The Impact of Digital Ink On Emerging Technologies in K-12 Education

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Abstract

With exponential growth comes exponential change. According to Sharon Oviatt (2016), the last decade has brought about mobile devices incorporated with new input modes and these modes "have eclipsed keyboard-based graphical interfaces as the dominant computer interface worldwide" (p.19). As new technologies emerge, their use and impact in K-12 education must be examined. As Zimmerman (2016) states, "it is no longer a question of *if* technology will become an integral part of our society, but, rather *how*" (p.242). In an environment in which pedagogy and learning is always evolving, mobile hardware platforms are continuously inundating the market with attention-grabbing technologies that promise enhanced teaching and learning opportunities (Varadarajan, Patel, Maxim, & Grosky, 2008). This paper examines the input mode of digital ink and its potential effect as a major factor impacting emerging technologies in K-12 education.

Keywords: digital ink, K-12 education, emerging technologies

The Impact of Digital Ink On Emerging Technologies in K-12 Education

Many K-12 educational organizations have implemented, or are thinking about implementing, programs that support the use of digital tools and technologies in their educational environments. At the core of many debates, amongst educators and educational system stakeholders, regarding the impact of potential digital tool use in the K-12 classroom is the question of whether emerging digital tools enhance or hinder learning. Oviatt (2015), who is internationally recognized for her contributions and research in human-centered interface design, said that "even with great teachers and excellent planning, computers can either enhance a student's ability to think, communicate and learn, or seriously undermine it" (p.2).

Traditional PCs and laptops are no longer the only digital tool options for K-12 educational settings. Schools are now implementing technology enhanced programs with mobile tablets, traditional laptops, and Tablet PCs. Tablet PCs were introduced in 2002 as a new category of mobile handheld devices that enabled "users to take notes in the most natural form of modality using a pen" (Varadarajan et al., p.212). Pen supported technology, combined with traditional PC technology, affords the user improvements with productivity and learning functions (Steinweg, Williams, & Stapleton, 2010). Writing with a digital pen on a Tablet PC has been coined "digital inking" (Steinweg et al., 2010). This paper specifically examines digital inking, and its potential effect on the acceptance of emerging digital inking tools and technologies in K-12 education.

Digital Ink and the Tablet PC

Multimodal digital interfaces have come with the introduction of mobile digital tools offering various input options: keyboard, pen, touch, and speech. Pen input, also known as digital inking, can be defined as "the ability to scrawl directly on the screen of a Tablet PC" with a stylus (Reins, 2007, p.159). It is important to note that digital inking in this context refers to the use of a digital pen or stylus, instead of writing on a tablet with a finger. Utilizing inking technology in an advanced interface that supports digital pens, which often times includes palm recognition, makes it "possible to write directly on the computer screen just as you would on a hardcopy of paper" (McVey, 2008, p.41).

Traditional PC user interfaces support routine classroom tasks such as word processing or compiling a spreadsheet, but lack support in performing tasks that require problem solving, specifically in the areas of math, science, and engineering. In addition, interfaces that only support keyboard input "present a major handicap for expressing 80% of languages that are not Roman alphabetic" (Oviatt, 2015, p.5). Pen interfaces offer more modes of use than a keyboard only interface. Interfaces that support pen input usually coincide with other input options, with the pen input specifically supporting "people's ability to communicate information involving different representations, modalities, and linguistic codes" (Oviatt, 2016, p.25). A multimodal interface, rich in ink-enabled capabilities, "will have an enormous effect on the way students learn and teachers teach" (Godsall, Crescimano, & Blair, 2005, p.21).

Ink-Enabled Tools and Software

In 2002, upon the introduction of Tablet PCs, digital inking supported software began to emerge. Various related tools and software included, but was not limited to, Classroom 2000, LinkDigger, HandleR, Pocket PiCoMap, Scribbler, OneNote 2003, Classroom Presenter and DyKnow (Varadarajan et al., 2008). The specialized software and applications that support

digital inking are commonly referred to as ink-enabled applications, and they allow users "to interact using a stylus on the screen" (Godsall et al., 2005, p.16). In utilizing Tablet PC tools and software, active student engagement was accentuated for better content understanding and retention. Both DyKnow and Classroom Presenter software utilized wireless technology with pen based computing (digital inking) "to actively engage students in a learning environment" (Varadarajan et al., 2008, p.214).

Throughout the last decade, ink-enabled programs (specifically Classroom Presenter) have focused on key instructional elements:

1. Distribution of examples and exercises
2. Collection of student work
3. Viewing and grading student work
4. Publically, but securely, showing student work during class instruction

(Varadarajan et al., 2008)

The above elements remain part of the core instructional strategies that need to be supported by continued Tablet PC software development, and "as more software is written, tablets will become indispensable in the educational setting" (Godsall et al., 2005, p.16).

It is difficult to specify the best or most important ink-enabled tools and software because of the rapid growth and change in the industry. By the time research relating to digital inking is published, the noted ink-enabled tool or software is often no longer current to the present market. Two ink-enabled applications that have stayed current as tablets and Tablet PCs have rapidly changed are Notability and OneNote. Notability is an iOS app, whereas OneNote is an application that works across various operating systems (Windows, iOS, and Android). These applications "allow students to record information in class more naturally" than with the

keyboard alone (Kassissieh & Tillinghast, 2016, p.324). Likewise, "teachers can keep, organize, and reuse notes on their Tablet PCs" by utilizing the ink-enabled application OneNote (Godsall et al., 2005, p.17). As Microsoft and other companies continue improving and designing ink-enabled technology, and as time progresses, "more programs are becoming a standard part of the tablet" (Godsall et al., 2005, p.16).

Digital Inking – Instructor

Technology is infiltrating K-12 education and is demanding a need for new and redefined teaching methodologies and strategies (Amelink, Fowlin, Nandy, Okoth, Pokorski, & Scales, 2016). As change occurs, instructors must adapt and "continue to deepen their practice" with digital-ink enhanced tools (Kassissieh & Tillinghast, 2016, p.327). In order to narrow the exceptionally broad topic of adapting teaching methods and practices, the focus will be given to interactive instruction, archiving course content, and providing online feedback.

Interactive Instruction

Inherently, ink-enabled software allows instructors to draw or write on presented screens, which naturally facilitates presentations to become more interactive (Stwinwed et al., 2010). Instructors can supplement prepared course content by digitally "capturing, writing, drawing, pointing, annotating, and highlighting" directly on top of the content before or during classroom instruction (Reins, 2007, p.159). It is vital for instructors to maintain active engagement to guarantee high learning benchmarks. A middle school Language Arts teacher from the Cincinnati Country Day School, Eleanor Brown, believes that being able to digitally ink on her instructional materials gives her the ability to actively help the students focus by the highlighting, circling, and using other digitally inked visual cues during instruction (Godsall et al., 2005). Also, the ability for instructors to immediately respond to a student or class question

or need by giving a visual (digitally inked) clue is vital to aiding 21st Century problem solving and thinking strategy skills.

Archived Course Content

Prior to Tablet PCs, archives of digital course content consisted of static content material. The content was created and archived prior to instruction and was not able to be dynamically changed before, during, or after instruction. Digital ink-enabled applications allow instructors (and students) to dynamically and actively change and enhance instruction in real-time, immediately archiving the changes. Researchers at California State University examined the use of digital inking in physics courses and found that inking afforded spontaneous augmentation of previously prepared course materials and provided the ability to electronically archive the materials and instruction for later use, for both instructors and students (Amelink et al., 2016). Some have said that "the most significant impact on the learning environment has been the availability of archived notes" (Fister & McCarthy, 2008, p.288). This is even more accurate when digitally-inked real-time archived notes are possible.

Online Feedback

Blended and online learning environments have become more prevalent in secondary education. One of the pitfalls to an online environment is the ability for students to receive effective and personalized feedback. According to McVey (2008), when referring to a study of multiple modes of online environment feedback, "the survey responses send a clear message" (p.42). The responses illustrated that when students were given digitally inked feedback, they perceived the situation to have "a more human aspect to the process and more closely approximating the personal interchanges found in traditional classrooms" and they saw this as particularly valuable in an on-line setting (McVey, 2008, p.42). The utilization of digitally inked

comments has the potential to heighten social presence, providing a human touch to online feedback and interaction (Steinweg et al., 2010).

Instructor Use Survey

The International Data Corporation (IDC) conducted an on-line survey of 685 United States educators who use computers in the classroom. The objective of the study was to "understand their [classroom teacher] classroom technology usage, and specifically how they are using Digital Inking devices" (International Data Corporation, 2015, p.2). The survey findings support the continued and future use of digital inking as an instructional tool in K-12 education. IDC (2015) selected findings are as follows:

- 88% believe stylus and touch allows them to increase the quality of instruction to the entire class (p.16)
- 68% say that using a touch-based device with a stylus increases the quality of communications with students (p.8)
- 67% said their stylus-based device helped save them time when preparing materials and curriculum for instruction (p.10)
- Teachers consistently reported benefits of being able to clearly and quickly communicate feedback to students at the 'teachable moment' (p.20)

Digital Inking – Student Role

Digital inking creates an environment in which students utilize cutting edge digital tools to foundationally support their learning. The utilization of digital tools is no longer futuristic. Digital tools, including digital ink, have begun emerging in K-12 education. Without guidance and instruction, the use of digital tools will not "become an extension of learning goals" (Zimmerman, 2016, p.247). With introductory guidance, students are afforded the opportunity to

actively engage in and process content that is being presented in an environment where their needs are met.

Engagement and Opportunity

A foundational classroom capability of digital inking is that students are able to annotate and draw on electronic documents and files (Reins, 2007). Student engagement is a primary concern of any K-12 classroom. Touch and digital inking have become central to classroom cultures because these tools are helpful in keeping students engaged (Williams, 2016). Students who otherwise might be passive in the classroom are granted new opportunities with the infusion of digital ink to become active participants and learners. Opportunities in which students are able to incorporate handwriting, typed text, and other media in digital files "can transform an arduous writing assignment into something more interesting" (Steinweg et al., 2010, p.57). Creating digital assignments that allow for student choice enable the student to actively engage in a manner that suits their personal learning needs and preferences. The barrier for active engagement is lowered by utilizing pen interfaces for all students, both low- and high-performing students (Oviatt, 2016).

Typed Versus Inked

Student use of new technologies cannot be overlooked. Following recent research, Oviatt (2016) claims that "the same student accomplishing the same tasks communicate more when using a digital tool than an analogous non-digital one" (p.21). Students are native to a robust digital climate and often naturally navigate towards the use of digital tools. However, with the onslaught of touch enabled devices and ink-enabled software applications, it is important to step back and look at the cognitive effects of typing and digital inking new cognition. The International Data Corporation (2015) stated very clearly that "keyboard interfaces were never

designed as thinking tools", but instead the ability to utilize digital inking to draw or diagram content is foundation for cognition (p.22).

The foundation for cognitive development, provided by digital inking, was substantiated in fMRI studies, on both children and adults, in which the findings relate that actively writing increases "brain activation" more than merely typing, viewing, or naming letters (Oviatt, 2016). When a writer's inking is converted to text, not only does writing letters provide brain stimulation and activation, it also affords the writer immediate feedback regarding the correctness of their written work. (Stwinweg et al., 2010). Writing, note taking, and cognitive connection is vital to the learning process. Student use of digital ink on a Tablet PC is normalized quickly because students are accustomed to note taking, thought forming, and writing activities using paper and pencil.

Educational interfaces that are more similar to students' preexisting interfaces "reduce extraneous cognitive load and improve performance" (Arthur, Brock, Cohen, & Oviatt, 2007, p.3). In fact, Mueller and Oppenheimer (2014) have suggested that "laptop note taking is less effective than longhand note taking for learning" (p.1159). Not only can laptop note taking be less effective, it can "negatively affect performance on educational assessments" especially if the intended used for the laptop is easier note taking (Mueller & Oppenheimer, 2014, p.1166).

Student Learning Needs

Every student has a unique set of learning needs. Multimodal devices, that support digital pen input, allow for student choice in digital tools and applications. For some students who have dexterity and fine motor skill deficits, writing provides an avenue to learn, problem solve, and garner new knowledge through robust and varied digital interfaces. Digital inking enabled devices and applications address the need to support "learning style differences", in

order to "enhance student ability to learn material" (Stwinweg et al., 2010, p.58). In her research studies, Oviatt has reported seeing positive shifts in student understanding and cognition. (2015). The following statistics follow from students using digital pens and pen interfaces:

- While using a digital pen in math and science, students produce 56% more diagrams, symbols, and numbers (p.4).
- In one study, students drew 126% more diagrams as their math problems became harder (p.8).
- In one study, Japanese users completing the same tasks made 14 times more errors when using a keyboard than a pen (p.5).
- When students diagrammed before solving a problem, their science scores were 25-36% higher than when they did not (p.6).

Students use digital inking both informally and formally in the classroom. Informally, students brainstorm, diagram, and map their thought process, while formally they refine their thinking and solutions to problems and scenarios presented. Informal digital ink marking "occurs at substantially higher rate in low-performing students" (Oviatt, 2016, p.22). According to Oviatt (2016) informal digital ink marking use among low-performing students led to 24.5% more accurate solutions to presented problems.

The Future of Digital Inking

A survey of 449 students and faculty at the North Carolina, Cary Academy, who utilize Lenova Yoga Tablet PCs shows significant cause to engage in conversations about digital inking and its impact on education. Results from this survey reflect that 83% of responders use a stylus daily, 87% like the availability of a stylus, and 77% want their computers to have a touch interface (Williams, 2016, p.332). In Williams (2016) survey results, it was apparent that the

Cary Academy students and faculty "would find their learning environment depleted" in the absence of a stylus and touch interface (p.332). Based on research and survey data, educational stakeholders would be remiss to ignore the documented benefits of digital inking.

Williams (2016) has conveyed that touch and pen-enables computers replace the need for other physical materials. Whether or not Williams is correct in her assumption that other physical materials are needed by student in a learning environment, other researchers do believe that pen-based interfaces have the "ability to bridge formal, informal, and mobile learning contexts" (Arthur et al., 2007, p.2). As digital inking and ink-enable interfaces continue to improve, infiltration into mobile and PC technology is inevitable. Currently on the market, ink-enabled mobile tablets, Tablet PCs, cell phones are making waves in the personal technology device industry.

It is only natural that the education sector must begin (and in some cases) continues to utilize emerging technologies that afford students with best and most effective interface features. While cost and availability will always be a grand challenge and play a vital role in decisions regarding technology programs, it is vital for organizations, schools, and universities to recognize emerging digital tools and technologies, specifically digital ink enabled interfaces, and begin planning for their implementation.

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