheld computing devices as a tool throughout the learning process and meet technology standards. While students used handheld computing devices to collaborate with others throughout the learning process, they worked toward meeting seven out of the ten performance indicators established by ISTE that students must meet before the end of second grade. The students successfully used the stylus and the beam operation to input information and operate their computer (performance indicator number one).

According to performance indicator number two, students need to use a variety of technology resources for learning activities. In addition to using the PC computers in the back of the classroom during center time and also the wireless laptop computers during instructional times, students used the handheld computing devices to do their work.

Students communicated about technology using developmentally appropriate and accurate terminology (performance indicator number three). Throughout the study, students used technical words such as beam, icon, Graffiti, stylus, charger, and called the software by name.

According to performance indicator number five, students need to work collaboratively with others when using technology. During each lesson, students worked with one another to use the handheld computer and the software. Students also beamed information to one another to learn content.

Students also worked toward meeting performance indicator numbers six and seven. They practiced social and ethical behaviors and responsible use of the handheld computers. Each student and their parent/guardian had to sign an agreement that reminded them how to take care of the handheld computer. Students were very responsible in keeping their computer in the padded envelope in their desk when it was not in use.

As for the ninth performance indicator, students constantly used their handheld computing device for problem solving, communication, and illustration of thoughts, ideas, and stories. Students communicated with their peers to solve problems and learn more about using the device. They also used the devices to solve content area problems.

Students used the handheld computing devices as a natural tool for learning everyday. They did not use the computers for "technology time". The use of the devices was integrated into their content area learning.

4) The fourth conclusion of this study is that the teacher's role is critically important as a facilitator in providing support for helping students learn to use the handheld computers. Mrs. Smith guided the students through learning the basics of how to use the handheld computer. During each content area lesson, Mrs. Smith had the students sit on the rug with their computer. She showed them what to do on her device then asked them to practice that skill. She frequently drew a picture on the board of what they should tap on the screen or which button they should push. She guided them through the beginning of each lesson then gave them time to explore on their own and with their peers.

Mrs. Smith began by having the students do their work using the basic pieces of software such as Memo Pad and Note Pad. Then they progressed to more difficult pieces of software such as PiCoMap and iKWL. This gave them time to master the technology skills while focusing on content area learning. During each lesson, they learned a new feature from Mrs. Smith because she integrated the skills into each lesson.

Mrs. Smith encouraged the students to ask each other questions. While the students worked, Mrs. Smith occasionally interrupted them and reminded them of the directions and commended students who were working quietly, helping each other, and using the handheld computers to work effectively. This positive reinforcement encouraged the students to exhibit those behaviors.

Mrs. Smith facilitated the kind of environment that encouraged the students to help one another which in turn encouraged collaboration. For many of the lessons, the students worked with partners. As partners, the students had the following responsibilities: make sure their spelling words were spelled correctly, check their work on a math problem, share words in a word building activity, share words for writing a story, and help each other with the software or technology. For more difficult lessons, Mrs. Smith established experts who the students could go to for questions about using the handheld computer.

Mrs. Smith modeled the process of working together. She facilitated the students working with and helping one another. As a result, the students knew how to collaborate to learn content and to use the handheld computer. They also formed a sense of self-direction. When the students had a question or a problem that they could not solve on

their own, they immediately went to a peer for assistance. A community of learners formed and students constantly worked together as partners.

5) The fifth conclusion of this study is that the discovery approach of teaching students how to use the handheld computers leads to independent learning. Mrs. Smith introduced the students to different pieces of software on the handheld computer gradually. During each lesson, Mrs. Smith encouraged the students to discover how to use different features on their computer. Students were self-directed in learning how to use many of the features in the software programs. They worked with partners and in groups frequently. Beginning with the learning of how to write the Graffiti characters, Mrs. Smith showed them how to write the first half of the alphabet while they wrote the letters on their devices with her. Then she sent them to their seats to do the rest on their own. She encouraged them to look at their Graffiti cheat sheet which showed them the characters and to also ask a neighbor for help.

Mrs. Smith always encouraged the students to try different functions on their computer and see what they could discover on their own. Therefore, they took ownership of their learning. “I’m going to see if my palm needs to be charged,” said one student as they put their computers away. During one lesson, Mrs. Smith encouraged the students to figure out how to do a return stroke while they wrote sentences in Memo Pad. After the students worked quietly on their own for a few minutes, Aaron whispered to his group, “I figured it out!”

Another way that Mrs. Smith encouraged the students to discover more features of the handheld computer was to ask the students, “Look at your screen, what do you think you should tap on now?” Because she facilitated this discovery learning, the

students began to transfer their knowledge from one application to the next. They began to realize that how to open a new project, how to save their work, and how to erase words were all performed similarly in different programs.

When it came time to use Sketchy which was a more difficult program with many more features, the students were so confident in their knowledge that they learned how to use it independently. She introduced the students to the program, showed them how to open it and begin the project, then told them to experiment with the few features she showed them for a few minutes on the rug. Then, she sent them back to their seats and encouraged the students to work on their own and with each other to discover the other features of Sketchy. Every now and then, you would see one of them get excited after discovering how to do something new in the program. They were definitely experimenting more with this software than with others and using more of the difficult features.

As time went on throughout the study, students asked fewer questions of the researcher and Mrs. Smith and more of their peers. The children immediately went to their peers to ask questions about the use of their handheld computer. Towards the end of the study, students either knew how to figure out the answers to their own questions or they just simply knew how to perform the task. Because Mrs. Smith continually encouraged the students to discover new things on their own and ask questions as they worked with their peers, they became more independent with their learning.

Significance and Implications for Research and Practice

This study has contributed to the field in several ways and supports the findings of the few studies that have been done in this field. However, more research needs to be done to inform the educational community about how handheld computing devices can be used as teaching and learning tools in the elementary classroom. Few studies exist (if any) that involve first grade students using handheld computers to learn collaboratively.

1) This study supports and extends various studies. The Crawford and Vahey (2002) study stated that initially, teachers are skeptical about K-12 students' ability to use the handheld computers. Contrary to the teachers' beliefs, this study with first graders showed that appropriate educational software exists, students have the motor coordination to use the stylus and write Graffiti, and they can take good care of the devices. First grade students can use the devices which supports the findings of Crawford and Vahey (2002), "…young students *are* able to use handheld computers as a productive learning tool" (p. 8).

In addition to being able to successfully use the handheld computers, students used them to learn with each other in all subject areas which supported the Zemelman et al. (1998) definition of collaboration. During this first grade study, students worked collaboratively and shared discoveries with their peers. This finding supports the findings of Crawford and Vahey (2002) and Curtis, Luchini, Bobrowsky, Quintana, and Soloway (2002) who found increased collaboration and communication when the students used handheld computing devices to learn. They found that the beaming feature facilitated small-group work. "The student suddenly transforms from an autonomous worker fully

absorbed in her own task to a collaborative team member, sharing insights and discoveries with fellow students" (Crawford & Vahey, 2002, p. 65).

During this first grade study, beaming also supported collaboration, peer-editing, and students sharing information which supported the findings of Curtis, et al. (2003). During a writing lesson, after writing a list of words on their handheld computer that ended with –ing, students beamed their maps to one another and as a result had many more words on their map. The entire group benefited from individual students' thoughts. Students who did not meet the standard after putting their work on their handheld computer and then beamed with other students then were able to meet content standards. This study with first grade students using handheld computers to learn collaboratively adds significant information to the literature in that it shows that in addition to the third through eighth students in the Curtis et al. (2002) study, first graders can also beam their individual work to classmates.

Students also collaborated to learn technology. Specifically, during the first grade study, when using PiCoMap to make a list of words that ended with –ing, Sarah whispered under her breath, "I got a line". Later during the work period, Jennifer asked Sarah, "How did you do that" and Sarah showed Jennifer how to get a line to connect her circles. Students took responsibility for their learning; especially with learning how to use the handheld computers. This study supports the Tinzmmann et al. (1990) finding that when students learn in collaboration with their peers, more meaningful learning occurs and in return students can solve problems better than they could individually. Students' collaborative learning resulted in learning technical information about the handheld computer.

Because Mrs. Smith encouraged the students to work on their own to discover new features of using the handheld computer, they used their problem solving skills frequently. Students constantly worked together to solve problems related to content and technical issues when working on their handheld computers. Specifically, students discovered new features on their own and then shared that information with peers. They also asked their peers how to perform functions on their computers and either figured out the answer together or one person knew how to answer the question.

First graders in Mrs. Smith's class were self directed in learning how to use the handheld computer which supports findings of Crawford and Vahey (2002). They reported that the students had increased proficiency and could take responsibility for their own learning because they had their own personal device. Mrs. Smith taught the students basic functions and then set them on their own to discover the rest. Students were successful in figuring out how to use the devices and worked closely with their peers to learn new features of the software and device. Whenever students discovered how to do something new on the computer, they immediately shared it with their peers. When students had a question about how to perform a function on the device, they asked their peers. Students took responsibility for learning how to use the device and sharing their knowledge with other students.

The way students learned how to use the handheld computers may provide insights to how children learn technology. Students were self-directed in how they learned to use the handheld computers. Students also collaborated to learn how to use the devices. Because of way they learned, they did a better job of remembering how to use

the computers and programs and transferred that learning to other software programs. They had a reason to use the features; to do content area activities.

2) This study is also significant because of the holistic nature of how the students learned to use the technology. The use of the handheld computers permeated the classroom. Because students had constant access to the technology Mrs. Smith integrated the use of the devices into the content area lessons. There were not separate lessons on how to use the computers. Students learned how to use the computers because of a need driven by the content. The handheld computers were accessible and therefore their use as a tool to learn content was seamless. When students needed to use the computers, they simply took them out of the bubble wrap envelope in their desk and began using them. However, when students' computers needed to be charged or were not functioning properly, they had no problem with getting out their whiteboard or a piece of paper to do their work. The students used the devices in a natural way when necessary as opposed to having to wait for their turn to use one of the few desktops in the back of the classroom or waiting for their day to go to the computer lab.

Mrs. Smith was also able to seamlessly integrate the handheld computers into the curriculum because she was an experienced user of the technology. Mrs. Smith was involved in a pilot program in her school district. The district provided her and several other teachers with their own handheld computing device. The teachers attended training on how to use the computer. Training included basic use of the handheld computer and how to use the handheld computers as teaching and learning tools. The Instructional Technology Coordinator met with the teachers throughout the project to assist in planning the integration of the handheld computer in teaching. Mrs. Smith became proficient in her

use of the handheld computer which made it easier for her to facilitate this learning for her students. She was comfortable using the device to do her work so that naturally transferred to her students.

3) The third significance of this study is students used reflective thinking about their use of technology. This reflective thinking is linked to independent learning. Students showed that they learned through collaborating with others during informal group interviews. They told the researcher that they learned from collaborating with their peers through the use of the handheld computer. Specifically, Mary said that her friends "…helped [her] learn different kinds of words…and make new words". While they used the handheld computing device to learn and collaborate with peers (through beaming), the researcher asked them a few questions. When asked what they used the handheld computer for, 62% of the answers were that the students learned content. About 29% of the students' answers were that they used the device to collaborate and less than 10% of the answers were that their peer helped them learn something new about their handheld computer.

The students were also asked what they learned from their friend. When students were asked what they learned from their friend, about 41% of their answers were content related answers telling the researcher that they learned how to spell new words or do math problems. More than half (59%) of the students stated technical answers; their friend helped them learn how to do Graffiti characters or how to beam.

Throughout the study, students developed awareness as to how the handheld computer helped them. They were able to talk about their own discoveries and share their

learning. They developed self direction in solving problems and learning new information about content and the use of the handheld computer.

4) The fourth significance of this study is that the methodology contributes to the expanding group of researchers who are looking at technology in a qualitative manner. This qualitative ethnography is one that will add to the constantly emerging field of qualitative research that is taking place in the field of technology in education. Savenye and Robinson (2004) completed a literature review of 20 years (1980-2000) of qualitative research in the field of educational technology. They found only 100 publications during that time and of those, "…almost half (46) [were] published in the more recent three years" (Saveyne & Robinson, 2004, p. 1067).

Saveyne and Robinson (2004) suggested that researchers examine educational technology from a broader perspective and examine instructional settings and interactions and views of participants. The current study with first graders did just that. The researcher was immersed in the field situation and captured exactly how the students used handheld computers to collaborate. She also conducted informal interviews to fully capture the first grade students' perspective of what they experienced as they used handheld computers.

Saveyne and Robinson (2004) call for this type of research to continue. "We support and congratulate those researchers and encourage them and the next generation of researchers to expand the questions and types of inquiry being conducted in our field" (p. 1067). The current study will add to the growing list of researchers who explore the uses of technology in education in a qualitative manner.

Limitations

This study was limited to a time period of 6 weeks. Participants in this study were selected purposefully because of their access to handheld computers. For that reason, generalizations are not made for all first grade students. Descriptions of collaborative learning through the use of handheld computers are limited to the students in this class.

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This study was completed as part of a dissertation requirement by a student from Drexel University and was not funded by or affiliated with PalmSource (http://www.palmsource.com/about/trademarks.html). However, because PalmSource, Inc. products were referenced, the attribution block is below.

Appendix A: Technology Foundation Standards for Students

1 Basic operations and concepts

1.1 Students demonstrate a sound understanding of the nature and operation of technology systems.

1.2 Students are proficient in the use of technology.

2 Social, ethical, and human issues

2.1 Students understand the ethical, cultural, and societal issues related to technology.

2.2 Students practice responsible use of technology systems, information, and software.

2.3 Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.

3 Technology productivity tools

3.1 Students use technology tools to enhance learning, increase productivity, and promote creativity.

3.2 Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.

4 Technology communications tools

4.1 Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.

4.2 Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.

5 Technology research tools

5.1 Students use technology to locate, evaluate, and collect information from a variety of sources.

5.2 Students use technology tools to process data and report results.

5.3 Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

6 Technology problem-solving and decision-making tools

6.1 Students use technology resources for solving problems and making informed decisions.

6.2 Students employ technology in the development of strategies for solving problems in the real world (ISTE, 1998, par. 1).

Appendix B: ISTE Performance Indicators for Technology—Literate Students Grades PreK-2

1. Use input devices (e.g., mouse, keyboard, remote control) and output devices (e.g., monitor, printer) to successfully operate computers, VCRs, audiotapes, and other technologies.
2. Use a variety of media and technology resources for directed and independent learning activities.
3. Communicate about technology using developmentally appropriate and accurate terminology.
4. Use developmentally appropriate multimedia resources (e.g., interactive books, educational software, elementary multimedia encyclopedias) to support learning.
5. Work cooperatively and collaboratively with peers, family members, and others when using technology in the classroom.
6. Demonstrate positive social and ethical behaviors when using technology
7. Practice responsible use of technology systems and software.
8. Create developmentally appropriate multimedia products with support from teachers, family members, or student partners.
9. Use technology resources (e.g., puzzles, logical thinking programs, writing tools, digital cameras, drawing tools) for problem solving, communication, and illustration of thoughts, ideas, and stories.
10. Gather information and communicate with others using telecommunications, with support from teachers, family members, or student partners (para 1).

FOCUS	CONTENT	ORGANIZATION	STYLE	CONVENTIONS
The single controlling point made with an awareness of task (mode) about a specific topic.	The presence of ideas developed through facts, examples, anecdotes, details, opinions, statistics, reasons, and/or explanations.	The order developed and sustained within and across paragraphs using transitional devices and including introduction and conclusion.	The choice, use and arrangement of words and sentence structures that create tone and voice.	Grammar, mechanics, spelling, usage and sentence formation.

CRITERIA	FOCUS	CONTENT	ORGANIZATION	STYLE	CONVENTIONS
LEVEL 4 EXCEEDS THE STANDARD	• Makes a sharp, distinct controlling point about a single topic • Displays awareness of mode (informative, persuasive, narrative) • Relates all text to the task/topic	• Develops ideas through use of directly related facts, examples, anecdotes, details, opinions, statistics, reasons, and/or explanations • Selects details related to the topic, purpose and audience	• Demonstrates defined beginning, middle and end using paragraphing appropriately • Develops introduction and conclusion well • Makes evident and/or subtle transitions • Uses pattern (chronological, historical, specific to general, general to specific, causal, sequential, other) appropriate to mode (informative, persuasive, narrative)	• Uses precise word choice • Uses a variety of sentence structures • Develops consistent writer's voice and tone appropriate to audience	• Demonstrates excellent control of grammar, mechanics, spelling, usage and sentence formation
LEVEL 3 MEETS THE STANDARD	• Makes a point about a single topic • Displays awareness of mode (informative,	• Develops most ideas through use of some related facts, examples, anecdotes, details,	• Demonstrates defined beginning, middle and end using paragraphing appropriately • Presents introduction and	• Uses a variety of word choice and sentence structures • Shows some evidence of writer's voice and	• Demonstrates clear control of grammar, mechanics, spelling, usage and sentence formation

	persuasive, narrative) • Relates most text to the task/ topic	opinions, statistics, reasons, and/or explanations • Selects some details related to the topic, purpose and/or audience	conclusion • Shows some evidence of transitions • Uses pattern (chronological, historical, specific to general, general to specific, causal, sequential, other) appropriate to mode (informative, persuasive, narrative)	tone appropriate to audience	
LEVEL 2 BELOW THE STANDARD	• Has yet to develop a point • Shows evidence of a specific topic • Displays unclear awareness of mode (informative, persuasive, narrative) • Relates some text to topic	• Develops limited ideas through use of directly related facts, examples, anecdotes, details, opinions, statistics, reasons, and/or explanations • Presents unrelated details	• Arranges content in a confused or inconsistent manner • Shows little evidence of transitions	• Uses limited variety of word choice and sentence structure	• Demonstrates limited control of grammar, mechanics, spelling, usage and sentence formation, so as not to interfere with understanding the text
LEVEL 1 LITTLE EVIDENCE OF THE STANDARD	• Has yet to develop a point • Shows minimal evidence of a topic	• Presents very little information	• Presents random, disconnected, or unfocused information	• Uses minimal variety of word choice and sentence structure	• Demonstrates minimal control of grammar, mechanics, spelling, usage and sentence formation, which interferes with understanding the text

Appendix D: Reading Response Rubric (K-12)

CRITERIA	UNDERSTANDING	INTERPRETATION	PERSONAL RESPONSE	CRITICAL RESPONSE
LEVEL 4 EXCEEDS THE STANDARD	The student correctly and completely recalls the important elements of the text in sequence, citing specific details.	The student demonstrates understanding of the text by making strong predictions, conclusions and/or comparisons and fully includes supporting details.	The student connects specific examples from the text to personal experiences, other texts and/or background knowledge.	The student makes judgments and states opinions using details from the text, and/or other texts, and/or personal experiences.
LEVEL 3 MEETS THE STANDARD	The student correctly recalls the important elements of the text in sequence.	The student demonstrates understanding of the text by making an appropriate prediction, conclusion and/or comparison and includes some supporting details.	The student connects the text to personal experiences, other texts and/or background knowledge.	The student makes judgments and states opinions using details from the text.
LEVEL 2 NEARLY MEETS THE STANDARD	The student correctly recalls some important elements of the text and/or the sequence is incorrect.	The student may make appropriate predictions, conclusions and/or comparisons but lacks supporting details from the text that demonstrate understanding.	The student makes connections that are fragmented, limited and/or not important to the text.	The student makes judgments or states an opinion without providing support from the text.

LEVEL 1 LITTLE EVIDENCE OF THE STANDARD	The student misses important elements of the text and the sequence is incorrect.	The student makes inappropriate predictions, conclusions and/or comparisons and also lacks supporting details from the text that demonstrate understanding.	The student makes a personal comment that is unrelated to the text.	The student states an opinion that is unrelated to the text.

Appendix E: Mathematics Rubric (K-12)

CRITERIA	COMPUTATION	APPLICATION	COMMUNICATION
LEVEL 4 EXCEEDS THE STANDARD	• Displays correct operations, calculations, and verifies work.	• Employs correct procedures. • May show an alternate solution if there's more than one correct answer. • Uses previously learned strategies, skills, knowledge and concepts to make decisions. • Organizes work and presents procedures and results clearly, systematically, succinctly and correctly.	• Explains all the work shown clearly and logically. • Explains strategies used. • Explains why procedures used make sense and thoroughly explains solution. • Uses appropriate mathematical language with appropriate accuracy. • Considers purpose and audience. • Labels all work.
LEVEL 3 MEETS THE STANDARD	• Displays correct operations and calculations.	• Employs correct procedures. • May show an alternate solution if there's more than one correct answer. • Uses previously learned strategies, skills, knowledge and concepts to make decisions. • Organizes work and presents procedures and results clearly, systematically, succinctly and correctly.	• Explains the work shown and demonstrates satisfactory understanding. • Explains why procedures used make sense and thoroughly explains solution. • Uses some math language with accuracy. • Considers purpose and audience. • Most labels are included.
LEVEL 2 NEARLY MEETS THE STANDARD	• Displays correct operation(s), but made some calculation errors.	• Employs procedures which are not systematic. • Uses operations which are not sequential. • Organizes work and presents procedures and	Explains some of the work shown. • Demonstrates partial understanding. • Considers audience and purpose.

		results in an unclear and incorrect manner.	
LEVEL 1 LITTLE EVIDENCE OF THE STANDARD	• Displays incorrect operations and/or calculations, and/or • Displays no calculations to support work.	• Uses partially developed process.	• Demonstrates a lack of understanding or incorrect explanation, and/or • Makes no connection to purpose and audience, and/or • There is no written explanation to support the solution.

Appendix F: Seven Goals for the Design of Constructivist Learning Environments

1. **Provide experience with the knowledge construction process.** Students determine the topics or subtopics in a domain they pursue, the methods of how to learn, and the strategies or methods for solving problems. The teacher is the facilitator.
2. **Provide experience in and appreciation for multiple perspectives.** Real world problems have multiple solutions. Students must be able to devise alternative solutions to problems as a means of testing and enriching their understanding.
3. **Embed learning in realistic and relevant contexts.** In order for students to be able to transfer what they learn in school to everyday life, learning experiences should be authentic.
4. **Encourage ownership and voice in the learning process.** Students play a strong role in identifying their issues and directions, as well as their goals and objectives. The teacher helps students frame their learning objectives.
5. **Embed learning in social experience.** Social interaction is important for intellectual development. Learning should reflect collaboration between both teachers and students, and students and students.
6. **Encourage the use of multiple modes of representation.** Learning experience should include the use of media, such as video, computer, photographs, and sound, to provide richer experiences.
7. **Encourage self-awareness of the knowledge construction process.** A key outcome of constructivist learning is knowing how we know. Students should be able to explain why or how they solved a problem in a certain way (Cunningham, Duffy, & Knuth, 1993; Knuth & Cunningham, 1993).

Appendix G: Comparison of Handheld Computers, Laptops, and Desktops

	Tungsten E	eMac	Compaq Presario 8000Z	iBook	PowerBook G4
	Handheld Computer	Desktop	Desktop	Laptop	Laptop
Price	$199	$799	$999.99	$1099	$1999
Size and Weight	4.5 in. X 3.1 in. X .5 in., 4.6 oz	15 in. screen, about 10 lbs.	15 in. screen, about 10 lbs.	12.1 in. screen, 4.9 lbs	15.2 in. screen, 1 in. thick, 5.4 lbs.
Keyboard	1. Stylus with grafitti 2. Palm Universal Connector - add peripherals such as a modem, keyboard, GPS receiver and more	Keyboard attached	Keyboard attached	Keyboard attached	Keyboard attached
Screen	Color	Color	Color	Color	Color
Operating system	1. Will run on PC running Windows 95/98/2000/ME/XP 2. Mac OS 9.1 or higher, Mac OS X v10.1.2 to v10.2.6	Mac OS X and 9	Windows XP	Mac OS X and 9	Mac OS X and 9
Memory	1. 32 MB built-in 2. expansion memory available	128MB	1.0 GB	256MB	256MB
Connection to the Internet	wireless	56K internal modem	Internal modem	56K internal modem	Gigabit Ethernet 56K internal modem AirPort

					Ready
Infrared for beaming	Yes	No	No	No	No
Word process, Spreadsheet, Database, concept mapping, research	1. View, edit, and create Word, Excel and PowerPoint 2. send email 3. read eBooks 4. view video clips and photos 5. browse Web content offline and more	1. View, edit, and create Word, Excel and PowerPoi nt 2. send email 3. read eBooks 4. view video clips and photos 5. browse Web content offline and more	1. View, edit, and create Word, Excel and PowerPoint 2. send email 3. read eBooks 4. view video clips and photos 5. browse Web content offline and more	1. View, edit, and create Word, Excel and PowerPoint 2. send email 3. read eBooks 4. view video clips and photos 5. browse Web content offline and more	1. View, edit, and create Word, Excel and PowerPoint 2. send email 3. read eBooks 4. view video clips and photos 5. browse Web content offline and more

Information Gathered from http://store.apple.com/1-800-MY-APPLE/WebObjects/AppleStore.woa and http://athome.compaq.com/store/default.asp and http://www.palmone.com/us/products/handhelds/tungsten-e/tungsten-e_ds.pdf

Appendix H: Contact Letter From the Principal

Dear Parents/Guardians of Students in Mrs. Smith's First Grade Class,

As parents/guardians of first grade students in Mrs. Smith's class, I would like to invite your child to participate in a research project. This research project is a student's research study from Drexel University and is part of a dissertation proposal. Dr. Elizabeth Haslam and her co-investigator, Mrs. Megan Fritz are exploring the use of handheld computers in the classroom.

Your child's class will be using the handheld computers throughout the learning process. The investigator will be present in your child's classroom for six weeks beginning in November, 2004 and ending in December, 2004. While the students take part in their normal daily activities, the researcher will ask the students about how they use handheld computers to learn and share information with other students. She will also watch the way students use handheld computers to learn with each other. The researcher will look at student's work using the handheld computer to determine what the student has learned and how the learning relates to technology standards.

Thank you for your consideration of this request. Please see the enclosed letter from the researcher for more information regarding this study.

Sincerely,

Dr. Kathleen Sommers
Principal

Appendix I: Contact Letter

October, 2004

Dear Parents and/or Guardians:

Dr. McCaul and the Southeastern Community School District School Board have allowed my co-investigator, Megan L. Fritz and me to conduct a research study in your child's classroom. This letter describes the study and is an invitation for your child to participate in it. Generally speaking, we are interested in answering the following questions:

1. In what ways do students use handheld computers to learn in collaboration with others?
    a) How does the use of handheld computers to collaborate impact students' learning outcomes?
    b) How does collaborative learning through the use of handheld computing devices relate to technology standards?

Specifically, we are interested in observing and interviewing your child, and looking at documents they create to learn about his/her experiences as he/she uses handheld computers. Students will be videotaped while they use handheld computers. Videotapes will only be viewed by the co-investigator and the principal investigator.

Your child's participation in the study is completely voluntary and he/she may withdraw at any time. The study will take place during November and December of 2004 and last approximately six weeks. The research findings will be based on summaries and analysis of the interviews, observations, and student documents. All information gathered during the data collection process will be kept anonymous.

The dissertation that results from this study will be published in hard copy and microfiche, which will be housed at Drexel University's Hagerty Library. If you have any questions, feel free to call Megan Fritz at 215-895-6770.

Sincerely,

Elizabeth Haslam, Ph.D.
Principal Investigator
School of Education
Drexel University

Appendix J: Permission for Conducting the Study

Dear Megan:

I reviewed your proposal with the Southeastern Board of School Directors at their work session on January 8, 2004. They have given consensus to proceed.

Because they have invested money into to Palm Handheld computers, they are very eager to hear the results of your research with our elementary students in the Rider Elementary School and the impact Handhelds have on student learning.

You also asked me to serve on your dissertation committee. I would be happy to do that if my schedule can be planned in advance. Please let me know what dates are expected for this commitment.

I am attaching a resume for your committee chair to review.

Best of luck with the dissertation!

Sincerely,

Jim McCaul
Superintendent of Schools
Southeastern Community School District

Appendix K: Signs of Spring Lesson Plan

Subject: Science/Language Arts **Grade Level**: First Grade

Learning Goals: Students will find signs of spring at their school and write three sentences about a picture they take of a sign of spring.

Technology Standards: (See Appendix A)

Standard 1.1 Students demonstrate a sound understanding of the nature and operation of technology systems.

Standard 1.2 Students are proficient in the use of technology.

Standard 3.2 Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.

Standard 4.1 Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.

Standard 5.1 Students use technology to locate, evaluate, and collect information from a variety of sources.

Standard 5.2 Students use technology tools to process data and report results.

Materials and equipment needed: The teacher and students will each need a handheld computer with iKWL software. The teacher will need Margi™ Presenter-to-Go™, PAAM™, and five Veo™ Photo Traveler cameras. Classroom desktop computers, cradles and presentation software will also be used.

Activities and procedures:

1. The teacher will instruct the students to open the program iKWL on their handheld computers and begin a new project. This software program is used to help students organize their ideas when learning something new. iKWL stands for: what I Know, what I Wonder, and what I Learned. Teacher will model the use of the software by projecting the image from her handheld computer to a large screen using the Margi™ Presenter-to-Go™.

2. As a large group, teacher and students will create a word list in the program by brainstorming words they associate with spring. Students will use Graffiti® to

enter words into the words list that they brainstorm as a group. The software program saves these words for the students and each time they enter new text in one of the sections (iKnow, iWonder, iLearned), the word list is visible for them to refer to.

3. After they finish brainstorming and entering words in the word list, teacher will instruct each student to open the iKnow section and enter what they know about spring. As they enter text, their word list appears on the screen. To use the words in the word list, they click on the word and it appears as part of their text.

4. Students will share their ideas with a partner and then share as a large group. The teacher will use Margi™ Presenter-to-Go™ to list students' ideas on the overhead.

5. Students will open the iWonder section of their project and work with a partner to write what they want to know. As they open the iWonder section of the program, they will see several prompts to assist them in writing their questions. They can click on the following words to assist them in writing what they want to know about spring: who, what, when, where, why, how, are, can, could, did, do, does and a question mark.

6. The teacher will put the students in five groups of five. Each group will have one Veo™ Photo Traveler camera. The class will go outside and one at a time, each student will connect the camera to his/her handheld computer to take a picture of a sign of spring.

7. Students will beam their pictures to the teacher who will put them on the overhead and show them to the class. Each student will talk about their picture and why it is a sign of spring.

8. The teacher will instruct the students to open the iLearned section of their project. Students will write three complete sentences about what they learned about the signs of spring. Students will share their sentences.

9. Throughout the day (lunch, recess and at the end of the day), student volunteers will work with the teacher to synchronize each handheld computer with a desktop in the classroom. This will allow the students' iKWL projects to be synchronized with the desktop computers. As a result, the photos they took will be on the desktop and their sentences will be visible to the teacher through the PAAM™ software. The teacher will be able to look at each student's three sentences, make notes to the student if corrections need to be made, and assess the sentences based on a rubric (see Appendix K). When the students synchronize their handhelds with the desktop the next day, the teacher's comments will appear on their screen. The students can then make necessary corrections.

10. The next day, the teacher will use the Margi™ Presenter-to-Go™ to show the students as a large group how to insert their picture into a PowerPoint slide and put their three sentences below the picture. Each student's slide will be put together to make a group slideshow. All of the student's slides will be put together to make a class presentation about the signs of spring.

Appendix L: Signs of Spring Writing Rubric

	Content	Style	Conventions
4	I wrote three detailed sentences about the signs of spring.	I used many detailed words to paint a picture in the reader's mind.	I used uppercase letters correctly. I used punctuation correctly. I used spaces. I spelled priority words right.
3	I wrote one or two detailed sentences about the signs of spring.	I used some words to paint a picture in the reader's mind.	I used most uppercase letters correctly. I used most punctuation correctly. I used spaces. I spelled most priority words right.
2	I did not write any detailed sentences about the signs of spring.	I used ordinary words.	I need to use my uppercase letters and punctuation correctly. I need to use spaces. I need to spell priority words right.

Appendix M: Field Notes

Detailed description of what occurs during the observation	Researcher's comments

Appendix N: Interview Guide

Subject heading	
Opening statements	
Key questions	1. What did you learn?
	2. Did your handheld computer help you learn?
	3. What did you use the handheld computer for?
	4. Did a friend help you get that information?
	5. How did your friend get that information to you?
Researcher comments	
Reflective notes	

Appendix O: Handheld Contract and Permission Form

Dear Parent(s)/Guardian(s) and Students of Room _____,

As you may know, your child's classroom has been using handhelds (small handheld computers) to help with basic skill development, problem-solving, organizational skills and curriculum integration. Students have spent time in the classroom learning how to use them respectfully and properly.

Because students have shown a great level of seriousness, responsibility and interest, they will have an opportunity to take them home in the near future. Taking a handheld home requires the following commitments:

1. Students must return this slip by: _____
2. The student must promise to treat his or her handheld computer exactly as they have been treating them in class. (Like a $200 egg.)
3. The student must promise to keep the handheld computer inside the protective, padded case at all times – except in the house. This means he or she should not show other students on the bus or pass it around to the other students who do not know how to treat the handheld.
4. The student must return the handheld on request of the teacher.
5. If the handheld is damaged or lost due to negligence on the student's part, the student will no longer be afforded the privilege of taking home a handheld computer however, he or she will still be allowed its use in the classroom where appropriate.
6. Upon return of this permission slip, your student will bring home a contract to be signed saying he or she understands and will uphold the above commitments.

Yes, my child has my permission to borrow a handheld computer. I will make sure he or she follows these commitments.

Child's Name: _____

Child's School: _____ Teacher's Name: _____

Parent's Name: _____

Parent's Signature: _____

Appendix P: Handheld Contract Between Student and School

Date: _____

I _____ promise to:
(Student name)

- Treat the handheld computer exactly as I have been taught in class.
  - I will only use the stylus on my handheld.
  - My handheld will either be left in its protective case or kept directly on a desk or table. When I am not using my handheld, it will be in its protective case or a safe place.

- I will leave my handheld in its protective case
  - at school
  - on the bus
  - and when not in use at home.

- I will NOT let other students play with the handheld or pass it around. I know that most students have not learned how to take care of a handheld or how to use a handheld. I can't control the actions of other people; I can only control my own actions.

I promise to bring the handheld back to school as instructed by my teacher.

_____	_____
Student's Name (Print)	Homeroom/School
_____	_____
Student's Signature	Teacher's Signature

Appendix Q: Rubric Used to Assess Content and Conventions in First Grade Writing

	Content	Conventions
4	My response makes sense. I used lots of details (5 or more) from the story. My illustration is neat, detailed and clear.	All of my sentences begin with an upper case. All of my sentences end with punctuation. I used upper/lower case letters correctly. I have spaces between my words. My letters are neatly written.
3	My response makes sense. I used some details (4) from the story. My illustration is neat.	Most of my sentences begin with an upper case. Most of my sentences end with punctuation. I have spaces between my words. Most of my letters are neatly written.
2	My response makes sense. I used few details (1, 2 or 3) from the story. My illustration is may/may not be neat.	Some of my sentences begin with an upper case. Some of my sentences end with punctuation. I have some spaces between my words. Some of my letters are neatly written.
1	My response is not clear. I have no details from the story. My illustration is not clear.	Few of my sentences begin with an upper case. Few of my sentences end with punctuation. I do not have spaces between my words. Few of my letters are neatly written.

Appendix R: Mathematics Task Specific Rubric – Grade 1 – Second Quarter Task

CRITERIA	COMPUTATION	APPLICATION	COMMUNICATION
LEVEL 4 EXCEEDS THE STANDARD	o On more than 3 of my problems, I counted correctly and used correct number models.	o I found more than 3 correct solutions to the problem. o My work is clear, well organized, and shows my thinking. o I correctly used at least 1 strategy (pictures, symbols, tallies, numbers or words).	o I have clearly shown all of my thinking (written or verbal). o I used the right math words when I explained my thinking (groups, sets, each, more, greater, less, fewer, total, equal, add, sort, divide, etc.)
LEVEL 3 MEETS THE STANDARD	o On 3 of my problems, I counted correctly and used correct number models.	o I found 3 correct solutions to the problem. o My thinking shows a good way to solve the problem. o I correctly used at least 1 strategy (pictures, symbols, tallies, numbers or words).	o I have shown my thinking (written or verbal). o I used some math words correctly to explain my thinking.
LEVEL 2 NEARLY MEETS THE STANDARD	o On 2 of my problems, I counted correctly and used correct number models.	o I found 2 correct solutions and may have tried another. o I may or may not have correctly used a strategy	o I have shown some of my thinking. o I was able to tell about some of my thinking.

		(pictures, symbols, tallies, numbers or words).	
LEVEL 1 LITTLE EVIDENCE OF THE STANDARD	o I found 1 solution and I may or may not have counted correctly or used a correct model. o I didn't find a solution.	o I found 1 or no solutions. o I may or may not have correctly used a strategy.	o I need to work on telling my thinking to solve the problem. My work does not help me explain my thinking.

Vita

The researcher is currently employed at Rosemont College, Rosemont, PA as an adjunct professor for both the Curriculum and Instruction and Technology in Education programs in the School of Graduate Studies. Her responsibilities have included instructing courses for Master's level students and supervising student teachers.

Professional experiences also include her work as the Staff Development Facilitator for Technology in Council Rock School District, Newtown, PA (2000 – presently on maternity leave) and as a teacher in Quakertown Community School District, Quakertown, PA (1996-2000).

The researcher became a Palm™ Education Certified Training Coordinator in 2002. She has presented at the Pennsylvania Educational Technology Conference in Hershey, PA and the Educators EmPOWERing Educators Internet Conference at Penn State Great Valley.

She received her undergraduate degree, a Bachelor of Science in Elementary Education in 1995 from Shippensburg University. She entered into graduate school at DeSales University and earned her Master of Education degree in Computers in Education (K-12) and her Instructional Technology Specialist Certificate in 2000. She enrolled at Drexel University in 2001 and earned her Ph.D. in Educational Leadership Development and Learning Technologies in June, 2005.