Digital Note Taking: The Use of Electronic Pens with Students with Specific Learning Disabilities

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This article describes a study of the use of a digital note-taking technology with high school students with specific learning disabilities. The goal of the project was to understand the degree to which this intervention has the potential to support students' note-taking skills, promote retention of material, and reduce cognitive effort during note taking. The authors offer recommendations for ways in which existing features and uses of this technology can be improved and enhanced. The findings of this research suggest that the use of digital pens can increase the quality of student notes and note-taking strategies. Based on this pilot study, the pens are recommended for use in particular types of course activities for students with language-based learning disabilities.

As Boone and Higgins (2007) pointed out, most of the developments in the field of special education technology have suffered from a lack of understanding of the specific instructional needs of students with learning disabilities. These researchers go on to assert that access to technology is not meaningful unless the tools are integrated into the instructional setting and matched to the needs of the learner. Anderson-Inman (2009) expands on this idea by suggesting that technology needs to match the media rich environments that exist in student's lives today. She suggests that students have the opportunity to make use of digital tools not only to collect information, but also to expand their own understandings and share their knowledge with others. Further research into the possibilities afforded to students with learning disabilities via new technologies such as digital note-taking tools is needed, particularly when that research is based in the classroom and connected to the curriculum and teachers' everyday practice.

Purpose of the Study

The purpose of this article is to describe a pilot study that investigated the use of digital pens in combination with the Cornell note-taking system with high school students with learning disabilities. The research draws from two complementary areas of the knowledge base in educational research: the use of technology for instructional purposes, and developing instructional methodologies to support achievement in students with learning disabilities.

Digital Note Taking

Use of the digital note-taking tools may allow students with learning disabilities to better use working memory, visuals, and auditory learning capacities to complement information processing during lectures and review. Digital note taking, which allows the user to make auditory recordings in addition to written notes, has shown promise in science classrooms with students with and without learning

disabilities (Horney et al., 2009). It is theorized that interventions that make use of this particular technology may improve the quality of student note-taking strategies and also support student comprehension by encouraging multiple reviews of the content. Previous studies suggest that the opportunities for multiple reviews of the text may reduce the burden of comprehension and attention that is imposed on students with learning disabilities in the typical classroom setting (Anderson-Inman, Quinn, & Horney, 1996; Salomon, 1993).

Students who have auditory processing disabilities may be at a significant disadvantage for verbal classwork and lectures (Carretti, Borella, Cornoldi, & De beni, 2009). Students who have these types of learning disabilities are likely to miss most classroom communication without significant accommodation. The ramifications for a student's inability to access classroom information are tremendous, both academically and socially (Hassanbeigi et al., 2011). As time passes and this disadvantage becomes more significant, there is a risk of students becoming disengaged and more likely to display disruptive behavioral problems (Mather & Goldstein, 2008).

Researchers and teachers have been using adaptive and assistive technology tools to help students with learning disabilities access the curriculum and develop study skills (Edyburn, 2007; Raskind, 1993). Technologies such as digital pens offer the opportunity to take better notes in class and help students better capture information from lectures, discussions, and textbooks (Horney et al., 2009).

The synchronous text and audio provided by a digital note-taking tool has the potential to facilitate better knowledge retention when students review notes they have taken themselves. This enhancement to note reviewing is critical, because researchers have found that students can make connections with prior knowledge, subsequent study material, and among parts of the lecture material. Several studies examining the efficacy of note-taking practices integrated with a variety of computer applications, handheld devices, and digital pens exist (Chao, Chen, & Chang, 2010). These focus on the digital annotation techniques and tools for content on the Internet and the development of tools to aid in the creation and organization of notes (Brotherton & Abowd, 2004; Hadwin & Winne, 2001; Hwang, Wang & Sharples, 2007; Rau, Chen, & Chin, 2004; Robinson, Katayama, Beth, Odom, Hsieh, & Vanderveen, 2006).

Technology (and particularly assistive technology) can provide students with greater independence, individualized instruction, and greater control over the learning experience (Blackhurst, 2005; Irvine Belson, 2003). There is a great need for more study on how specific assistive technologies can support the needs of students with specific learning disabilities (Anderson-Inman & Horney, 2007; Boone & Higgins, 2007; Edyburn, 2007; Perry & Beyer, 2009). The use of digital pens—those that can record both auditory and written information—has potential for students with specific learning disabilities. As the price of these pens (currently at about $150) drops, there will be increasing interest in their use. However, in order to make effective use of them, techniques and tools need to be developed to facilitate their incorporation in the classroom.

Digital pens can support a variety of learning needs and lessen the cognitive load for students as they transition into postsecondary settings where lectures will be longer and more detailed. For example, the pen currently requires the user to take notes by hand. For many students, writing notes by hand may be tedious and frustrating. The pen could also be used solely as a recording device, allowing the user to listen to a lesson or lecture multiple times.

Note-taking Strategies for Students with Learning Disabilities

Many students with learning disabilities produce notes that are incomplete, incoherent, or ineffectively organized. They may fail to record many important points (Baker & Lombardi, 1985; Kiewra & Benton, 1988). Kiewra and Benton suggest that good note takers "attend, store, and manipulate information selected from the lecture simultaneously, while also transcribing ideas just presented and processed" (p. 35). Those with limited working memory capacity, including many students with language-based learning disabilities, have difficulty attempting to execute these multiple tasks. Although note taking often facilitates learning for those with greater working memory capacity, it may be detrimental for learners with more limited language capacities (Berliner, 1971; Hughes & Suritsky, 1994; Mayer, 2010; Siewert, 2011). It appears that while writing previously mentioned ideas students might miss or misinterpret critical information (Hughes & Suritsky; Siewert). Boyle and Weishaar (2001) suggest that students with learning disabilities in high school settings need specific note-taking strategies.

In the general education student population, note taking helps the learner attend to and record important lecture details (Tran & Lawson, 2001). For example, Englert et al. (2009) found that students who both write and review their notes perform better on synthesis tests that require generative processing (e.g., "cross-topical connections") than students who either take notes and do not review them or review notes taken by a selected note taker (an accommodation frequently offered to postsecondary students with learning disabilities). This suggests that if taking lecture notes is too demanding on a student's working memory to permit the student to carry out generative processing in real time, this can occur during the review of the notes (Swanson & Jerman, 2006).

Cognitive Load and Note Taking

Students with learning disabilities can benefit greatly from the use of study skills strategies, note-taking methods, test-taking preparation, approaches to written language, and the development of metacognitive skills—all of which encompass a broad set of techniques known as "learning to learn" (Bulgren, 1988; Englert Dunsmore, Collings, & Wolbers, 2007; Gettinger, & Seibert 2002). For example, Englert et al. (2009) found that when teachers developed a program to help students with learning disabilities develop questioning strategies in science class, these students progressed significantly, improving their awareness of textual units and comprehension of texts.

Reducing the need to focus on the mechanics of note taking may reduce the cognitive load required to both attend to lectures and keep track of important information. Cognitive load theory suggests that working memory is based on using three different systems: an executive attention function and two supporting functions, visual-spatial and auditory/phonological (Baddeley, 2003). When more systems of working memory are taxed, there may be extraneous cognitive load and limited working memory capacity may be overwhelmed. Brünken, Plass & Leutner (2003) suggest that measurement of cognitive load may be important in the context of multimedia. These researchers suggest the dual coding required by two areas of working memory (visual and auditory) may be more clearly synchronized in multimedia learning. The use of digital pens may be able to reduce the effort required by both areas of the working memory by building connections between them.

Reducing cognitive load should reduce the effort to focus on tasks that are secondary to learning, particularly among individuals with learning disabilities (Paas, Tuovinen, Tabbers & Van Gerven, 2003). Reducing cognitive load may facilitate learning by directing cognitive effort toward activities that are relevant to learning (Sweller, 1994). For example, as pointed out by Chandler and Sweller (1991) ineffective instruction can occur when students are required to integrate disparate sources of mutually referring information such as separate text and diagrams. These researchers suggest that asking students to deal with more than one presentation of information at a single instance may generate a heavy cognitive load because material must be integrated mentally before it can be comprehended (Chandler and Sweller).

This project was built around establishing a consistent model of note-taking training, the Cornell note-taking system (Pauk, 1962). The features of this system are designed to cue students into the use of several key features in the structure of the notes, as well as a process of revising notes based on key "strategy questions." The Cornell note-taking system is advantageous for organizing, recording, and reviewing notes. With this method, students divide their paper into three sections: one for notes, one for questions, and one for a summary. Students record important notes during class in the largest column, on the right. After each note-taking session, students are encouraged to review their notes and create questions in the lefthand column. These questions highlight the main points of the lecture and define main points, reveal relationships, and organize information in a systematic way to help prepare for tests. Finally, students create a short summary, in their own words, that wraps up the information.

Faber, Morris and Lieberman (2000) found that the Cornell note-taking system increased comprehension and achievement. In a 2008 study, Jacobs (2008) found that students performed better after learning the Cornell note-taking method and determined that it is valuable to students when they need to synthesize and apply information at a high level. Likewise, Fisher, Frey, and Lapp (2009) noticed that students became more engaged in their learning when they adopted the system during a school-wide literacy plan.

Previous studies also have found that the bimodal experience provided by text-to-speech technologies can enhance

the reading comprehension, fluency, accuracy, speed, endurance, and concentration of individuals with reading deficits (Lindstrom, 2007). Given the difficulties many students with learning disabilities face when reading—even reading their own writing—the bimodality of the synchronous juxtaposition of text and audio provided by a digital note-taking tool should induce greater learning from the students reading their own notes during review time. This enhancement to reviewing notes is critical, because researchers have found that when students review their own notes they can make connections with prior knowledge, with subsequent study material, or among parts of the lecture material. This strategic organization of lecture material can result in powerful knowledge representations that can be accessed in later problem solving (Tran & Lawson, 2001).

The use of digital pens, when paired with specific note-taking strategies, holds promise for students with learning disabilities in high school classrooms where capturing information and concepts is essential to success. The current literature base provides a foundation for examining the degree to which this promise can be realized. This pilot study was grounded in this theoretical framework and addressed the following research questions:

1. How did the use of digital pens with students who used the Cornell note-taking system improve the quality of students' notes?
2. How did the use of digital pens impact the organization, content, selectivity, and potential in the students' notes?
3. What aspects of digital pens were most useful from the students' perspective?

Method

Participants

During the 2010–11 school year, 10 high school students (four male, six female) with language-based learning disabilities, attention deficit hyperactivity disorder (ADHD), visual and spatial disorders, and other specific learning disabilities participated in the study. Their ages ranged from 14–18 years ($n = 15$) and their years of special education placement varied from 2–8 ($n = 5.7$). All students had individualized education plans (IEPs) indicating that they had processing difficulties and difficulty with reading fluency.

Based on a survey of technology use, participants reported a daily engagement with various technologies for at least three hours per day. Activities included texting/email/calling, using Internet research tools and a word processing program for school assignments, and social networking. All participants felt that technology was exciting and easy to use, and they agreed that it helped them learn. The findings from this aspect of the survey are presented in Table 1.

Setting

This project took place at a self-contained high school for students with learning disabilities in the Mid Atlantic region of the United States. All experimental sessions took place during the students' reading strategies class over a 16-week period. The teachers already made use of a number of instructional technologies throughout the process, including a large interactive white board to display material used for note taking, the use of laptops, and the use of digital books. The master teacher and the graduate research assistant who attended the intervention sessions engaged and interacted individually with each

Table 1

Technology Use by the Students

For what purpose do you use technology? (Check all that apply)	
Answer Options	**Response Percent**
Texting/calling/email	90.9%
Word processing/write papers for school	90.9%
Online research for school	100.0%
Social networking—i.e., Facebook, online chat, twitter	90.9%
Organizing my thoughts	45.5%
Art/photography/music	36.4%
Playing games	54.5%
Online shopping	18.2%
Just surfing the web	63.6%

student while he or she took notes, providing clarification or redirection when needed.

Materials and Equipment

This project made use of digital smartpen technology, specifically the Livescribe Echo ™ pen. This tool allows the user to record both audio and visual forms of information while taking notes. Specific dot-embedded paper tablets (which look like a traditional spiral or bound notebook), with controls located at the bottom of each page, serve to record auditory information while the notes are being taken. Once the record button is tapped, the pen automatically records what the student writes down as well as any and all auditory stimuli within range. The recording can be paused or stopped by using the controls located at the bottom of the page or on the pen itself. These controls, which look like a printed version of the controls on any playback device, allow the student to record, stop recording, and play back the recording from the session. Once the session has been completed, it can be played back by touching the pen to the notes or by using the headphone jack on the pen. A student does not need to review the entire audio session as a single recorded file. He or she can touch the pen to the section of interest and the recording will begin playback from that location forward. This eliminates the need to listen to an entire lecture or lesson. The volume and speed of the playback also can be controlled at the bottom of the page. Notes can be uploaded to a computer using the Livescribe desktop software or to a public website where audio and visual files can be stored and shared. These shared and stored files are known as pencasts, viewable as Quicktime ™ movies online. Students can view and listen to notes online by scrolling over the notes, or they can turn notes into a portable document format and print them. Notes can be shared with others and pencasts created by other students can be accessed through the site as well.

Data Collection

Data were collected with regard to students' levels of performance in note taking prior to the introduction of the digital pen. The research team used content analysis to evaluate samples of students' notes to determine a baseline measure of student note-taking skill. Two or three samples of notes prior to the use of the pen were collected and analyzed. Changes in the quality of students' notes after the implementation of the digital pen were examined. Again, two to three samples were collected for each student during the intervention stage. To evaluate the quality and features of students' notes both before and during the intervention, a rubric and analysis method designed by Englert et al. (2009) was adopted and used. The rubric (Figure 1) examines the organizational structure, extent of coverage, and the reduction (and selectivity) of the students' notes. Samples of students' notes were evaluated both pre- and postimplementation across four areas as presented in the rubric, including organizational structure, extent of coverage, and the reduction and selectivity of the notes. Both pre- and postimplementation data were coded separately by two individuals to ensure consistency of evaluation and to establish a level of interrater reliability. The individuals who did the coding were the high school technology teacher and a graduate student intern; both observed the implementation of the project and were knowledgeable of the students and of the school setting. Each had a Masters degree in learning disabilities education and in-depth knowledge of the technology and of the rubric that was used for the pilot study.

Table 2

Preimplementation Results

Variable	Observations	Mean	Standard Deviation
Organization	33	3.33	1.190
Content	33	3.58	1.199
Selectivity	33	3.55	1.201
Potential	33	3.39	1.297

Figure 1

Rubric with a summary of the primary traits for highlighting and note taking.

Trait	Advanced {5}	Satisfactory ({4}	Developing {3}	Partial {2}	Undeveloped {1}
Organization	• All major ideas and related details • Sophisticated • No irrelevant info • Hierarchical notes	• Organizational pattern mostly represented • Most main ideas and details included • Notes: Have labels and/or categories	• Some main ideas and details included • Some decision making • Notes: Some evidence of hierarchy (2 levels)	• Very little organization • Few main ideas, but minor details included • Notes: Bulleted list but no labels	• Everything highlighted in a passage **–OR–** • Very little highlighted in a passage • Notes: Resemble essay or report
Content **A**. Breadth: Representation of major ideas from passage **B**. Depth: Representation of supporting details for major ideas **C**. Percentage of guideline	**A**. Nearly all five major ideas (breadth) included **B**. Virtually all related details (depth) included **–OR–** **C**. 90+ percent of main ideas and details	**A**. Breadth good (e.g., at least 5 or more main ideas) **B**. Depth good but somewhat imperfect (e.g., missing a few key details) **C**. About 80% of main ideas and details included	**A**. Breadth of coverage fair, but missing several main ideas or details **B**. Some main ideas and details included **C**. 50–70% of main ideas and details included	**A**. Missing all main ideas **B**. Spotty or inconsistent coverage of details **C**. 30% of main ideas (3 main ideas) and corresponding details (~20) included	**A**. No content discrimination: Includes everything **–OR–** **B**. Ideas included with no apparent value or meaning **C**. Too few or random ideas
Reduction or Selectivity **A**. Evidence of summarization and reduction; includes key words and phrases **B**. Recorded ideas make sense	**A**. Fairly selects and paraphrases important ideas and details **B**. Artifact makes perfect sense; all information condensed and paraphrased	**A**. Highlights or records phrases but less than perfect in identification and selection of phrases and ideas **B**. Most, but not all, information condensed, paraphrased, and makes sense	**A**. Evidence of selection of ideas at word, phrase, and sentence level **B**. At times, entire sentences included, but not sole strategy **C**. Some summaries and reduction	**A**. Evidence that information is selected at sentence level **B**. Selects essential information	**A**. No evidence of purposeful selection of information **B**. Not enough reduction **C**. Too sketchy or incomplete
Potential to be a useful tool **A**. Artifact is useful in studying learning and writing **B**. Uniformly covers passage and artifact makes sense	**A**. Artifact covers key passage information, is well organized and easy to follow **B**. Artifact is useful as a study and writing tool **C**. Mature and sophisticated	**A**. Mostly, the artifact looks like a useful tool, but could be slightly improved	**A**. Artifact shows some evidence of being a useful tool but fails to sustain the effort **B**. Artifact succeeds at some levels but may contain some distracting, excessive, extraneous, or unorganized info	**A**. Artifact is generally insufficient in quantity or quality; not especially useful for studying and writing **B**. Misses too many ideas and details to help student succeed on a test or write a report	**A**. Artifact is too incomplete to be helpful **B**. Artifact copies passage information without transformation

Used with Permission. From Englert, C. S., Mariage, T. V., Okolo, C. M., Shankland, R. K., Moxley, K. D., Courtad, C. A., Jocks-Meler, B. S., et al. (2009). The learning-to-learn strategies of adolescent students with disabilities. *Assessment for Effective Intervention, 34***(3), 147-161. doi:10.1177/1534508408318804**

Thirty-three observations were collected in the preimplementation setting. The average score for organization was 3.3, for content was 3.6, for selectivity was 3.5, and for potential was 3.4. Sample means and standard deviations for these observations are presented in Table 2.

Procedures

Samples of students' notes were collected prior to the beginning of the intervention. When the intervention began in the second semester of the academic year, students were given a tutorial by their study skills teacher on how to use the Livescribe pen to record notes. During the first two weeks, students practiced note taking using the Cornell method and they learned how to play back their notes and upload them as pencasts. The teacher scaffolded the Cornell note-taking training to help students develop mastery of the method at each level. This scaffolding included providing students with very detailed notebook pages and worksheets at the beginning of the training. Fewer and fewer prompts were provided via preformatted materials until the students were given plain lined paper. All samples of students' notes were taken from notes taken during their reading strategies course, a semester long course in which students develop strategies relating to reading comprehension, concept mapping, and vocabulary development.

Students used the Livescribe microdot notebook paper as they took notes and applied the Cornell note-taking template on their own. During the two weeks of training in the use of the pen, students participated in 15–20 minute in-class practice note-taking sessions using PowerPoint™ presentations. Students uploaded and shared their notes at the end of each class. PowerPoint presentations were scaffold using color coded text to correspond with the different Cornell note-taking sections. These adaptations were slowly phased out and concluded halfway through the semester. Students were encouraged (but not required) to use the pens in all of their academic subjects, and they reported using the pens in history courses, mathematics courses, and a computer science course.

Following this testing phase, the students continued to use the Cornell note-taking strategy along with the Livescribe Echo pen to take notes during lectures. The study skills teacher made use of PowerPoint slides and highlighted the information students were instructed to record in their notebooks. Note-taking templates were recreated from student memory. Again, all samples were taken from the students' reading strategies course. Students were instructed to choose a symbol to jot down if the lecture was moving too fast and they missed important information. This symbol would let the students know they needed to revisit and review this section of their notes. Students used the playback feature in the Livescribe pen to review their notes and create summaries. Students were encouraged to condense their notes into phrases and bullet points after listening to the audio recording of their notes. Each week, students were responsible for uploading and sharing their notes from their study skills class, as well as one content class, with their teacher. Students used the audio playback to revise and refine their notes. The final set of notes uploaded by the students was used for the content analysis.

Data Analysis

The researchers used both quantitative and qualitative methods of analysis to understand the effects of digital pen use on students' note taking. Statistical analysis of pre- and postintervention analyses of the students' notes took place using Statistical Analysis Software (SAS), and a simple *t*-test observation method was used. Observers' qualitative notes from the tests were collected and those comments were analyzed via HyperResearch, a software program allowing for qualitative data analysis. Descriptive statistics from the student and parent surveys were calculated by the survey medium (surveymonkey.com).

Results

Results from the survey indicate that the participants in this study had access to and were comfortable with the use of technology; all made use of laptops and most had access to cell phones or iPods. The introduction of the pen, albeit a new tool, was in line with the students' previous experiences with technology.

Research Questions 1 and 2 asked how the combination of the Cornell note-taking system and the use of digital pens affected quality of students' notes. This study found that students' notes were improved in the intervention phase in some but not all areas. Postimplementation assessments of students using the scoring rubric (Figure 1) are presented in Table 3. Thirty-five observations of students' notes were collected in the implementation phase. The *t*-tests were

Table 3

Postimplementation Results

Variable	Observations	Mean	Standard Deviation
Organization	35	3.69	0.900
Content	35	4.14	1.141
Selectivity	35	4.20	1.079
Potential	35	3.83	0.954

performed using SAS to examine the relationship between different aspects of the quality of students' notes before and after introducing the pen. Comparison of baseline evaluation of students' note taking with notes taken with the digital pen indicated that there was a significant positive difference in some areas of note quality with the use of the pen when added to the Cornell note-taking system. Table 4 presents the findings for each of the elements on the rubric: organization, content, selectivity, and potential. Findings in each area include the following:

Organization (defined as the organizational nature of the notes including hierarchical outlines and use of emphasis through underline) was lower in the postimplementation setting, although not at a statistically significant level (t = -1.38, ρ = 0.1716.)

Content, which observes the degree to which the students' notes included both the main idea of the lecture and the appropriate degree of breadth and depth of the topic, was significantly higher in the postimplementation at the .05 confidence level (t = -2.00, ρ = .0499)

Selectivity was also significantly higher in the postimplementation setting at the .05 level (t = -2.37, ρ = 0.0209). Selectivity is a measure of the student's ability to summarize and include only important words or ideas.

Potential, which is a measure of the potential of the notes to be used as instructive given the degree of usefulness of the information included, was higher in the postimplementation setting, although not significant (t = -1.58, ρ = 0.1189).

During baseline data collection, students reported that their own handwriting was difficult to read and they were primarily focused on creating templates, transcripting, and organizing their notes. Students stated they were often unable to interpret what they had written given their lack of accuracy in handwriting skills. One student noted, "I never look at my notes from class. I know they will be a

Table 4

Student *t*-tests for Organization, Content, Selectivity, and Potential

	Intervention Phase								
	Pre			Post					
	n	***μ***	***σ***	***n***	***μ***	***σ***	**df**	***t***	***ρ***
Organization	33	3.33	1.19	35	3.68	.90	-0.35	-1.38	.1716
Content	33	3.58	1.19	35	4.14	1.14	-0.56	-2.00	.0499
Selectivity	33	3.56	1.20	35	4.20	1.07	-0.64	-2.37	.0209
Potential	33	3.39	1.30	35	3.83	.95	-0.44	-1.58	.1189

Note: ***n*** **= sample size, μ = sample mean, σ = sample standard deviation, ρ = significance (if ρ < .05 then statistically significant)**

Table 5

Participant Feedback on the Use of the Digital Note-taking Pen

Rating Options	Agree Very Much	Kind of Agree	Kind of Disagree	Disagree Very Much
The digital pen was easy to operate.	4	6	0	0
Uploading notes was easy to do.	6	1	1	2
Accessing saved files was difficult.	1	5	2	2
I like writing on the paper provided by Livescribe.	4	3	3	0
The functions (piano, translator) of the pen are fun.	5	2	1	2
Registering the pen was a difficult process.	1	2	6	1
Listening to notes was easy to do.	8	2	0	0
The volume of the playback is good.	8	2	0	0
The background noise makes it difficult to listen to notes.	1	3	5	1

big mess!" Another student used copies of another student's notes, and another didn't take any notes at all.

During the implementation phase, students reported having some difficulty learning to use the desktop application and website; these aspects of the technology were reported not to be intuitive to the users. One student reported that she enjoyed the playback feature of the pen but didn't make use of the uploaded notes from the Livescribe system. Although no data were collected outside the reading strategies class, teachers and students alike commented that note taking with the pens was most conducive to the mathematics classroom, where they could follow along with formulas or procedures written on the board and replay them to correct any misunderstandings.

Participating students (and their parents) also were asked in both pre- and postimplementation surveys and/or interviews about their general attitudes and practices related to technology and study skills. This was designed to answer Research Question 3. This survey was based on the Technology Adoption Model as presented by Davis (1989). The model examines two elements of the technology adoption process: effort, and perceived usefulness. As illustrated in Tables 5 and 6 (postimplementation survey findings), students and their parents found the pen to be easy to use, were excited to use it, and did not find the pens or process of using the pens to be frustrating.

Throughout the study, participants provided feedback on the use of the pen in their courses. One student stated, "Now I can actually listen in class!" Another student suggested that his use of the pen in math class was helpful because, "I can watch the teacher write on all the boards and not try to copy down the formula *and* her description of why the formula works." Several students and the mathematics teacher observed that use of the pen in the mathematics class was helpful, as the pen allowed the student to listen to the description of the formula or procedure while looking at the copies of the notes.

Discussion

This small pilot study found that the use of a digital note-taking pen significantly increased the quality of students' notes in the areas of content and selectivity. These findings in particular might be especially important, as students with learning disabilities may have difficulty in both content knowledge development and determining the important parts of the lecture. The observed quality of students' notes (based on the use of the rubric) did not vary significantly in terms of organization and potential, which indicates that the use of the pen did not seem to have a negative effect on these areas of note taking. Given the lack of significant difference between pre- and postimplementation outcomes, findings indicate that

Table 6

Parent/Guardian Feedback on the Use of the Digital Note-taking Pen

Rating Options	Strongly Agree	Agree	Disagree	Strongly Disagree	Rating Average
I am familiar with digital note-taking pens.	0	1	5	1	3.00
My child is excited about the digital pen.	1	4	2	0	2.14
Using a digital note-taking pen has helped improve my child's note-taking abilities.	1	4	1	1	2.29
Using the pen is confusing and cumbersome for my child.	1	1	3	2	2.86
My child looks forward to using this technology in the future.	3	2	2	0	1.86
The pen is a distraction for my child.	1	0	5	1	2.86
This technology has no effect on my child's note-taking abilities.	1	1	4	1	2.71
I see improvement in my child's work from using the pen.	1	4	1	1	2.29

the use of the digital pens was helpful for many of the students, particularly those who were able to take more concise notes or who used the playback mode to listen to a lecture and then refine their notes. This research project stressed the importance of audio playback as feature of the learning process. Similar findings can be found in research examining the effectiveness of assisted reading with the use digital texts to help students with learning disabilities become successful readers (Anderson-Inman, 2009). Carbo (2005), in a study of using audio books, found that this technology could asssist learners with reading difficulties in better understanding story plot and developing fluency.

It should be noted that this study's small sample size limits its generalizability. Also, although the students had an entire 16-week semester to learn the Cornell note-taking system, they only had two weeks to work with the Livescribe pens before implementation of the observation. Extended training with the pen might increase the observed effects of the pen on the students' note-taking ability. Additionally, notes from only one course, the reading strategies course, were used for analysis Samples from other courses would strengthen the analysis of the usefulness of this tool. Finally, direct causal relationships or comparisons between groups for our findings cannot be made, given the lack of a control group.

These findings also can be associated with current research examining the impact of reading aloud standardized testing material to students with learning disabilities (as afforded to students whose IEP warrants this accommodation). Studies suggest that audio presentation compensates for poor reading comprehension compared to students without learning disabilities (Laitusis, 2010; Straub, 2009; Wise, 2010). Having access to recorded audio presentations allows students to hear information again in the same manner in which it was presented. These studies suggest that audio playback would help the note taker with poor reading comprehension skills ascertain important information for future tests and assignments better than reading copies of notes from a classmate or an IEP-designated note taker. Given that approximately 80% of students with learning disabilities struggle with reading (Shaywitz, 2003), the importance of audio playback is represented in our findings. In combination with previous studies, this project may lay the groundwork for more enhanced research on the utility of this technology for tiered accommodations in a response to intervention model.

This study's qualitative findings also indicate that audio playback may have allowed students to compensate for difficulties in following along and attending to details, which have been found to be an advantage of using note-taking technology in other research (Konrad, Joseph, &

Eveleigh, 2009). The majority of students (90%) reported in the postimplementation survey that they agreed they were more attentive to class lectures because they were less anxious about recording all of the details presented. These findings are similar to those by Anderson-Inman (2009) in the use of digital texts—the students could explore the embedded details.

While the pen itself was exciting and widely adopted, it was clear to the investigators and teachers that a more robust intervention is needed if this type of technology is to be useful in classroom settings. For example, the reading strategies teacher in this study made extensive use of visual presentations. Throughout her lessons, she pointed out and highlighted key words and phrases. However, not all teachers give visual prompts while teaching, particularly at the postsecondary level. Kennedy, & Deshler (2010) suggest that educators need to have opportunities to experiment with these types of technologies in order to create meaningful interventions. While the digital pen was not necessarily helpful for every student, the opportunity to study what particular aspects were helpful to individual students gives teachers the ability to determine when best to make use of this tool. Further examination of the process of revision, based on students' audio recordings, may be an avenue to determine how students refine their understandings based on auditory feedback. Additional research into different intervention models, additional focus into other content areas—e.g., the effect on students' cognitive load, and/or the implications for students at different age levels (particularly in the transition to college)—are necessary to explore this potentially valuable technology in greater depth.

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