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A Tablet Computer for Young Children? Exploring Its Viability for Early Childhood Education

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Abstract

This study explored the viability of tablet computers in early education by investigating preschool children's ease in acclimating to tablet technology and its effectiveness in engaging them to draw. A total of 41 three- to six-year-old children were videotaped while they used the tablets. The study found significant differences in level of tablet use between sessions, and engagement increased with age. Teachers reported high child interest and drawings as typical to above expectation. Children quickly developed ease with the stylus for drawing. Although technical issues in learning this new technology were encountered, children were interested and persisted without frustration. What seems to matter for children's learning is the ways teachers choose to implement this technology. (Keywords: technology and young children, tablet computers, computers and early education, pentop computing)

Technology is increasingly recognized as an integral learning tool for promoting the social, linguistic, and cognitive development of young children (Gimbert & Cristol, 2004; Information Society for Technology in Education [ISTE], 2007; National Association for the Education of Young Children [NAEYC], 1996). Today, the question that educators ask is no longer about whether and to what extent technology should be used with young children in the classroom, but rather how it should be used (Clements & Sarama, 2003). Keeping up with new technologies for the classroom presents an ongoing challenge for educators (Clements & Sarama, 2002) as they recognize the ever developing potential of technologies to enhance the ability of children to learn, problem solve, and convey their ideas. One of the key questions for teachers to consider is the role of new technology in the curriculum (Swaminathan & Wright, 2003). We explored the question: Can stylus-interfaced technology in tablet computers be used with young children to implement preschool curriculum?

The Context of Technology in Early Childhood

Early childhood is the period of life from birth through age 8 years (Copple & Bredekamp, 2009), when growth and development is rapid. During that time, many children attend preschool, where they have access to technology as a learning tool. Accrediting bodies in teacher education (National Council for Accreditation of Teacher Education [NCATE], 2008), as well as researchers and educators in the field of early childhood education (ISTE, 2007; NAEYC, 1996), highlight the importance of the children's active use of technology in making decisions, technology resources in writing and drawing, and logical thinking programs to solve problems and illustrate ideas. Children's active use of computers in the classroom means that they must not be in control only of the operation of the computer, but also of the software they are using. Swaminathan and Wright (2003) indicate that a key question in evaluating technology is: Who does the thinking? Technology that encourages children's thinking affords them opportunities for active control and problem solving while providing teachers with a window into children's development.

In their review of the literature, Vernadakis, Avgerinos, Tsitskari, and Zachopoulou (2005) indicated that computer-assisted instruction (CAI) in preschool holds much promise as the technology becomes more accessible. CAI offers pictures and sounds to support the natural ways that young children learn. Engagement in the learning process is directly linked to motivation, as illustrated in Haugland's study (1999), which found the motivation of kindergarten and primary-aged children increased when academic instruction was paired with the use of computers. Handwriting, an early academic task, can be a challenging and often arduous process for children due to developing fine-motor skills. For this reason, motivation is a crucial factor to engaging children in the writing process. Further, Arrowood and Overall (2004) found that using computers improved the motivation of young elementary children in the writing process. Guthrie and Richardson (1995) as well as Talley, Lance, and Lee (1997) found that children were intrinsically motivated to use computers, as evidenced by the fact that they spent a longer time and had more focused sessions at the computer compared with non-computer-related activities. Other studies reach similar conclusions, reporting that the motivation and engagement of kindergarten and primary-aged children in learning increased through the use of computers compared with non-computer-related learning activities (Chung & Walsh, 2006; Sandholtz, Ringstaff, & Dwyer, 1997; Schmid, Miodrag, & DiFrancesco, 2008).

Although some have argued against the use of computer technology for young children's learning (Cordes & Miller, 2000), the effects of technology in educational settings on the development of young children have been widely documented and strongly positive. For example, children who use computers have been found to show greater gains in intelligence, structural knowledge, problem solving, and language skills compared with those who do not use technology in their learning (Clements & Samara, 2003; Haugland, 1999; Swaminathan & Wright, 2003; Vernadakis et al., 2005). The challenge in early education then becomes discovering new ways to more fully integrate technology into the curriculum to encourage the active engagement and thinking of young children.

Active learning in preschool. In the preschool classroom, children draw and paint using a variety of traditional tools, such as pencils, crayons, markers, paints, and paintbrushes. With development and experience, young children gain increasing control over these tools, thereby producing increasingly more accurate representations of their thinking. These active learning activities enhance children's eye-hand coordination, motor and cognitive development, and emergent literacy skills (Copple & Bredekamp, 2009), paving the way for later academic learning, including writing.

Drawing and painting, precursors to formal writing, are representational forms of communication. As such, freehand drawing is a common activity through which preschoolers represent their thoughts and knowledge (Lancaster, 2007; Matthews, 1984). One way teachers assess young children's development and learning is through careful examination of documentation of their work, including photographs, video clips, anecdotal records of children's experiences, and authentic work samples, such as drawings and paintings. Children's drawing of self-portraits is a common closely related activity that teachers in early education use as an indicator of developmental progress. This practice is consistent with formal assessment tools, which include the Draw-a-Man Test as a marker of development (Ter Laack, de Goede, & Aleva, 2005).

Technology and children's drawing. The use of computers for drawing with preschool children is not new. Matthews and Jessel's (1993) study of the development of graphic representation in preschoolers 22–46 months using a computer paintbox (a mouse-driven computer program for electronic painting) revealed that children used similar techniques and went through a similar process for producing drawings, regardless of whether they were using electronic or traditional media. Much like when children are learning to use a marker or pencil for the first time, their initial challenge with the paintbox was to understand the movement and resultant manipulation of the mouse in relation to the product on the screen. They not only required instruction from adults, but also time and opportunity to explore the properties and potential of the new drawing medium. Therefore, computers provided another medium for preschool children to represent their thinking.

The use of computers in preschool has also been found to increase children's interest and engagement in drawing. Trepanier-Street, Hong, and Bauer (2001) reported that children's self-portrait drawings were sometimes more detailed and had a higher level of representation when constructed on the computer. They hypothesized that this may be because the computer requires different fine-motor skills than does drawing freehand. Certainly, the most common forms of computer software involve the use of a mouse and a different set of visual-spatial skills than writing on paper with pencil or markers. They also suggested that, for some children, the computer could be a more interesting tool and therefore might be able to maintain their interest longer and lead to the inclusion of more details in their drawings. However, these studies used mouse-driven programs for drawing, whereas the current interface with technology has evolved to include the use of a stylus, which is more similar to traditional writing and drawing experiences.

Evolving Technology for Classrooms

Technology found in K–12 schools is changing. In her review of technology, Garland (2006) indicated that portable computers are becoming increasingly common in schools. The inclusion of laptops, tablet PCs, Alpha Smarts, and Palm Pilots, which make up a larger share of school technology, is estimated at upwards of 48% (McLester, 2003), and a full 72% of elementary students have online access (Gray & Lewis, 2009). Computer-based technologies have evolved substantially over the past two decades, from point-and-click software designed to reinforce rote learning of concepts and skills to current multimedia authoring software (e.g., Kid Pix, Hyper Studio, and Kidspiration) that encourages children to represent ideas through both image selection and drawing with a keyboard or mouse control functions. More recently, new forms of stylus-interfaced or pentop technology that have become common in gaming systems are now available in laptop computers, known as tablet computers (van Mantgem, 2008). Although pentop computing may seem foreign to adults, Payton (2008) noted, "For younger students, the pen may be a much more comfortable and familiar input device than a keyboard. Indeed, introducing tablet PC pen functionality at the lowest grades can establish pen input as a normal part of the computing experience" (p. 50).

Potential of tablet computers in the classroom. The introduction of tablet computers in educational settings has been primarily limited to middle and senior high school students. Barton and Collura (2003) found that tablets have advantages for improving the writing and organizational skills of high school students, because they are able to type or handwrite stories, and handwritten notes can also be converted to typed text. A case study by Borse and Sloan (2005) focusing on the fourth and eighth graders' use of stylus-interfaced technology reported benefits such as high levels of student engagement, improved writing process, higher rates of homework completion, and fewer absences. Further, Schroeder (2004) found anecdotal support for improved student engagement with high school students due to the highly interactive nature of tablet computers.

More limited support for stylus-interfaced technology in education has also been reported for early elementary students. For example, the integration of technology into the 100 days of school curriculum for children in kindergarten through grade two resulted in increased student motivation in math, reading, and writing (Mouza, 2005). Teachers reported that this was particularly true for students who were not typically motivated by these activities. Chang, Mullen, and Stuve (2005) also reported that kindergartners using PDA technology exhibited high engagement and were easily able to manipulate the stylus for writing and drawing.

We found one small descriptive study involving very young children with tablet computers. Matthews and Seow (2007) looked at the symbolic representation of 12 children ages 2–11 years using electronic paint on tablet computers. The researchers videotaped children drawing with both tablet computers and traditional media (pencil, markers, paint, and paper) in naturalistic settings. Although they reported similarities in the children's drawings using both types of media, they found that the stylus-interfaced technology was a superior tool for drawing when compared with the results of the earlier study by Matthews and Jessel (1993), which used mouse-driven electronic paint. However, this study did not provide specific information about the participants (e.g., how many within an age group, such as preschoolers) or a descriptive methodology, which limits our generalized knowledge about the viability of tablet technology with very young children. Consequently, although a few studies provide anecdotal support, the question remains of whether stylus-interfaced technology aligns with curriculum standards for early education.

Technology standards and tablets for young children. An examination of the National Educational Technology Standards (ISTE, 2007) reveals that stylus-interfaced technology holds potential as a learning tool and as a means to implement technology standards in early education. The relevant standards include: Creativity and Innovation, Communication and Collaboration, Critical Thinking, Problem-Solving and Decision-Making, as well as Technology Operations and Concepts (see Table 1, page 80). For example, Matthews and Seow (2007), in their study of children using tablet computers, found the stylus was superior to the mouse for children's drawing. The stylus responded to pressure children applied, thereby yielding thicker lines and texture in their drawings. This allowed children to employ expressive action in their drawings to create dashes, dots, blobs, and spots, resulting in drawing expressions that they were unable to achieve with mouse-driven electronic paint (Matthews & Jessel, 1993). The tablet computer allowed children to create original works as a means of personal expression. Potentially the tablet will allow opportunities for children to collaborate with peers using digital media and transform their current knowledge to learning a new technology.

Although Berque (2008) asserts that education provides a natural forum for pen computing, and the future of stylus-interfaced computing looks bright, few empirical studies in the literature examine the use of stylus-interfaced technology, particularly with very young children. The studies we found that were conducted with tablet computers involved older students, were primarily based on observation or teacher-child reports, and lack strong empirical findings. Further, evidence of applying pentop technology with preschool-aged children is scant.

Table 1. National Educational Technology Standards for Students (NETS•S)

Creativity and Innovation: Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology.

Communication and Collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.

Research and Information Fluency: Students apply digital tools to gather, evaluate, and use information.

Critical Thinking, Problem Solving, and Decision Making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.

Digital Citizenship: Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.

Technology Operations and Concepts: Students demonstrate a sound understanding of technology concepts, systems, and operations.

Note: From "National Educational Technology Standards for Students: The Next Generation," by ISTE, 2007. Retrieved January 8, 2008, from http://www.iste.org/inhouse/nets/cnets/students/pdf/NETS_for_Students_2007.pdf

Although the available studies provided anecdotal support and guidance for the use of technology in early elementary settings, the potential of stylus-interfaced technology in early education settings with preschoolers has not yet been explored. Given that tablet computer technology allows a unique opportunity for children to be in control of their thinking and learning in a way that is more closely aligned with traditional paper and pencil media, investigation is warranted. The question remains of whether stylus-interfaced technology is a viable tool, and how it aligns with standards in early education.

Thus, the purpose of this study was to answer two research questions:

1. Is stylus-interfaced technology a viable tool for early education?
2. How can stylus-interfaced technology align with technology curriculum standards for early education?

We first investigated the ease with which preschool children become acclimated to the tablet technology. Next, we examined this technology' effectiveness in keeping children engaged and motivated to draw as a means to implementing curriculum standards.

Method

This explanatory research study used a mixed-method approach. We gathered both quantitative and qualitative data to assess the viability of the tablet computer as a learning tool with preschool children. The quantitative component used a multiple single-subject research design (Creswell, 2002). The unit of analysis was the child; we examined individual interaction with the computer both during and after instruction. Next, we looked across classroom groups

Table 2. Demographic Information of Subjects by Age Group

Age Group	N	Age	Gender		Ethnicity	Home Computer Use	Home Touch Screen Use
		M(SD)	M	F		M(SD)	N
3- to 4-year-olds	13	3.8 (0.5)	4	9	1A, 1B, 11C	23.91 (20.15)	5
4- to 5-year-olds	14	5.0 (0.3)	11	3	3A, 1AA, 10C	21.67 (18.51)	5
5- to 6-year-olds	14	5.9 (0.3)	11	9	1A, 1B, 11C, 1H	22.54 (17.55)	2
Total	41	4.9 (1.0)	26	15	5A, 1AA, 2B, 32C, 1H	22.67 (18.17)	12

Note: Ethnicity: A = Asian, AA = African-American, B = Biracial, C = Caucasian, H = Hispanic

to determine if there were differences by age in the ways children worked with the computer. We used grounded theory in the qualitative research design to more deeply understand, through the experiences of the children and teachers, the process of using the tablet computer in a preschool setting (Bogdan & Biklen 2007). To address concerns of internal validity, the data collection for each child occurred within a six-week timeframe to negate concerns of maturation. In addition, we confined child interaction with stylus-interfaced technology at school to the research study to limit concerns about the effect of outside learning on children's response.

Early Childhood Setting

A university-based early childhood center located in the northeastern United States served as the setting. The second author had an administrative role for curriculum development at the school in addition to familiarity with children and teachers, and the first author had university affiliation but no direct relationship with the school. Children and teachers from three preschool classrooms serving children 3–6 years old participated in this study. The integration of technology was a feature of children's daily learning experience in these classrooms. In addition to everyday access to computers, the light table, CD player, tape recorder, and overhead projector were also common parts of the classroom equipment. Digital photography and video were common techniques teachers used to document children's learning. Tablet computers, however, were not a part of the classroom. Six out of seven teachers from the three classrooms indicated that they were daily users of computers, both for personal and teaching purposes. Although all teachers indicated that incorporating technology into young children's learning experiences had high importance, there was variability among the teachers as to the age at which they felt computer technology should be introduced.

In this preschool, as in many others, teachers assess children's developmental progress through analysis of work samples, including freehand drawings, writing samples, and self-portraits. Children draw self-portraits at three points during each year. The timing of this study coincided with the second round of self-portrait drawings that was occurring in their classrooms. Thus we explored the viability of the tablet computer as a technological tool for young

Figure 1. Three-year-old children draw on tablet computers.

children by engaging them in freehand drawing and self-portraits on the tablet to determine if it could be used as a medium for representing their thoughts and knowledge.

Subjects

Forty-one children between 3.1 and 6.3 years (mean = 4.9 years) enrolled in three classrooms participated in this study. Most (75.6%) were Caucasians; 12.2% were Asian; 4.9% were biracial; and 2.4% were Hispanic and African-American respectively (see Table 2, page 81). The overall consent rate from parents for participation was 89.1%.

The researchers distributed a background survey to parents (adapted from Chung & Walsh, 2006) soliciting information about demographics, the types of technology available in the home, and the patterns of children's home computer use. The survey comprised 16 items that focused on the types of technology available in the home, children's patterns of usage, and adult facilitation in computer use. The question formats included check-off and open-response items for length of time and frequency of use. The survey return rate was 88% (36 out of 41). Most children were from two-parent families with family incomes of $50,000 and above. On average, they spent 22.67 minutes (SD = 18.12 minutes, ranging from 0 to 60 minutes) per session at home playing games or using educational software. Although every family had a computer at home, only 30 of the children (73.2%) used them at home; 12 children (29.2%) have used touchscreen

Figure 2. Child drawing on tablet computer wtih access to rebus cards.

and stylus technologies such as Leap Pad and Game Boy. Even though two children (5%) had a tablet computer in the home, they were very infrequent, non-independent users of this equipment.

Procedure

We invited children in pairs to a quiet room outside the classroom equipped with child-sized tables and chairs to use the tablet computer with us. This was a familiar space, as children frequently use it with their teachers for small-group work. The tablet computers were equipped with Microsoft Word software, and the number of icons on the menu bar were limited and enlarged for ease of selection by the children (see Figures 1 and 2). The clocking of each session began when the child picked up the stylus and ended when the child put it down to indicate that s/he was finished. Each child received a hard copy of his or her drawing at the end of each session.

Data collection entailed four distinct phases: introductory and subsequent warm-up sessions focused on learning how the tablet works with each child; a final self-portrait drawing session with each child; and two separate interviews, one with each child for delayed memory recall, and one focused group interview session with each classroom group of teachers. To address potential concerns with internal validity, Phase 2 followed immediately after Phase 1 for individual children, frequently on consecutive days. When this was not possible due to unforeseen events (e.g., absence), in all cases, we collected data in these two phases within a 2-week time frame. These phases are summarized below:

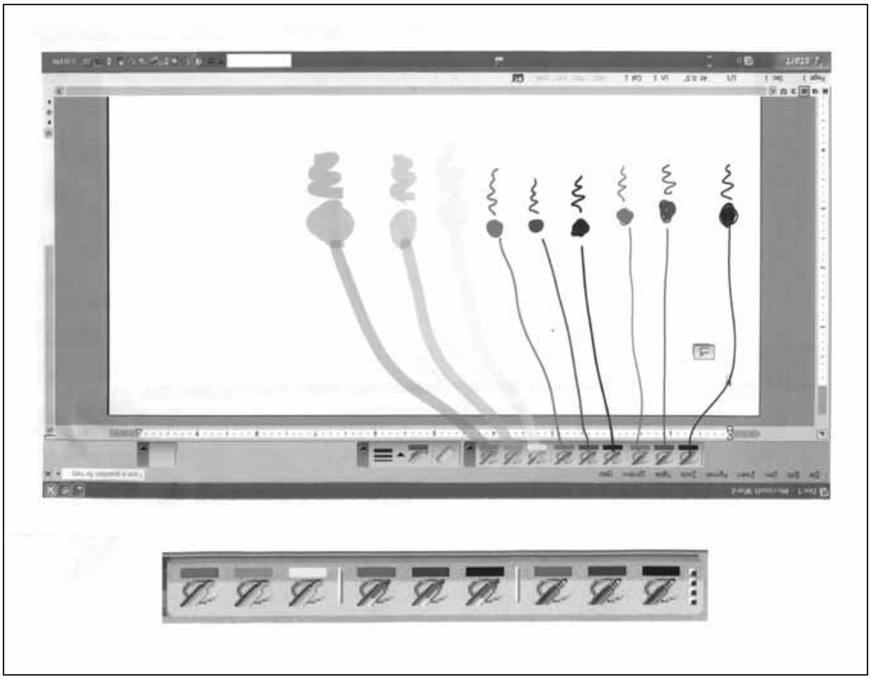

Figure 3. Rebus card for teaching how to use tablet computer.

Phase 1: Introductory and warm-up sessions. Following the recommendations of Clements and Samara (2003), children from the same classroom worked side by side at a child-sized table, each on their own Gateway tablet, and a researcher who acted as instructor (see Figure 1). At the introductory session, a researcher first gave direct instruction about the tablet's inking feature, beginning with drawing, then erasing, followed by the pen selection features. As natural opportunities occurred in their drawing process, the researcher gave additional instruction in how to use the color pallet, how to scroll down for more drawing space, and how to change the drawing using "undo." Rebus cards picturing screens, menus, and tools were available to both the children and adults for instructional support throughout all sessions (see Figure 3). The researchers, both experienced preschool teachers, took on the instructor role, guiding children through each session and encouraging them to explore and problem solve using think-aloud statements (e.g., "I wonder what would happen if you tapped the picture of a blue pen"), peer modeling (e.g., "See what happens when Alex draws with red on top of blue"), and peer teaching (e.g., "Looks like Alex is using a different color on this picture. Ask Alex how he got that color"). As part of a socio-constructivist approach to teaching young children (Bodrova & Leong, 2006), the order of the instruction and the length of the sessions varied according to each child's level of interest and attention span, although the protocol for instructional content was consistent.

Our initial protocol called for children to have up to four warm-up sessions to allow them to develop sufficient ease with this technology to draw a self-portrait. But as children began to work on the tablet, we quickly realized the children were ready to draw a self-portrait. Thus, this protocol was modified by week 2: Those who displayed comfort with the inking features after the introductory session moved on to Phase 2 to draw a self-portrait by their second session. Ultimately, most of the children (n = 31) engaged in only the introductory session before moving on to Phase 2; the 10 children from the first week of the study engaged in one to three warm-up sessions following the introductory session. For all cases, only the first introductory session was used in the data set for analysis presented here.

Phase 2: Final self-portrait drawing session. In this session, we prompted each child to draw a self-portrait. As they entered the room, they were encouraged to look in a full-length mirror and notice their hair, eyes, facial features, and clothing before proceeding to the tablet. A tabletop mirror was placed by each tablet to allow children to look at themselves as they drew.

Phase 3: Child interviews to elicit recall. Exposure to the tablet at school ended once children completed their self-portraits. To ascertain the extent of their semantic memory (content) of the information introduced during previous tablet sessions, we invited the children back individually to the same setting to interview them using a semi-structured format that involved asking them to recall how to use the tablet, what they liked or disliked, and what was difficult about using it, as they freely drew on the tablet. Finally, we asked the children to indicate their preference for a drawing tool among the tablet and traditional materials (paper with pens, pencils, markers, and paintbrushes). To ensure that children's event trace memory of the tablet was decayed but that some memory aspects of the tablet events remained, we conducted these delayed memory recall interviews after a 3- to 4-week lapse from the final self-portrait drawing sessions in Phase 2 (see Leichtman, Pillemer, Wang, Koreishi, & Han, 2000). To address concerns of internal validity, interviews took place within one month of the initial data collection, and children had no further interaction with the tablet at school.

To encourage expression of what they remembered, children were asked to pretend that the interviewer was a new friend who had recently joined their classroom and had never used a tablet, and to show and tell this new friend how to use it. The researcher noted what the children remembered as they drew and probed using questions from the Child Interview Protocol (see Table 3, page 86). Finally, the researched asked the children to indicate their preference for a drawing tool among the tablet and traditional materials (paper with pens, pencils, markers, and paintbrushes).

Phase 4: Focus group teacher interviews. We interviewed seven teachers in classroom focus groups of two to three for one hour, using a semi-structured interview format. Teachers compared the free-choice drawings and self-portraits of children from their classrooms using traditional media with those

Table 3. Child Interview Protocol

Adult:

"Good morning. It's been a while since you came to work on the tablet computer to do some drawing and writing. Today we're going to talk about the computer, and I'm going to have you show me what you remember. So we won't be doing a lot of drawing today, mostly talking and showing."

"If you had a new friend at school who didn't know how the tablet computer works, what would you say/do to teach them how it works? Pretend I'm the new friend. Teach me how this works. How do you get it to draw? What do you have to do first? Second? Show me how it works."

If child is unsure of what is being asked, prompt with:

"How do you tell the computer you want to draw?"

"How do you change colors? Do you remember how to find lots of colors?"

"My paper is full. How do I find more room to draw?"

"What if the computer doesn't hear or understand what you want to do? What do you do?"

"What if you make a mistake and want to change your drawing? How do you do that on the tablet? Did that work well for you?"

"What do you think about using this tablet to write and draw pictures?"

"Which parts do you like about it?"

"Which parts do you not like about it?"

"What else do you think you'd like to do with this tablet?"

As the child shows you what they remember, allow him/her to instruct you for up to five minutes, then prompt with the last question. Move your tablet computer to the side and bring out paper and markers. Start the child with a new page on his/her tablet.

"I have one more question for you, and then we will be done." **Show child markers and paper.**

"Do you think you'd rather draw/write with this tablet or with markers/pencils/pens? Why? What can the tablet/paper and markers (insert child choice) do that the tablet/paper and markers (insert opposite of child choice) can't do?"

from their tablet sessions, for consistency in quality and detail, evaluating the tablet-created self-portraits as below expectation, typical, or above expectation. They also responded to questions about their perceptions of child's interest and the potential of tablet computers as a technology for classroom use.

Coding

Training of the independent coder. An independent coder (a senior undergraduate student who was blind to the study) coded a total of 82 videotaped segments of the first and last drawing sessions of each child. We conducted training with the independent coder across multiple meetings. Fifteen (18.3%) of the 82 sessions (five from each of the three age groups) were randomly selected for review and coded as a part of the training using the following categories:

1. Levels of tablet use referred to whether children were simply exploring and experimenting with what they could do with this new technology to see how it works, investigating how to use it to produce a desired effect, or actually creating desired effects in their drawings. The highest level reached in each session was noted.

Table 4. Description of Measures and Kappa Scores

Category	Definition
Levels of Tablet Use (Kappa = 1.0)	
Level 1: Explore/Experiment	Child tries to figure out what the tablet can do, clicking with the stylus pen on different options to see what will happen if….
Level 2: Investigate	Child tries to figure out how to use the tablet to create a desired effect (e.g., How can I get this color? What do I need to do to make a thick, translucent/highlighter line?)
Level 3: Create	Child produces desired effects in drawing even if the drawing is not a realistic representation of real life objects that have been described. The child is content with, and is clear about what is being drawn
Incidence of technical issues (Kappa = 1.0)	Child perceived technical difficulty or glitch that that interrupts or hinders work on tablet
Affective Response (Kappa = 0.94; range from 0.89 to 1.0)	
Frustrated	Verbal or non-verbal expressions: pouting, frowning, putting down the stylus, … saying WHY is it doing…. and, I don't want to do this anymore.
Not frustrated	Verbal or non-verbal expressions: smiling, laughing, raised brows, … saying with a smile, Hey, what's happening? … or WOW!

2. Technical incidents referred to computer-related interruptions to children's work on the tablet, coded as technical incidents (TI). These were assigned to two categories, computer-based and non-computer-based technical incidents. Non-computer-based TI arose when children asked for help and instruction was given, whereas computer-based TI were the result of a "glitch" the child experienced in using the technology (see Table 4 for further explanation). The number and type of technical issues encountered were coded for each session.
3. Affective response of the children to the technical incidents encountered was examined by looking at whether they were frustrated or not with each incident.
4. Time spent per session was determined by beginning the clocking (to the nearest minute) when children picked up the stylus and ending it when children put it down.

Table 4 reports the details of these coding categories and the corresponding Kappa scores.

Establishing intercoder reliability. To establish the reliability of coding by the independent coder, an additional 25 (30.5%) of the 82 sessions were randomly selected for coding by both the second researcher and the coder. These sessions represent 18 (43.9%) of the 41 children in this study and 83 (23.0%) of the 361 technical incidents across the first and last sessions. Intercoder reliability was first conducted on 11 of these 25 sessions representing eight children. A second round was conducted on the remaining 14 sessions. Table 4 reports the intercoder agreement and

Kappa scores for each measure with the descriptions of the coding categories. Kappa for each measure ranged from .89 to 1.0 with an overall Kappa of .94 to 1.0.

Dependent Variables

Ease of use. We examined the ease of use by first looking at the highest level of use each child reached by the final session when prompted to draw a self-portrait. Levels of tablet use were coded as: 1 = Explore/Experiment, 2 = Investigate, 3 = Create (see Table 4 for definitions). Second, we asked children's classroom teachers (N = 7) to compare the quality of drawings produced on the tablet with those produced using traditional drawing tools.

Nature of tablet engagement. To examine how children used the tablet, we looked at the following measures: time spent in each session and persistence. Time spent was measured from the time the child picked up the writing stylus until s/he set it down. Three components were used to determine children's persistence with using the tablet in spite of the technical issues encountered: the proportion of technical issues encountered in each session (total number of technical issues divided by the total number of minutes in session), children's affective response as indicated by proportion of frustration exhibited to computer-based interruptions to their work, and their expressed choice of drawing tool as indicated in the delayed memory recall interviews.

Our approach was to analyze the data using mixed-methods. We conducted quantitative analysis of videotapes and parent surveys by obtaining descriptive statistics, along with an examination of the mean and percent agreement across groups and sessions. Further, we used a chi-square analysis to compare the percentages of children in categorical groups, such as the level of drawing attained by children drawing on the tablet. To determine the relationship between the variables time spent and persistence, we compared means using an ANOVA. For example, we were interested in whether the mean scores for the amount of time spent in a session differed across age groups and across sessions. We analyzed child and teacher interviews using qualitative methods (Bogden & Biklen, 2007). A research assistant blind to the study's purpose transcribed the interviews. The two authors independently read the transcriptions for evidence of child motivation for tablet use, teacher ideas regarding viability of the technology, and ratings of child drawings. To assure credibility of the data (Golafshani, 2003), the authors then compared their results and did a member check with teachers to confirm interpretations. For the child interviews, we compared the transcription results with the videos for evidence of confirmation between what children said and did. Finally, we triangulated findings from teacher interviews with quantitative results.

Results

Ease of Use

Highest level of tablet use. Although we found no significant differences between children's access to computers at home and the level of tablet use, we found significant differences between the children's highest level of tablet use at the introductory and final sessions ($x^2 = 8.50$, $df = 1$, $p < .01$). At the introductory session in Phase 1, 31 (75.6%) children reached the highest level (Create), and 10 children (24.4%) reached the second level (Investigate), in which they tried to figure out how to produce desired effects in their drawings. By the Phase 2 session, most children (98%) had reached the highest level, with only one child (2%) still operating at the Investigation level.

Teacher qualitative assessment of drawings. Overall, teachers rated 66% (27 of 41) of drawings as typical, whereas 20% of children's drawings (8 of 41) were above expectations for what they usually produced in the classroom with traditional drawing tools. The distribution of teacher ratings was fairly consistent across the three age groups, with the older preschoolers performing most consistently between the tablet computer and traditional media. Figure 4 (page 90) depicts the self-portraits of a 3-year-old girl and 4-year-old boy drawn on the tablet. Figure 5 (page 91) contains self-portraits of the same children completed in traditional media, as part of their regular classroom curricula during the same month. The qualities of the electronically drawn self-portraits are comparable to those drawn in traditional media.

Nature of Tablet Engagement

Time spent in sessions. In the first session children spent an average of 24.05 minutes (SD = 10.72) engaged in their drawing (range: 12–47 minutes), and an average of 20.32 minutes (SD = 10.15) in the last session (range: 5–46 minutes). No significant differences were found between the average amount of time children spent across the two tablet sessions and in the amount of time spent on home computers. However, significant differences were found among the age groups for the average time spent in the final session (F (2, 38) = 6.24, $p < .01$): 3-year-olds spent significantly less time (M = 13 minutes) than 4- and 5-year-olds (M = 23.64 minutes and 23.79 minutes, respectively). Table 5 (page 92) provides greater detail of time spent by age group across sessions.

Persistence. Even though most children experienced multiple occurrences of technical incidents, the vast majority showed little to no frustration. Of the 76 sessions with technical incidents, 47 (57.3%) resulted in no frustration at all. Additionally, 73 sessions (96.1%) involved three or fewer incidents of frustration. No significant differences were found in children's affective response to the technical incidents they encountered between the two sessions

Self-Portrait of 3-year-old girl completed on tablet computer

Self-Portrait of 4-year old boy completed on tablet computer

Figure 4. Self-portraits completed on tablet computers.

or in the affective response among the three age groups. Thus, in spite of the technical issues encountered, children showed little frustration in using this technology, and older children tended to spend significantly longer time working on the tablet as they developed familiarity with it.

Overall, children encountered 0–13 incidents (M = 4.4, SD = 3.35) per session. There were no significant differences in technical incidents as measured by the proportion of technical incidents that children encountered across the first and last sessions and across the three age groups. However, we found significant difference in the proportion of computer-based incidents encountered across the two sessions (F (1, 74) = 7.15, p < .01). The mean proportion of computer-based TI for the first session (N = 40 sessions) was 0.49 (SD = 0.31), whereas the mean proportion for the last session (N = 36 sessions) was 0.68 (SD = 0.31). Thus, although the frequency of encounters with technical incidents in general remained the same across the sessions, children encountered more computer-based TI than non-computer-based TI in their last session. This was due to the fact that in the last session, children showed more independence and asked for less adult assistance, resulting in a decrease of non-computer-based TI. Although the proportion of computer-based TI was significantly higher in the last session, children persisted in their drawing, as the time they spent in session did not significantly change.

Child interviews. We interviewed 40 children (one was absent), one of whom gave no response. Of the 39 responses, 25 children (64.10%) indicated that they preferred to use the tablet rather than traditional writing materials, 13 (33.33%) preferred traditional materials, and one (2.56%) indicated no preference. The majority of the oldest and youngest children (83.33% and 75%, respectively) indicated a preference for the tablet, whereas only 42.87% of the 4-year-olds indicated the same preference. Although some children's reasons for choosing the tablet were often, "I just like it," or "I want to," others were able to be very specific:

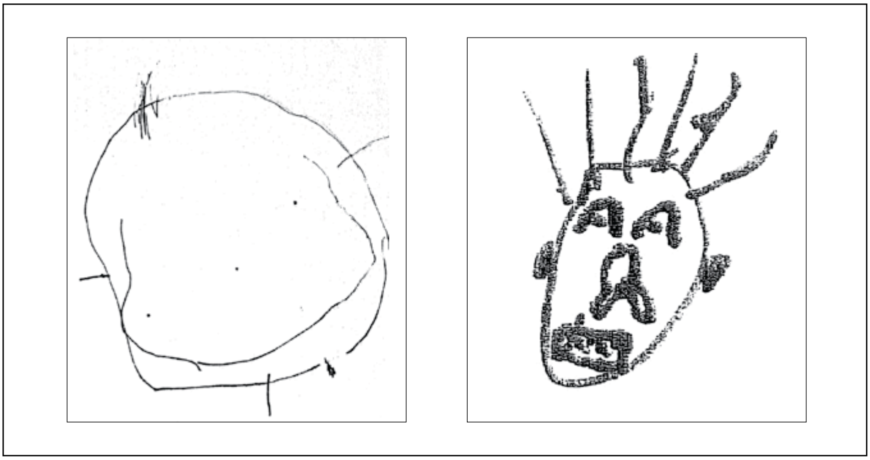

Figure 5. Self-portraits in traditional media.

"There are lots of bright colors."

"It can erase better."

"You can just change something up here [indicating the tool bar] and it actually happens."

"You can draw on it, and on other computer games you don't often get to draw." "You can run out of ink with markers and pen, but on the tablet, it doesn't run out."

"It is easier to draw on."

"You can print out things and you can make the whole background one color."

"It is much easier, and you don't have to rinse off your brush."

Children indicated that they liked the tablet in spite of the technical issues they frequently encountered. One child's comment accurately describes what we have observed time after time with children on the tablet: "Sometimes the computer doesn't hear you.… I just keep trying and trying until it [the computer] gets it right."

Teacher Perceptions of Child Interest and Tablet Viability

In the focus group interviews, teachers provided qualitative descriptions of evidence of children's interest and the viability of the tablet as a tool for use with young children in early education settings. In addition, all teachers perceived the children's interest in tablet use as very high. One teacher reported about children's excitement upon returning to the classroom from a tablet session:

Table 5. Time Spent in Minutes by First and Last Sessions and Age Groups

Item	N	Range	M (SD)	*F* (df)	Significance
First Session	41	12–47	24.05 (10.72)	3.10 (2, 38)	$p > .05$
3-year-olds	13	12–29	18.54 (5.09)		
4-year-olds	14	12–44	25.07 (11.36)		
5-year-olds	14	13–47	28.14 (12.29)		
Last Session	41	5–46	20.32 (10.15)	6.24 (2, 38)	$p < .01$
3-year-olds	13	7–25	13.00 (4.90)		
4-year-olds	14	17–37	23.64 (6.08)		
5-year-olds	14	5–46	23.79 (13.40)		

> They seem very excited to show their picture. So they seemed to have fun with it. It was a way for them to tell stories, to create, and to be creative and explore technology. I think that is so great for children to explore because that is just … where we are heading [toward using technology].

Another teacher talked about her observations concerning the value of this new technology in motivating children who do not usually choose to draw:

> It was just a new media for them to use. There are some children that are very capable of using pen and paper and showing a lot of their work and their development of writing and letters and drawing. And there are some children who work very well with paint or construction paper. I feel like this is just another tool for children to show their abilities to us. Where Phillip does not often draw but he was willing to go with you and draw and show some of his work. And so that might be more inviting for him … than maybe a pen and a piece of paper would be.

When queried about whether the children's excitement for using the technology may be due to being invited to leave the room for a novel activity, the group of teachers responded:

> Children were constantly asking, "Can I go now, can I go now?" And sometimes it was hard to figure out, if they were excited to work on the tablet, or if they were excited just to go do work other children are getting to do. [Were they] simply motivated that they are getting to go do something that other children are not getting to do? I think that could play a part, but a small part, because [when] they came in [to a tablet session] they did not want to come out.

To follow up on the possible "novelty effect" as a threat to the validity of children's interest in using the tablet, two tablet computers were brought in to one of the classrooms as a part of a regular learning center for the remaining two months of school. Interest in using the tablets remained very high. A sign-up sheet was necessary to monitor turn-taking in the learning center throughout this time. This extended interest that children displayed is consistent with teachers' observation during formal data collection. Nevertheless, given the overall limited exposure children had to the tablet, this finding should be considered with caution.

Discussion and Implications

Young children between the ages of 3 and 6 years old were able to quickly learn to use the tablet computer as a medium for representing their ideas and learning. The children in this study were able to become comfortable using the tablet for drawing when given some adult instruction and peer modeling for a total exposure of one hour or less. All but one child was able to use the tablet to create a self-portrait by the second session. Children were able to select from a wide palette of colors and pen options. The quality of the drawing and writing that children were able to attain was comparable with traditional media. Finally, the use of computers in the home did not influence the ease with which children became acclimated to this new technology.

Consistent with Haugland's (1999) finding that the motivation of kindergarten and primary-aged children toward handwriting increased with the use of computers, in this study, children's interest for using the tablet was also high. However, we interpret our finding of interest cautiously, as our measure of interest was qualitative in nature and may not translate to other settings. We did find that the amount of time children spent on the computer varied by age, with the youngest children spending significantly less time. This finding is consistent with that of McBride and Austin (2001), who found cognitive maturity increased engagement with technology. However, our finding is in direct contradiction with Buckleitner (2006), who found that younger children (younger than 50 months of age) stayed engaged with the computer for longer periods of time. In our study, we found that children who were 53 months and older were the ones who persisted longer. This difference in findings may be relative to the difference in technology interface between the two studies. In the Buckleitner (2006) study, children used a mouse, whereas this study used a stylus computer interface. Children older than 50 months of age have more refined motor skills and are more familiar with paper-and-pencil tasks than younger children. Therefore, this difference could be more a factor of fine-motor development and maturity rather than of intrinsic preference.

As the children gained familiarity with the tablet, they became more independent, asking for less instruction and assistance from the adults. Their independence was coupled with an increase in the number of computer-based technical incidents. This is to be expected, as independence leads to more exploration and fuller utilization of the technology to productively represent ideas (ISTE, 2007), resulting in encountering more new situations. What is particularly encouraging is that children were seldom frustrated and persisted in their work even when the number of technical incidents increased. Further, in the last session, when children experienced more computer-based technical instances, they attained a significantly higher level of tablet use. Thus the technology does not seem to inhibit children's persistence or ability to use it.

Similarly, previous research found software that allows children more control results in children experimenting more and completing more tasks. Buckleitner (2006) reported that while the number of errors children experienced increased, because they experimented more, the resultant number of correct responses was significantly greater. Likewise, in this study, as children developed ease with the tablet, their independence with the technology increased, resulting in more experimentation, an increase in technical incidents, and increased ability to use it to create/represent their thinking. Therefore, children's engagement with technology does not appear to be a simple function of age, but rather a more complex relationship between technology characteristics and child development that warrants further study.

As technology continues to change and evolve, educators need to explore new tools, such as the tablet computer, to use with their students in order to effectively integrate technology in the early childhood curriculum (Buldu, 2002; Franklin, 2007). One teacher described the potential of this stylus-interfaced technology in this way:

> I think it adds a different dimension. Some children showed up to do their work, but they did above what we would have expected in the classroom with a regular drawing tool. So I think it offers them a different language tool. The more languages you can offer to them, the more likely they are to show what their true abilities are. So certainly it would be beneficial [in the classroom] in that sense.

A criticism of technology as a tool to support learning is the lack of empirical research (Evans Schmidt & Vandewater, 2008). We set out to begin to develop an empirical basis for the viability of the tablet computer as a learning tool in early childhood settings. Yet this study was descriptive in nature, and data are limited to the children in this sample, who were from one university-based early childhood program, which limits the empirical validation of the benefits of this technology for young children's learning. Future research should include a larger sample in a variety of early-childhood settings to better represent the diverse experience of children, including the digital divide (Subrahmanyam, Kraut, Greenfield, & Gross, 2000) that is experienced by many children who lack access to technology in their homes. Although not all children in this sample were regular users of technology, all children in this study did have access to a computer in their home. Further, future research should consider a comparison of children's work created using traditional drawing media, general technology (keyboard/mouse), and tablet computers, to determine what, if any, empirical evidence there is for using interactive technology tools, such as the tablet, to increase the quality of children's drawing and engagement along with general support for children's learning.

The tablet computer appears to be a viable tool to offer young children for representing their ideas in the early-childhood classroom. We found children readily became at ease with using the stylus and the inking features. Although they encountered glitches associated with learning this new technology, children were able to persist without becoming frustrated. Giving children language for what is happening (e.g., "the computer is thinking," or "the computer didn't hear you, try again") supported their interface with the new technology. This is consistent with Mathews and Seow's (2007) findings that the role of adults in supporting children's learning of new technology is crucial and that responsive scaffolding strategies adapted to the specific needs of the situation are important. Further, although it was not a focus of this study, we found having children work in pairs offered an opportunity for peer modeling and peer teaching (Clements & Sarama, 2002), along with opportunities for less dependence on adults.

In addition, the majority of the children indicated a preference for the tablet computer over traditional drawing media. Children not only indicated a preference for drawing with the tablet, but the explanations they offered were consistent with the research literature. Children indicated that the "colors were brighter," "you don't run out of ink," and "you don't have to rinse off your brush." These are the same explanations offered by Matthews and Jessel (1993) as advantages for the use of electronic paint with young children. Electronic painting is actually painting with light, so the colors are more vivid. When children mix colors, the colors stay true and do not become muddy, as they can with traditional media (Matthews & Seow, 2007). We found several incidents where children mixed colors both intentionally and unintentionally. Given the ease with which the children in this study were able to acclimate to using this new technology, along with the high level of interest and engagement they demonstrated, the tablet computer appears to be a potential learning tool for young children.

Finally, what seemed to matter in regard to technology and learning are the ways that teachers choose to use the technology (Evans et al., 2008). When teachers provide social facilitation for children using computers in the form of scaffolding (Schmid et al., 2008) and scripting the environment, positive peer interaction significantly increases (Lau, Higgins, Gelfer, Hong, & Miller, 2005). Future research should examine the ways that teachers of young children are able to integrate the tablet into the curriculum to enhance children's learning. The use of tablet computers with young children warrants further research to more fully understand the potential of this new technology to support learning and assessment in early-childhood settings.

The tablet computer appears to be a viable tool for use with preschool children. It provides early-childhood teachers with another tool for implementing technology standards and curriculum to prepare children to be digital citizens who are technologically literate. As the expectations of formal education and the capability of technology evolve, a careful examination of their interface for very young children is needed. Continued inquiry to advance our knowledge of technology and how it facilitates learning will support increased efficacy of new technology in early education.

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