Digital Note taking: The use of electronic pens with students with specific learning disabilities

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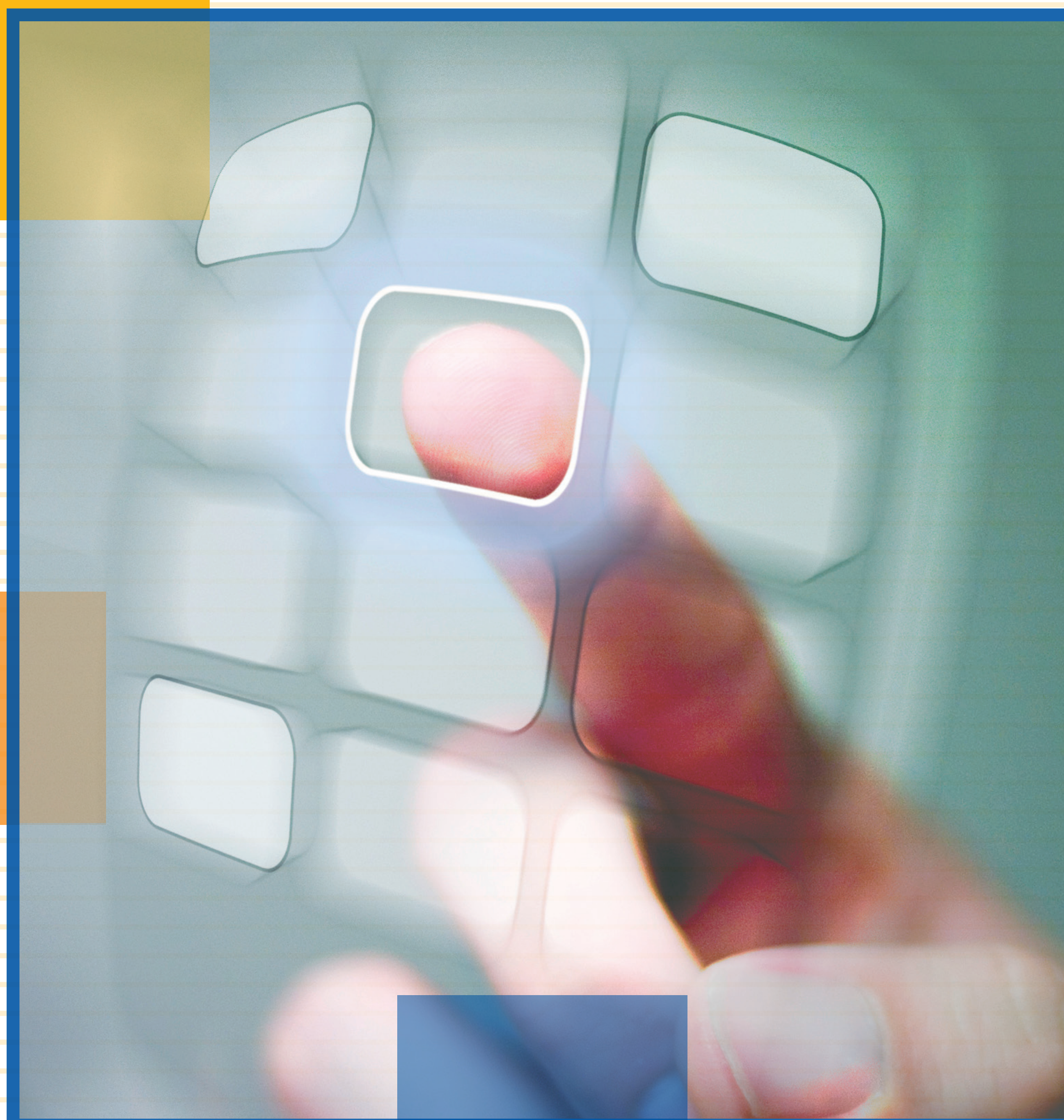

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Clicking Away: Repurposing Student Response Systems to Lessen Off-task Behavior

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Self-monitoring is a well-documented practice to assist educators with addressing students' behavioral challenges. However, little research has examined technology to support students' self-monitoring. Within this study, three elementary students were taught self-monitoring skills using student response systems to increase on-task behaviors in an inclusive setting. When prompted by the teacher, students identified as having an emotional disability or students at risk for behavioral challenges used a student response system to record if they were on or off task. A single-subject withdrawal design indicated the frequency of each student's off-task behavior decreased during use of the student response system. During the withdrawal and maintenance phases, frequency of the behavior returned to baseline levels. The technology supported improved student behavior when used, but students were unable to maintain the improved on-task behavior when they were not self-monitoring. Student and teacher perceptions of the student response system technology verified the off-task behavior data; students and teachers were positive about the use of the technology as a self-monitoring tool.

General education teachers face many challenges in their heterogeneous classrooms, from educating students with a range of academic abilities within the general education curriculum to taking responsibility for students' behavioral progress (Hawken, Vincent, & Schumann, 2008). Teachers also confront challenges regarding the implementation of practices relative to educational laws in their classrooms (i.e., No Child Left Behind, 2002 and the Individuals with Disabilities with Education Act, 2004). One important aspect of these educational policies involves the use of evidence-based practices by teachers, meaning teachers are to use practices supported by research in conjunction with professional wisdom (United States Department of Education, 2002). Included in the call to implement evidence-based practices is a focus on all areas of education. Implementation of evidence-based practices is not only limited to academics; it also extends to behavior (Cheney, Flower & Templeton, 2008).

One behavior-focused intervention considered to present a strong evidence base is self-monitoring (Fitzpatrick & Knowlton, 2009; Lee, Palmer, & Wehmeyer, 2009; Reid, Trout, & Schartz, 2005). Self-monitoring—defined as identifying and regulating one's own behavior—is a common strategy for changing behavior by teaching students skills to recognize a specific undesirable behavior and adjusting it through self-identification and recording (Ackerman & Sharipo, 1984; Agran, 1997; Rafferty & Raimondi, 2009). Self-monitoring is frequently discussed as two approaches: self-monitoring of attention, and self-monitoring of performance (Reid et al., 2005). Self-monitoring of attention addresses attention-based behavior (e.g., on or off task), and self-monitoring of performance focuses on academic performance (e.g., accuracy or productivity; Reid, 1996). Frequently seen in many disciplines, this strategy has been employed to teach students with a range of disabilities—including students with emotional/behavior disorders or students who experience challenging behavior—how to monitor their own behaviors (Agran, Sinclair, Alper, Cavin, Wehmeyer, & Hughes, 2005; Levendoski & Cartledge, 2000; Maag, Reid, & DiGangi, 1993; Wehmeyer, Yeager, Bolding, Argan, & Hughes, 2003).

Research on self-monitoring for behavior (i.e., attention) and students with disabilities is primarily limited to paper-and-pencil techniques (Blood, Johnson, Ridenour, Simmons, & Crouch, 2011; Gulchak, 2008). For example, Mathes and Bender (1997) found the on-task behavior (i.e., looking at appropriate things such as lesson materials, the teacher, or the blackboard and making eye contact) improved for students with attention deficit hyperactivity disorder (ADHD) and emotional/behavior disorders following implementation of paper-and-pencil self-monitoring within the special education classroom. In a more recent study, Harris, Friedlander, Saddler, Frizzelle, and Graham (2005 found students with ADHD improved in on-task behavior—operationally defined as looking at appropriate materials (e.g., spelling list, self-monitoring sheet), completing study activities, or asking for help—following paper-and-pencil self-monitoring for attention. This study compared the effects of self-monitoring for attention (i.e., on-task behavior) and self-monitoring for performance for this population of students and both increased on-task behavior. In a related study, Rafferty and Raimondi (2009) compared paper-and-pencil self-monitoring for attention and self-monitoring for performance with three elementary students with emotional/behavior disabilities in a mathematics classroom. While both aspects of self-monitoring improved students' on-task behavior (i.e., defined as looking at appropriate materials, using appropriate materials, or asking for assistance), in contrast with Harris et al. (2005), self-monitoring for performance resulted in greater increases in on-task behavior.

Although paper-pencil self-monitoring techniques continue to be the primary tool for self-monitoring behavior in the classroom, researchers have examined technology to support self-monitoring (Amato-Zech, Hoff, & Doepke, 2006; Blood et al., 2011; Epstein, Willis, Conners, & Johnson, 2001; Gulchak, 2008; Stahmer & Schreibman, 1992). For example, Amato-Zech and colleagues evaluated a handheld device (the MotivAider), which vibrated every five minutes to remind elementary students who displayed off-task behavior to stay on task during reading and writing instruction (i.e., pay attention to instruction or work). Using self-monitoring to document whether they were on task, students successfully increased their on-task behaviors. Similarly, Epstein et al. investigated a middle school student using a pager to cue behavior self-monitoring. The student was able to program the pager to remind himself to remain on task during instruction. An increased initiation of on-task behaviors and completion of tasks (e.g., turn in homework, take medication) was reported. More recently—and with more common technology, Gulchak found that an elementary-aged student who displayed clinically significant challenging behavior used an MP3 player to successfully self-monitor within the general education classroom with positive results (i.e., increased on-task behavior, defined as not picking one's nose, doing one's work, and asking questions by raising one's hand). And, Blood et al. used an iPod Touch in combination with a self-recorded checklist or behavior self-monitoring with an elementary-aged student with an emotional/behavior disability who displayed disruptive, off-task behaviors.

Despite the aforementioned studies, Xu, Reid & Steckelberg (2002) discussed the need for further research on using assistive technology effectively with students who struggle with on-task behavior. The need to explore technology to support self-monitoring in students who struggle with behavior extends to common, easily accessible technology in schools (Gulchak, 2008). Schools might currently have the technology, but are not using it for behavior purposes—in other words, a technology repurposed to support self-monitoring (Mishra & Koehler, 2009). One such technology to consider is student response systems (i.e., clickers; Blood, 2010). Although research on student response systems is largely restricted to postsecondary educational settings, as university professors adapt this tool to document student performance (i.e., self-monitoring and engagement) and attendance (Bunce, Flens & Neiles, 2010; Kay & LeSage, 2009; Kay, LeSage & Knaack, 2010; Trees & Jackson, 2007), emerging research suggests that it can be repurposed to support behavior self-monitoring in younger students (Blood, 2010; Penuel, Boscardin, Masyn & Crawford, 2007).

The current study focused on using a student response system as a self-monitoring tool for students with behavioral challenges in an elementary school general education setting. Specifically, students used the student response system to self-monitor their on-task behavior. A lack of research exists regarding use of technology for self-monitoring (Gulchak, 2008), despite the positive outcomes for paper-and-pencil self-monitoring (Fitzpatrick & Knowlton, 2009; Harris et al., 2005; Lee et al., 2009; Reid et al., 2005). The substitution of technology for tasks successful with paper-and-pencil self-monitoring should be studied, given the increased use of technology for students outside and, increasingly, inside of school (Jayson, 2010; Prensky, 2001; Rideout, Foehr, & Roberts, 2010; Rosen, 2011). The research study sought to answer the following questions: can student response systems assist students with behavioral challenges to self-monitor and regulate behavior in a general education classroom, and what are students and teachers' perceptions of the student response system technology?

Method

Setting

The study occurred in an urban midwestern elementary school. The K–5 school had a total enrollment of 538 students and employed 30 teachers. The school was diverse, with a 45% free and reduced lunch rate; 46% of the students were African-American, 27% were Caucasian, 11% were Hispanic, 4% were Asian, and 12% were multiracial. In addition to serving students in the neighboring area, the school also housed the high-ability program for the southern portion of the school district. Students who qualified for the gifted and talented program were sent to the school to receive services. The school system clustered students in classes by ability level as determined by Northwest Educational Testing, guided reading levels, and classroom performance. Grades 1–5 had four classes per grade, including one gifted and talented class. The school followed a continuous calendar, meaning its school year was divided into trimesters. The students received a two-week winter break, a four-week summer break, and two additional three-week breaks.

The school employed Response to Intervention (RTI) to simultaneously support students who struggled academically or behaviorally and to identify students for special education services. RTI was the school's response to the overidentification of students receiving special education services. Following the RTI model, a three-tiered program was used throughout the school system for both academics and behavior. Tier 1 involved instruction using the general education curriculum and behavior expectations for all students in the general education classroom; Tier 2 interventions included general education curriculum and behavior expectations with accommodations to assist students succeed in the general education classroom; and Tier 3 included any services or accommodations outside of the general education curriculum or behavior expectations. For example, students received Tier 3 RTI services for behavior by failing to show success with the classroom behavior plan (i.e., typical classroom expectations by all students in the grade level). Office referrals, in-school suspensions, and out-of-school suspensions determined failure. Teachers and school administrators created plans outside of general education behavior expectations for students experiencing Tier 2 or Tier 3 services. Strategies implemented through behavior plans focused on teaching students positive social behavior.

The study occurred in an inclusive second grade general education classroom during mathematics instruction. The teacher held a teaching license in elementary education and had seven years of teaching experience. There were 24 students in the class, five of whom were students identified as receiving special education services. Four out of the five students qualified as students with specific learning disabilities and one student qualified as a student with an emotional disability. Two additional general education students received RTI services for behavioral support. Students sat at six round tables, with four students per table. Each student had a book sack attached to the back of his or her chair, and all needed supplies were placed within these sacks. The students shared pencils, erasers, and crayons, which were located in a tote on the top each table.

Mathematics class was chosen because two out of three participants excelled in this area, and hence their off-task behavior was less likely to arise from a failure to understand the content presented. In addition, language arts instruction consisted of more small-group instruction, while mathematics instruction was more whole-group, direct instruction. During the project, the general education teacher was located in the front of the classroom. The three participants were located in the back of the room, each seated at a separate table with the student response system remote on the desk. Mathematics textbooks and materials were placed in the center of the desk, the typical placement for all subject instruction. The participants were given very specific procedures during the project in regard to the remote used for the response system. Procedures were used to eliminate any false off-task behavior responses. When prompted, student would use the response system and then place it back on the top of the desk. Data collection occurred in the back of the classroom by the first author.

Participants

Purposive sampling was used to identify the study participants. Criteria included students enrolled in second grade, receiving either special education or RTI services, and failing to demonstrate expected classroom behavior. All participants received either Tier 2 or Tier 3 services, meaning each student had a specific behavior plan. Average to above-average mathematics scores were considered, but were not mandatory for a student to be included in the study. Parents of the students who met the criteria received a letter explaining the project and a consent form for student participation. The children of the first three parents who responded were selected for participation. Participating students also signed a consent form after having the study explained to them.

Brian. Brian, an eight-year-old second grade student, was identified by his pediatrician as having ADHD; he took daily medication for the condition. After receiving an average of three office referrals weekly over a two-month period and failure to follow the universal classroom behavior plan, educators determined that Brian required a more individualized behavior plan. He often exhibited noncompliant, aggressive behavior toward staff and peers. At the time of the study he was not receiving any special education services; however, he received RTI Tier 2 services for behavior support. Although Brian was involved in the RTI program at school, his parents refused to allow any type of evaluation that would result in his receipt of special education services. Academically, Brian was on grade level in mathematics and reading. At the end of the first trimester his mathematics score was 85% of second grade state standards mastered in mathematics. In reading, his teacher assessed Brian at 87% of second grade state standards mastered in reading.

During the academic year of the study, Brian was repeating second grade; he was retained because of his inability to complete assignments and his low test scores as well as the lack of academic growth on classroom work and the assessment device utilized by the school district. His behavior also was a concern, as it affected his school performance. The previous year's staff observations and suspension reports indicated that Brian consistently displayed disruptive behavior (i.e., yelling out answers, slamming school materials, making noise during class) and bullying. He was unable to successfully meet the expectations required of all second grade students. A daily chart (recording behavior every 45 minutes) was implemented in his classroom to document his behavior, and he received positive reinforcement for appropriate behavior (i.e., extra computer time, lunch with the teacher).

Chris. Chris, age seven, also was in second grade and identified as having ADHD. Although a licensed pediatrician prescribed medication, Chris's parents chose to use nonmedical methods of treatment. They incorporated a dietary regime and a structured environment to help modify his behavior. Community social services staff worked with Chris and his family in the home setting. At the time of the study, Chris had just moved into the district, and the school team determined that he required more time with his individual behavior plan (i.e., Tier 2 services) before making a recommendation for evaluation for special education services. Academically, Chris was above grade level in reading and his teachers assessed him as mastering 93% of second grade state standards in reading. Reading was a preferred activity of his during class instruction and choice time. In mathematics, Chris was assessed as mastering 75% of the second grade state standards in mathematics because of his difficulty with math computation. Throughout the class day, Chris also chose to work independently rather than working with peers. He struggled to work with classmates, often telling his general education teacher, "This just isn't going to work," when asked to do partner or group work.

Like Brian, Chris was not receiving special education services, but received RTI Tier 2 support for behavioral and mathematics computation challenges. He displayed aggressive behavior (i.e., punching and kicking) and became verbally aggressive with other students (i.e., threatening and using profanity). During the year of the study, Chris was suspended for physically assaulting both students and staff. Because he was unable to meet the expectations required of all second grade students, he required a more specific plan (daily behavior plan) for his behavior. The behavior plan was divided into 45-minute sections.

John. Also in the second grade and seven years old, John received special education services through the identification of an emotional disability; he had been receiving these services for one year. John enrolled in the school district with an active IEP from his previous school, which identified him as having an emotional disability. However, the previous school had yet to share his multidisciplinary report, which contained the actual assessment information. John's parents opted to contact an outside agency for behavior support, and community counseling was implemented. With parental permission, school-to-counseling communication occurred. The counselor and the special education teacher discussed John's school behavior on a weekly basis. A community counselor monitored John's progress through school visits and weekly phone calls, and John met with the counselor outside of school time. Academically, he was above grade level norms in all areas. John's teacher assessed him as having mastered 90% of second grade state standards in mathematics. In reading, he was at 97% of second grade state standards. Observed behavior at home and school included lack of motivation (i.e., refusing to complete work), stealing (i.e., food, classroom supplies/toys), physical aggression (i.e., punching, kicking, throwing school materials), inappropriate language, and self-injurious behavior (i.e., hair pulling/punching self).

Materials

Student response system. The student response system is a tool used to document prompted responses given by the individual user (Kay & Knaack, 2009; see Figure 1). The system consists of a handheld control system and a computerized system to collect data. In general, a participant is asked a question and prompted to respond using the handheld device. The device has either numbers or letters for the respondent to push when answering a question; in this study the handheld control system had numbers. The response choices and questions are typically placed on an overhead screen (Martyn, 2007). For the purposes of this study, the screen was not used because of concern the other students in the classroom would find the screen distracting. Rather, the teacher used a signal to prompt the students. The specific model used for this study was the CPSTM Student Response System.

Signal. To lessen the disruptive nature of the intervention in the general education classroom, the general education teacher used a hand signal to prompt the three students to respond to the student response system to answer the one predesignated question, Am I listening to my teacher and following class expectations? The question was chosen because it was addressed in each student's behavior plan and typically was reviewed throughout the day by the school staff prior to and throughout the study. The students were taught to associate the hand signal with the question and, because of the frequency of use and the familiarity with the question in their typical classroom routines, no additional prompting was needed. Nonparticipants were instructed to ignore the hand signal.

Figure 1

eInstruction device.

Note: Image provided by and used with permission from Einstruction, **http://www.einstruction.com**

Independent and Dependent Variables

The independent variable in this study was student self-monitoring of behavior through the student response system. The dependent variables were the number of occurrence intervals and the percentage of occurrence intervals. The dependent variables were measured by partial interval recording (Kennedy, 2005). Specifically, the number of occurrence intervals and percentage of occurrence intervals identified students being off task any time within a five-minute interval. For all three participants, the operational definition of off-task behavior included getting out of their seat (although movement in seat was allowed); fidgeting with pencils, paper, books, or any other instructional materials (other than student response system) when not instructed to be using them;

and disruptive talking, including shouting out responses, talking to classmates, and talking to self. The classroom teacher and researcher established these criteria prior to the start of the study.

Experimental Design

A withdrawal design was implemented (i.e., ABAB). This design required a functional relationship to be established, replication of the intervention (treatment), and the ability to identify individual participant behavior (Kennedy, 2005). Hence, the study started with no intervention (i.e., A). The treatment (i.e., the student response system for behavioral self-monitoring) was introduced during the intervention phase (i.e., B), withdrawn (A'), and then reintroduced (B'). Replication of the phases allowed the experimental control of the intervention while studying the behavior of an individual participant (Kennedy).

Data Collection

Data collection involved partial interval recording (Kennedy, 2005). Partial interval recording was used to determine the number of occurrence intervals, and subsequently the percentage of occurrence interviews (i.e., number within the 50-minute time span or 10 intervals each session). If the student displayed off-task behavior at any time during the five-minute interval period, the student was considered off task. The first author recorded the behavior with paper and pencil during all phases of the study following the same criteria for off-task behavior.

Procedures

The study was divided into four phases, alternating between no intervention (A phases) and intervention (B phases). During all phases, the researcher recorded whether or not the students were off task at any time within the five-minute intervals. The first and third phases were without the student response system (i.e., no intervention), and hence students did not record if they were off task. The second and fourth phases (i.e., intervention) included students recording their behavior with the student response system. The intervention and withdrawal phases all lasted five days. A five-day system per phase was chosen because of the natural weekend breaks that occur. The maintenance phase occurred three weeks after the completion of the last intervention phase and lasted three days.

Pretraining. After parents and students provided consent, and prior to the start of the study, the students and teachers completed training activities on the student response system with the researcher. The students completed three training sessions on how to use the student response system with the first author until mastery was achieved. Mastery was defined as students being able to receive the signal and respond with 100% accuracy. The students also were introduced to the criteria for off-task behavior: talking out, fidgeting, or being out of their seat. The students practiced identifying these behaviors during the training sessions. The teacher received one 10-minute training session in which the system and the definition of off-task behavior were reviewed.

Baseline (A). During each 50-minute mathematics session, the occurrence of off-task behavior was recorded every five minutes by the researcher. The baseline period was completed during a five-day period, a consistent time frame per research phase.

Intervention (B). Similar to baseline, the occurrence of student's off-task behavior was recorded every five minutes over a 50-minute instructional period. Students also recorded whether they were off task using the student response system every five minutes. Again, to lessen the possible distraction to other students, the general education teacher gave the students a signal to answer the question, Am I listening to my teacher and following class expectations? "Listening to my teacher and following classroom expectations" was operationally defined as a student sitting with his hands on the desk, his bottom in his seat, his feet on the floor under the desk, materials placed in the center of the desk, and eyes on the teacher. These expectations were included in each participant's behavior plan.

Withdrawal (A'). During the withdrawal phase, the researcher withdrew the intervention and students were asked to follow the same behavior directions as during baseline and intervention. During the withdrawal phase, the researcher continued to record the behavior, although students did not record whether they were off task.

Intervention (B'). During the second intervention phase, the student response systems were reintroduced. The participants were again given the student response system to record their on-task behavior every five minutes during their 50-minute mathematics instruction period. The second intervention phase followed the same procedures as the first intervention phase.

Maintenance. Three weeks after the conclusion of the second intervention phase, a maintenance phase was completed to determine whether or not the intervention changed students' off-task behavior, particularly following two instances of receiving the intervention. Students did not use the student response system to self-monitor their behavior during the maintenance section. It was completed over a three-day period with one session per day, during the same instructional time as the previous conditions of the study.

Data Analysis

Data were analyzed through visual analysis (Kennedy, 2005). While reviewing visual analysis, overlapping of data points between the baseline/withdrawal and intervention conditions were inspected to determine if a functional relationship existed between the dependent and independent variables. The percent of nonoverlapping data was also determined (Kennedy; Scruggs, Mastropieri, & Casto, 1987). The number of intervals of off-task behaviors and the percentage of occurrence intervals per session were calculated for each student to report in the results. The percentage was calculated by taking the number of occurrence intervals and dividing it by the total number possible within the 50-minute session, 10.

Social Validity

The participants and the general education teacher were interviewed prior to the pretraining sessions as well as at the conclusion of the study. All participants—students and teacher—were interviewed individually (see Table 1 for a list of interview questions).

Interobserver Reliability and Treatment Integrity

A second observer was present in the classroom during the mathematics instruction for 30.4% of the sessions. The second observer independently recorded and documented the number of off-task behaviors identified. The number of agreements by the second observer was determined by dividing the intervals of agreement by the intervals of agreement plus the intervals of disagreement. The interobserver agreement was 100%.

Treatment integrity was completed during 30% of the intervention sessions. Steps completed by students and the teacher were reviewed. The first author checked the procedures followed by each student and the teacher. During these observations, the first author recorded 95% accuracy with procedural reliability.

Results

Brian. During the baseline phase, Brian was off task 49 of the 50 intervals (98%) observed; in other words, Brian was off task an average of 9.8 intervals per session. When

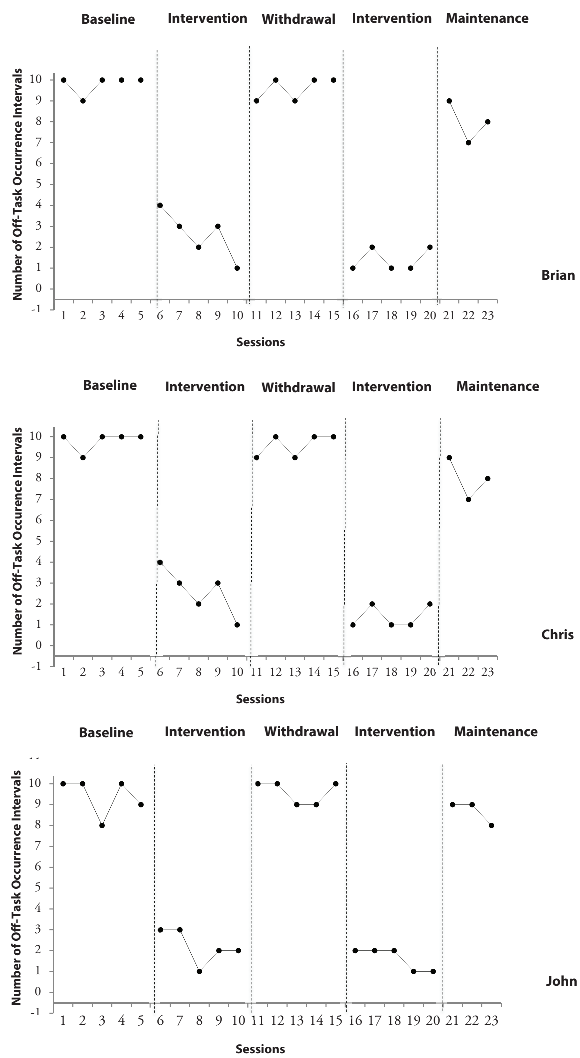
Table 1

Social Validity Questions

Question Phase	Students	Teacher
Preintervention Questions	1. Do you enjoy playing video games? 2. Do you pay attention at school? 3. Do you know when you are off task?	1. Do you think that the students can identify and monitor off-task behavior? 2. Do you think that using the student response system will disrupt class instruction?
Postintervention Questions	1. Do you enjoy using the clicker? 2. Do you pay attention at school? 3. Do you know when you are off task?	1. Do you think that the students can identify and monitor off-task behavior? 2. Do you think that using the student response system will disrupt class instruction?

Figure 2

Comparison of off-task behaviors.



introducing the first intervention phase, Brian's intervals of off-task behavior fell to 13 (26%) across the five sessions; he averaged 2.6 off-task intervals per session. During the withdrawal phase Brian's off-task behavior returned to near baseline levels (i.e., 48 out of the 50 observed intervals [96%], or an average of 9.6 intervals per session). When the intervention was reintroduced, Brian's off-task behavior decreased again to 7 of 50 (14%) intervals (an average of 1.4 intervals per session). During the maintenance phase, Brian's off-task behavior was observed during 24 out of 30 (80%) intervals, representing an average of eight intervals per session. Visual analysis indicated no overlapping data points for Brian between either of the no intervention phases and the intervention phases (see Figure 2); Percent of Non-Overlapping Data (PND) was calculated at 100%.

Chris. Chris was off task 49 of the 50 intervals (98%) observed during baseline. Stated differently, during baseline, Chris was off task an average of 9.8 intervals per session. With the first intervention phase, Chris' off-task behavior intervals fell to 14 (28%) intervals across the five sessions, with an average of 2.8 off-task intervals per session. During the withdrawal phase, Chris' off-task behavior returned to near baseline levels (i.e., 47 of the 50 observed intervals [94%], for an average of 9.4 intervals per session). With the second intervention phase, Chris' off-task behavior was below even that of the first intervention phase, with seven intervals out of 50 (14%), an average of 1.4 intervals per session. During the maintenance phase, Chris had 26 out of the possible 30 intervals observed (86.7%), resulting in an average of 8.7 intervals per session. Visual analysis of Chris' data also indicated no overlapping data points between baseline and intervention and withdrawal and intervention; PND was calculated at 100% (see Figure 2).

John. During the baseline phase, John was off task for 47 of the 50 (94%) intervals observed, resulting in an average of 9.4 intervals per session. During the first intervention phase, John was off task during 11 of the 50 (22%) intervals observed, for an average of 2.2 occurrence intervals per session. His off-task behavior levels returned to baseline levels (48 of 50, or 96%, for an average of 9.6 occurrence intervals per session) during the withdrawal phase and then returned to below first intervention phase levels during the second intervention phase (8 out of 50, or 16%, for an average of 1.6 occurrence intervals per session). During the maintenance phase, John was off task at some point during 26 of 30 (86.7%, for an an average of 8.7 intervals per session) intervals. Visual analysis indicated no overlapping data points between the baseline and withdrawal phases and the two intervention phases; PND was calculated at 100% (see Figure 2).

Social Validity

When interviewing the students prior to the start of the study, participants admitted to not paying attention during instruction. Brian indicated he was bored during instruction, and John discussed the anger he felt during school. All said they were excited to use the student response system and referred to the student response system as a video game. During the social validity interviews prior to the start of the intervention, while the general education teacher said she thought that the student response system would have no impact on the students' behavior in the classroom, she also felt the technology would not hinder the instruction in the class. The teacher also questioned whether or not the students would be able to identify either off- or on-task behaviors in the classroom.

When interviewing the students at the conclusion of the study, all stated they enjoyed using the student response system. In addition to enjoying the system, students noted some social benefits to using it in class. For example, John said, "I really liked using the clickers in class. During lunch, my friends asked me about using the clicker. They asked me if they could use the clicker. I really felt like I was the clicker expert in the class." The participants reported they were able to control their behavior and enjoyed being considered "role models" when other students asked them about the student response system and what it was like to use it. Participants reported that mathematics class became fun to them. Chris commented that he felt like the math expert because he got to use the student response system. At the conclusion of the study, the teacher indicated that students were able to monitor their behavior and decrease the fidgeting that typically occurred during instruction. She stated, "I couldn't believe the how the off-task behavior lessened. The students not only used the devices to monitor their behavior, but used the devices as a fidget tool."

Discussion

This study sought to expand the literature on using technology to assist students in self-monitoring their behavior. Specifically, three elementary students who received special education services for behavior or who were at risk to do so used a student response system to self-monitor their off-task behavior in an inclusive mathematics class. Using an ABAB design, two main results were found: (a) students experienced decreased off-task behaviors during the intervention phases of the research as compared to baseline, meaning students decreased their off-task behavior when they self-monitored their behavior with the student response system; and (b) according to the social validity responses, students not only came to be viewed in a more positive manner by classmates when using the student response systems to self-monitor their behavior, but they also learned how to change undesired actions to more appropriate behavior.

A visual analysis indicated that all three students decreased the intervals in which off-task behaviors occurred when using the student response system to self-monitor (see Figure 2). However, during the withdrawal phase intervals of off-task behavior returned to baseline levels (i.e., Brian, 96%; Chris, 94%; and John, 96%). Similarly, during the maintenance phase following the second intervention intervals of off-task behavior also returned to near baseline levels (i.e., Brian, 80%; Chris, 86.7%; and John, 86.7%). The lack of overlapping data between the baseline/withdrawal phases and intervention phases suggests effective use of the student response system to assist students in self-monitoring and regulating their behavior, resulting in fewer intervals in which off-task behavior occurred. Yet, students were unable to maintain these lower levels of off-task behavior when they were not self-monitoring with the student response system.

Beyond the lower off-task behavior for all three students when they used the student response system— similar to previous research on the use of paper-and-pencil to self-monitor off-task behavior (Harris et al., 2005; Hughes, Copeland, Wehmeyer, Agran, & Rodi, 2002; Maag et al., 1993; Wehmeyer et al., 2003)— students implied there was something inherent about the technology that needs to be given greater consideration. Social validity interviews and classroom observations noted the positive peer reaction that participating students experienced as a result of using the student response system. The students reported other classmates referred to them as "math role models," and that other students perceived them as technology experts. Further, at recess and lunch other students inquired about the system, expressed an interest in the student response system, and indicated that they wanted to be included in the study. The general education teacher commented that, for some of the three students, this was the first time all year they had experienced positive interactions with their peers in the social arena. Given the students' histories of behavioral struggles in the classroom, including interacting positively with peers, the student response system served as a socially acceptable way to address behavior while providing a positive sense of self-worth to the students. Furthermore, the students' perception of mathematics turned from dread to excitement. The teacher also noted a decrease in office referrals during mathematics lessons during the study.

The results of this study extend the literature on using technology to self-monitor behavior. Recent studies looking at using technology to self-monitor capitalized on common everyday (i.e., outside of school) technology (e.g., Blood et al., 2011). This study examined a common in-school technology used for academic purposes, student response systems. The results of this study, in conjunction with the previous although limited research on technology for self-monitoring (Amato-Zech et al., 2006; Blood, 2010; Blood et al.; Epstein et al., 2001; Gulchak, 2008; Stahmer & Schreibman, 1992) showed that students can effectively use technology to self-monitor their behavior, particularly with regard to on-task behavior. However, research is needed to actively compare the effectiveness of self-monitoring with technology to traditional paper-and-pencil techniques as well as to determine how technology might support the continued decrease of off-task behavior or the increase of on-task behavior following removal of the self-monitoring technology.

Implications

The results of this study support the strong research base that indicates teaching students to self-monitor their behavior results in decreased off-task behavior (Fitzpatrick & Knowlton, 2009; Lee et al., 2009). Yet—and similar to other research without technology (Edwards, Salant, Howard, Brougher, & McLaughlin, 1995; Freeman & Dexter, 2004; McDougall & Brady, 1998; Rock & Thead, 2007)—when the intervention was removed the decrease in off-task behavior did not last. On the positive, uses of this particular technology were successful in assisting students to self-monitor and decrease off-task behavior, and students expressed enjoyment in using it and receiving positive peer feedback. The study demonstrated that a common technology could be repurposed as a tool to assist students to self-monitor and decrease off-task behavior (Bouck et al., 2012; Mishra & Koehler, 2009). Instead of relying on specific assistive technology devices to teach self-regulation, the student response system has duel functions as both an academic and behavioral tool. Hence, teachers could use it for multiple purposes. They could use it for academic engagement, as perhaps originally intended, and also repurpose it for student self-monitoring (Mishra & Koehler). The repurposing of the tool for self-monitoring can result not only in a decrease in the occurrence of off-task behavior, as demonstrated in this study, but also increase positive interactions between students and their peers over a common interest—technology.

Limitations and Future Directions

By definition, a single-subject design involves a smaller number of students. In this study, the sample size was limited to three, which may affect the overall results in terms of generalizability. Limitations also exist with the length of the study. The study occurred over a four-week period during mathematics instruction. If the study had been conducted for a longer period of time the effectiveness of student self-monitoring may have produced stronger results, such as maintaining the decreased off-task behavior when intervention was withdrawn. In addition, future research should involve an extended maintenance section in which the implementation of the intervention is continued but data are collected after a significant period of time to determine if the effectiveness of using the technology to self-monitor can be maintained. Future research also should involve a generalization phase. For example, can students generalize the use of the technology to self-monitor in other subject areas? A more difficult subject should be considered in reviewing student response to self-regulation and academic challenges in future research; students may have exhibited more off-task behaviors even with the self-monitoring technology if they were in a content area that posed more frustrations. Future research should continue to explore technology as a means of student self-monitoring, particularly multipurpose technology such as student response systems. However, research also should be undertaken to directly compare paper-and-pencil means of self-monitoring to self-monitoring with technology.

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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

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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 ($t = -1.38$, $\rho = 0.1716$.)

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 ($t = -2.00$, $\rho = .0499$)

Selectivity was also significantly higher in the postimplementation setting at the .05 level ($t = -2.37$, $\rho = 0.0209$). 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 ($t = -1.58$, $\rho = 0.1189$).

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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Multimodal Composing in Special Education: A Review of the Literature

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Focus on multimodal learning, especially composition, is increasing in K–12 classrooms, particularly among those whose populations are struggling academically. This shift toward multimodal learning also is evident in special education classrooms. This review explored multimodality and its impact on the composition practices of students with disabilities. Eleven empirical studies discussing research designs, research questions, and various sample characteristics were included. Themes from the findings and implications included the role of technology in instruction, its use in providing scaffolds, and its impact on student success. Additionally, several nonempirical articles advocating the use of multimodal composition were addressed. This review concludes with implications for teachers and researchers, focusing on the benefits of multimodal composition, particularly the underexplored area of digital video (DV) composition, for students with disabilities.

Even in supportive academic environments, the literacy demands of K–12 curricula often present a challenge to students with disabilities. However, with the rapid emergence of various technologies, the ways in which students access and produce information in classroom settings are changing (Coiro & Dobler, 2007). Educators are being forced to broaden and shift their concept of literacy instruction to one that is more multimodal, interactive, and learner controlled (Jewitt, Kress, & Mavers, 2009). This change represents an opportunity to create learning experiences that are more engaging and responsive to the needs of students with disabilities while increasing their access to the general curriculum.

This multimodal shift—or what Mills (2010a) has termed “the digital turn” (p. 246)—is happening across education. Professional literacy organizations, such as the National Council of Teachers of English (NCTE, 2003), the International Reading Association (IRA, 2001), and the Literacy Research Association (Alvermann, 2001; IRA; NCTE) as well as the National Commission on Writing (2006, p. 15) all have embraced the move toward recognizing the importance of composing with multiple forms of texts. The Common Core State Standards (2010), which have been adopted by 45 states, advocate that students need “to analyze and create a high volume and extensive range of print and nonprint texts in media forms old and new” (p. 4).

While scholars such as Kress (2003, 2010) argue that even print is multimodal (considering issues such as font size, shape, page layout, color, etc.), the term *multimodality* tends to be associated with multiple forms of representations. This is evident in Miller and McVee's (2012, p. 1) definition of multimodality: "reading and writing multiple forms of nonprint 'texts' such as images, web pages, and movies," texts comprised of image, sound, and other modes in addition to print. In essence, multimodality relates to conveying meaning through a combination of various modalities with each resource or mode carrying a unique set of abilities and constraints related to transmitting knowledge (Jewitt, 2008).

Multimodality tends to be used synonymously with multiliteracies and new literacies, and it is inherently linked to technology. These multiple terms tend to confuse the issue of students with disabilities and technology, specifically assistive technology (AT). This is especially the case as a wide range of remedial and compensatory technology tools is available to students with disabilities (Edyburn, 2008a). In the context of special education, AT tools can help students overcome the barriers presented by their disabilities. The Assistive Technology Act of 2004 defines assistive technology as "any item, piece of equipment, or product system, whether acquired commercially or off the shelf, modified, or customized, that is used to increase, maintain or improve the functional capabilities of a child with a disability" (U.S. Government, 2004, p. 118). Abundant research exists on AT that aims to reduce these barriers and increase access for students with disabilities (Edyburn, 2007; Hasselbring & Bausch, 2006). The precise manner in which these tools are being harnessed to assist students in the writing process varies considerably, but researchers are exploring the effects of combining visual, audio, video, textual, gestural, and spatial modalities (Coiro, Knobel, Lankshear, & Leu, 2008). For the purposes of this review, we were interested in exploring the empirical evidence for how multimodal technology might improve the composition skills of students with disabilities through an increased opportunity to engage in alternative forms of expression.

While many of the multimodal tools/instructional supports could qualify as AT devices if an individual student demonstrated a specific need to produce written composition, we focused on the use of such technologies in the context of providing students with additional means by which to compose their ideas, consistent with the principles of Universal Design for Learning (UDL). UDL is defined as a "research-based set of principles that forms a practical framework for using technology to maximize learning opportunities for every student" (Rose & Meyer, 2002). AT and UDL aim to support the learning process, but they approach this goal from opposite ends of the continuum; thus, at times it can be difficult to distinguish between the two (Rose, Hasselbring, Stahl, & Zabala, 2005). AT operates at the person level, and is uniquely adapted to meet the needs of individual learners, while UDL aims to level the playing field by providing adaptable and inclusive learning environments (Rose et al., 2005). We situate this review within the framework of UDL, while paying special attention to how multimodal tools are utilized to provide students with multiple means of representation and expression of knowledge.

While many scholars have examined the potential for multimodality to increase reading achievement (e.g., Alvermann & Wilson, 2011; Lange, McPhillips, Mulhern, & Wylie, 2006), access to the curriculum (e.g., Elder-Hinshaw, Manset-Williamson, Nelson, & Dunn, 2006; Marino, 2009; Meyer & Rose, 2005) and engagement (e.g., Mills, 2010b; Vasudevan, 2006) for students with disabilities, we sought to examine how multimodality might enhance their composing. To the extent that multimodality can be leveraged to impact students with disabilities' composition skills positively, the interfacing of special education and multimodal technologies represents a critical avenue toward which future research should be directed. Consequently, in order to determine what path this research could take, a review of the literature regarding the impact of multimodality on the composition skills of students with disabilities is warranted. In the following sections, after detailing the methods, the results of our review of the literature are presented.

Methods

To explore how multimodality impacts the composition skills of students with disabilities, we searched the following databases: Academic Research Complete, ERIC, Education Teacher Research, Education Research Complete, and Professional Development Collection. We conducted ancestral searches of articles cited in this review. The following journals were included: *Learning Disabilities Research and Practice, Journal of Special Education Technology, Learning Disability Quarterly*, *Journal of Research in Childhood Education,* and *Education Communication and Information*. The search terms included, but were not limited to: *digital video, special education, multimodal, writing, composing,* *literacy,* and *media*. Eleven studies fulfilled the selected criteria: (a) published in a peer reviewed journal in the last 15 years, due to the changing nature of technology; (b) focused on special education; and (c) focused on multimodal composing (See Table 1). Excluded were articles using video modeling as an artifact, video reflection, AT for writing for the purpose of accessibility, and video social stories created for students. These studies were omitted as they did not examine the students' use of multimodal tools for the purpose of expressing their ideas. Each of the 11 empirical articles was read and analyzed by two authors. Subsequent to this initial review, all authors reviewed and conferred on the analysis of each study. We also examined a number of practitioner-based articles that offered potential insight for further research in the field.

Results

In the 11 empirical studies, the participants used a variety of multimodal tools—including computers, digital cameras, and specialized devices—to express their ideas (see Table 2). Most commonly used were computers with specific multimedia software programs that allowed for word processing and text-to-speech functions. Additional software features included word prediction (Cullen, Richards & Frank, 2009; Silió & Barbetta, 2010), speech-to-text (Garrett, Heller, Fowler, Alberto, Fredrick, & O'Rourke, 2011), and multimedia software (Faux, 2005; O'Brien, 1998; Rao, Dowrick, Yuen, & Boisvert, 2009). The Internet also was used to gather digital media such as photographs and sound bites (O'Brien) as well as to support digital scaffolding tools (Englert, Manalo & Zhao, 2004; Englert, Wu, & Zhao, 2005; Englert, Zhao, Dunsmore, Collings, & Wolbers, 2007). Additional devices were used in a few of the studies such as a digital camera for gathering images and video (Faux; O'Brien) and a pen top computer called a Fly Pen used to provide audio writing scaffolds (Bouck, Taber Doughty, Flanagan, Szwed, & Bassette, 2010). Although multimodal tools were used for composition in all 11 studies, only four studies resulted in a multimodal output from the students; the rest had a print-based product.

The results are divided into trends in the research design, trends in the research findings, and trends in multimodal composing advocacy.

Trends in Research Design

The following categories were examined for trends in the research designs across articles: (a) research methodology, (b) research questions, (c) sample size, (d) grade level, and (e) identified disability classifications.

Research methodology. Overall, there was a fairly even distribution in the research designs utilized in the empirical studies selected for this review. Studies utilized single-case designs (e.g., Bouck et al., 2010; Garrett et al., 2011; Silió & Barbetta, 2010); qualitative designs (e.g., Faux, 2005; McGrail & Davis, 2011; O'Brien, 1998); mixed methods designs (e.g., Cullen et al., 2009; Rao et al., 2009); and quantitative designs (e.g., Englert et al., 2004; Englert et al., 2005; Englert et al., 2007). The even distribution of research designs is a strength in this research as it represents a balance in the research approaches used to examine multimodal composition practices for students with disabilities.

Research questions. As research questions guide empirical studies, it was important to notice trends in these questions to determine the lens through which researchers examined multimodal writing skills with special populations of students. Two of the studies (McGrail & Davis, 2011; O'Brien, 1998) were exploratory in nature, with broad research questions examining themes and perception of various multimodal technologies. McGrail and Davis examined the effects of classroom blogging on writing and literacy development. Although a research question was not explicitly stated, O'Brien focused on how the implementation of a literacy lab affected students' perceptions and work in English language arts.

Some studies investigated the effect of multimodal features on written convention. Three of the studies (Cullen et al., 2009; Garrett et al., 2011; Silió & Barbetta, 2010) utilized research questions that involved software or word processing features such as word prediction, spell checker, speech recognition, and text-to-speech. For example, Garrett et al. examined "the effects of speech recognition software to word processing across written production rate and accuracy on first draft writing" (p. 27). Word prediction and spell checker were the focus of the other two studies. These investigations focused on features of word processing programs harnessed for use with students with special needs.

Table 1

Articles Included in the Literature Review

Studies	Purpose	Participants	Methodology	Findings
Bouck et al. (2010)	Examined the effects of the Fly Pen, a pen top computer, on student writing performance	• 1 male, and 2 female students aged 15–18 classified with mild intellectual disabilities (ID) or learning disabilities (LD)	• Multiple probe across participants • Likert-type rating scale for essay quality • Event recording for 10 preidentified skills	1. Researchers documented gains in both quality and quantity of writing when using the Fly Pen. 2. Results did not generalize or maintain with the removal of the tool 3. Student and teacher feedback provided social validity
Cullen, Richards, & Frank, (2009)	Examined the effects of two computer-based writing interventions: (1) Write: Outloud, a talking word processor; and (2) Write: Outloud in conjunction with CoWriter, a word prediction software, on student writing performance	• 5 male and 2 female students aged 10–11 with LD or mild ID	• Modified multiple baseline across interventions • Data collected: word count, misspellings, accuracy percentage, rubric scores for overall quality	1. The group as a whole improved on each of the 4 dependent variables during both intervention phases. 2. No students scored consistently better in all 4 areas with either intervention. 3. Student and teacher feedback provided social validity.
Englert et al. (2007)	Examined the effects of TELE-Web, an Internet-based scaffolding support for writing, on student writing	• 35 elementary-age students classified with LD	• Quantitative between-groups design • ANCOVA and MANCOVA used to compare rubric scores for 6 writing traits.	1. TELE-Web group scored significantly higher in holistic quality of their papers. 2. Technology was not a replacement for effective instruction or teacher support.
Englert et al. (2005)	Compared students' writing quality under three conditions: (1) paper-pencil, (2) unsupported writing on the computer, and (3) supported Web-based writing using TELE-Web scaffolds	• 10 male, 2 female students aged 9–12 classified with LD	• Quantitative between-groups design • MANOVA used to compare writing production; Bonferroni post hoc used to compare organization scores	1. Significant differences in organizational quality between the computer-based and paper-pencil groups; the computer-based groups were nearly identical. 2. Writing production did not differ significantly between groups. 3. Effective instruction and support was necessary to maintain long-term changes.

continued

Table 1 (continued)

Studies	Purpose	Participants	Methodology	Findings
Englert et al. (2004)	Examined how a TELE-Web impacted student composition of personal narratives in three writing conditions: (1) supported paragraph (using TELE-Web), (2) unsupported paragraph (using TELE-Web), and (3) control condition (pencil-paper)	• 7 male, and 9 female students in Grades 1 and 2. • Participant traits: 1 ADHD, 2 ESL, 2 nonreaders, 4 repeating students, 3 referred for special education services	• Quantitative between-groups design • MANOVA, ANOVA, and Tukey Post Hoc used to evaluate scores on writing rubrics	1. Students generated more words, utilized more correct conventions, and produced better organized papers in the supported paragraph condition than in the paper-and-pencil condition. 2. Sixty-two percent of at-risk students received higher ratings on paper quality in the supported paragraph condition. 3. Results indicate some generalization of organizational skills when the scaffolds were removed.
Faux (2005)	Explored how students used multimedia software to assist them in story creation	• 3 males aged 11–12 • 2 classified with LD and 1 diagnosed with attention deficit hyperactivity disorder (ADHD)	• Qualitative design • Field notes, work samples, videotaped sessions, and student interviews used to analyze data	1. Students used a technology scaffold that did not require them to conform to the typical writing standards. It supported them in producing a greater volume of high-quality work with greater independence. 2. Using the scaffold, students were able to offload some of the cognitive tasks such as spelling, which allowed them more access to their working memory.
Garrett et al. (2011)	Examined the effects of speech recognition software (Dragon Naturally Speaking 7) vs. word processing software (Microsoft Word 2003) on writing fluency and accuracy	• 4 females, and 1 male aged 15–18 with physical disabilities (classified other health impairment [OHI] or mild ID)	• Alternating treatments design • Student writing samples assessed for fluency, accuracy, and length	1. Students wrote more with a higher fluency rate when using speech recognition software, but they had greater accuracy using word processing. 2. Speech recognition software may be best used during drafting, rather than publishing stages, when accuracy is less important.
McGrail & Davis (2011)	Explored the effects of blogging on writing and literacy development	• 9 female, and 7 male Grade 5 students, some of who had disabilities • 1 classified with LD • 1 ELL • 2 Gifted/talented	• Qualitative case study • Pre- postwriting samples, • Student and teacher interviews and videotaped class blogging sessions were used for analysis	1. Students began the year with a weak sense of audience. Personal relationships with their readers, developed through blogs, gave them a better understanding of how to write to a specific audience. 2. Evidence of social validity: Students felt more confident and motivated and were willing to take more chances in their writing.

continued

Table 1 (continued)

Studies	Purpose	Participants	Methodology	Findings
O'Brien (1998)	Explored how the implementation of a literacy lab affects student perceptions of and student work in English language arts	• 90 high school students with a main focus on 1 male and 4 female at-risk students Grades 9–12	• 4-year qualitative study • Interviews, surveys, observations, and work samples were used to draw conclusions pre- and postintroduction to the literacy lab	1. Impact: 71% of students reported they benefited from the literacy lab and 89% felt reading was an important skill that would benefit them after graduation. Using technology along with reading and writing allowed them to break the cycle of failure they had experienced throughout their school years. 2. Implications: Students are the stakeholders in their own education. Teachers need to allow more student choices, which will lead to greater engagement. Assignments should be challenging yet flexible so students can control the level of difficulty.
Rao et al. (2009)	Examined the impact of multimedia software (Classroom Suite IntelliPics Studio) on three specific areas of written expression: ability to convey meaning, clarity of writing, and use of conventions	• 21 male, and 4 female students Grades 9–12 classified with LD	• Mixed methods • Paired *t*-tests used to compare pre-posttest rubric scores • Teacher observations and interviews used for further analysis	1. Multimedia opportunities allowed students to practice their writing skills in a nontraditional way in order to gain confidence. 2. Students exhibited an increased sense of independence, were self-directed, sought answers from each other rather than the teacher, and remained engaged even when they had difficulties. 3. Positive results generalized to other skill areas
Silió & Barbetta, (2010)	Examined the effects of word processing, word prediction, and text-to-speech software as well as their combinations on student writing	• 6 students ages 12–13 classified as LD • Students were formerly English language learners, but are no longer receiving services	• Multiple baseline design across both participants and settings • Student narrative writing samples assessed with a holistic rubric	1. Data suggest word prediction, alone and in combination with text-to-speech software, has a positive effect on the writing fluency and syntax of students with specific learning disabilities (SLD), particularly Hispanic students. 2. The participants improved their holistic rubric scores with word prediction alone and in combination with text-to-speech. This, along with the low cost and ease of use, suggest it may be an appropriate and valuable technology to utilize in the classroom.

Table 2

Multimodality in the Studies Included in This Review

Studies	Tool	Multimodal Features Used	Student Composition Output
Bouck et al. (2010)	**Fly Pen**: An audio writing scaffolding tool in the form of a digital pen with the ability to upload student writing into a word processor	Audio prompting scaffolds for: • Concept mapping • Essay organization	• Handwritten persuasive essay • Handwritten compare/contrast essay
Cullen, Richards, & Frank, (2009)	**Write**: Outloud: Talking word processor **CoWriter**: Word prediction software	• Translates text to speech • Speaks words as typed • Spell checking • Word prediction	Journal writing
Englert et al. (2007)	**TELE-Web**: An Internet-based scaffolding writing support program with customizable prompts, the ability to share drafts with peers, and an online submission system	• Text structure scaffolds • Organizational scaffolds • Text monitoring prompts • Concept mapping tool • Spell checker	Expository papers
Englert et al. (2005)	**TELE-Web**: An Internet-based scaffolding writing support program with customizable prompts, the ability to share drafts with peers, and an online submission system	• Text structure scaffolds • Organizational scaffolds • Text monitoring prompts • Text-to-speech	Narrative text with descriptive or expository information about a newsworthy event or topics
Englert et al. (2004)	**TELE-Web**: An Internet-based scaffolding writing support program with customizable prompts, the ability to share drafts with peers, and an online submission system	• Customizable prompts • Text-to-speech • Spell checker	Paragraph about a specified topic
Faux (2005)	**TextEase 2000**: Multimedia authoring software; includes word processing, desktop publishing, and multimedia authoring	• Speaks all onscreen text • Speaks words as typed • Spell checker with sound • Customizable word bank (students can click word bank words and they will be inserted into the text) • Ability to insert pictures, video, and animation • Records audio	Multimedia stories (composed of text, pictures, video, animation, and/or sound)

continued

Table 2 (continued)

Studies	Tool	Multimodal Features Used	Student Composition Output
Garrett et al. (2011)	**Dragon Naturally Speaking 7** **Microsoft Word 2003**	• Speech-to-text	Self-selected topic writing compositions
McGrail & Davis (2011)	**Blogs**	• Online blog • Option for inclusion of pictures to accompany blog entry • Ability to respond to comments from authentic readers from around the world	Personal self-expression blogs (multiple entries over the course of 1 year)
O'Brien (1998)	**Literacy Lab**: The lab consisted of 15 networked computers, multimedia workstation machines, a scanner, laser printer, digital camera, and multimedia authoring software	• Word processing • Digital cameras • Internet access • Multimedia software programs	In this longitudinal study, the students created both traditional and multimodal compositional pieces: • Persuasive letters for a newspaper • Movie or TV reviews • Multimodal biographies including digital photograph slides • Short stories • Letters for the lab's digital post office • Integrated media projects including text, graphics, video, and audio
Rao et al. (2009)	**Classroom Suite IntelliPics Studio**: A multimedia authoring environment; includes the ability to combine text, pictures, and audio	• Text-to-speech • Ability to insert pictures • Records audio	Multimedia stories (composed of text, pictures, and/or sound)
Silió & Barbetta, (2010)	**WordQ**: A word processing program with word prediction and text-to-speech features	• Word prediction • Text-to-speech	Narrative writing

Six of the studies (Bouck et al., 2010; Englert et al., 2007; Englert et al., 2005; Englert et al., 2004; Faux, 2005; Rao et al., 2009) used specific types of hardware or software to examine their questions. The focus of these pieces was the examination of a particular form of technology. For example, one of these research questions examined if "the use of a pen top computer and writing software result in student acquisition of writing skills" (Bouck, p. 35). One commonality through a majority of the studies (9 of the 11) was that the research focused on specific types of technology (e.g., TELE-Web, pen top computer, etc.) rather than broad perspectives of multiple forms of multimodal technology. These questions were exploratory and examined technical issues, software tools, and hardware technology to guide their research questions.

Sample size. One of the main findings regarding sample size was that the majority of the studies had only three to seven participants. Five of the studies (Bouck et al., 2010; Cullen et al., 2009; Faux, 2005; Garrett et al., 2011; Silió & Barbetta, 2010) had fewer than eight participants. The small samples in these studies can be attributed to the fact that the majority of these studies were single-case design, or exploratory qualitative research. Single-case design is most often used with smaller groups of participants with an individualized focus (Kazdin, 1982) and qualitative designs also are typically used for exploratory and case study research with a small number of participants (Strauss & Corbin, 1998). Even the studies with larger samples still focused the majority of their research on relatively few students. In one of the few studies involving a larger number of students ($n = 90$), O'Brien (1998) examined a macro perspective of a literacy lab. Though the study sample was large, the researchers focused in-depth interviews on two of the users of this lab and provided anecdotal accounts of experiences with several other students; thus, the actual focal number of students was much smaller.

Some studies explored a slightly larger number of participants. Four of the studies with a quantitative component of the design method (Englert et al., 2007; Englert et al., 2005; Englert et al., 2004; McGrail & Davis, 2011) had between 12 and 35 participants. Despite these studies having a larger number of participants than the others reviewed, they are still relatively small samples. Overall, the studies tended to have small number of participants as most of these studies were exploratory in nature.

Grade level. More than half of the studies on writing instruction with technology focused on elementary school students. Six of the studies used participants from Kindergarten to Grade 5 (Cullen et al., 2009; Englert et al., 2004; Englert et al., 2005; Englert et al., 2007; McGrail & Davis, 2011; Silió & Barbetta, 2010). There was little diversity in grade levels selected at the elementary level; these studies utilized participants from either Grade 1 or Grade 5.

Of the remaining studies, middle school participants were selected in one of the studies (Faux, 2005). Four of the studies used secondary school participants (Bouck et al., 2010; Garrett et al., 2011; O'Brien, 1998; Rao et al., 2009). In the high school setting, there was a balance in the grade levels, with nearly equal participation from Grades 9–12. Given the broad range of participant grade levels, the research indicates multimodal technology has potential for integration across grades.

Identified disability classifications. Most studies exploring technology and composition with students with special needs focused on a narrow range of disability classifications. The main disability classification in these studies was learning disability (LD), as this category appeared in six of the studies (Bouck et al., 2010; Cullen et al., 2009; Englert et al., 2007; Englert et al., 2005; Rao et al., 2009; Silió & Barbetta, 2010). In their study with participants with LD, Cullen et al. also included two participants with mild intellectual disabilities. Additionally, one study included participants with other health impairments (OHI), dyslexia/dyspraxia, and communication disorders (Faux, 2005). Lastly, one study included students with orthopedic impairments and a child with an intellectual disability (Garrett et al., 2011). Of the 13 defined disability classifications, the studies in this review explored only four. It is important to note a gap in the literature regarding the use of technology for composition with students having more severe or profound disabilities.

Additionally, at-risk populations of students were explored in two of the studies (Englert et al., 2004; O'Brien, 1998). There was limited exploration of other populations. One study (Silió & Barbetta, 2010) examined former English language learner (ELL) students, and one study had both an ELL and two gifted students included as participants (McGrail & Davis, 2011). As with students with disabilities, examination of these special populations is limited to a small focus in the literature.

Trends in the Research Findings

In addition to the research design, we examined trends from the findings of the 11 studies. Three major themes emerged from our review: (a) technology's role in instruction, (b) technology as a tool for writing, and (c) technology's impact on writing quality.

Technology's Role in Instruction

One theme uncovered in our review of literature was how technology was used in the classroom. Resonant throughout the referenced studies was how both the teachers and the students must interact with the technology for successful implementation.

A key idea in the literature addressed how the use of technology should not and cannot replace good instruction (Englert et al., 2004, 2007). Englert, Wu, and Zhao's (2005) research on their TELE-web program provided evidence of the tool's cognitive support for student writing. The authors noted, however, that the "technology itself was not sufficient to teach or to affect long-term changes independent of the classroom instruction" (p. 195). The program was designed to build upon prior instruction and students' familiarity with language and the writing process. Another study investigating participant ability to read and write e-literature discovered that students are not inherently able to make the shift from print to e-literature and must be taught the necessary skills (Luce-Kapler & Dobson, 2005). Even though these Internet-based interventions were able to present new opportunities for digital reading and writing, neither could be used without proper instruction.

These studies emphasized that the teacher is at the center of good instruction. With the use of any technology-based support, the teacher is vital to the implementation and facilitation process (Bouck et al., 2010; Luce-Kapler & Dobson, 2005). In one study that examined the influence of classroom blogging on writing and literacy development, the teacher served as an orchestrator, a writer, and a facilitator of classroom dialogue (McGrail & Davis, 2011). The authors described the instructor's function as both fulfilling the traditional insider role of classroom teacher as well as an outsider role of a reader commenting on student blogs. In Parette, Hourcade, Dinelli and Boeckmann's (2008) study on the use of a computer program called Clicker 5 to enhance the writing of young learners, the teacher was needed to create specific Clicker grid templates that were linked to the writing curriculum. Even in studies resulting in greater student independence when writing the teachers provided the initial support and served as the technology expert throughout the process (Faux, 2005; Rao et al., 2009). It is very likely that without teacher involvement the interventions would not have been successful.

In addition to teacher interaction with technology being crucial to the instructional process, another finding in the review dealt with the need for the students to interact with the technology in meaningful ways. One way for this to happen was to individualize technology-based writing tools according to student needs. By tailoring these tools, students received appropriate supports as opposed to universal supports that may have targeted areas in which they were already strong. Providing intrusive supports to areas of competence could hinder any automaticity in a student's writing process. In one of the studies on the use of the TELE-web program as a cognitive support for student writing, the authors made note of how the program supported each participant in a different way (Englert et al., 2005). One student in particular was a strong writer and was only in the classroom because of behavior problems. This student showed less growth than other students who were using the TELE-web program because he already had the requisite skills needed for writing. O'Brien (1998) stated that teachers "need to know each of the students as unique individuals" (p. 46). He asserted that teachers should keep assignments both challenging and flexible and should be willing to allow for student choice. Allowing for individualization of technology engages and motivates students as they progress as writers. Technology provides needed assistance to students, but only when they are engaged as willing participants and a knowledgeable teacher facilitates the process.

Technology as a Tool for Writing

While several of the hardware and software applications addressed multiple functions within a single program, others delivered more targeted supports. Technology tools can serve a variety of purposes, and the results of this literature review suggest that most multimodal writing technologies serve as scaffolds, addressing both lower order concerns and higher order concerns of the composition process (Keh, 1990).

Technology as scaffolds. Technology tools were often used to scaffold the writing process for students whose disabilities made such tasks difficult. Broadly, scaffolds refer to support systems that enable the completion of a certain task. Previous research, not reviewed here (Leu Jr., Kinzer, Coiro, & Cammack, 2004), has documented how scaffolds were used to support a writing task (e.g. Englert, Mariage, & Dunsmore, 2006). The utility of such scaffolds lies in their ability to help learners attend to crucial elements of an activity and direct this activity toward task achievement. In the case of technology scaffolds, this increases the effectiveness of the learner's actions by offloading other less important aspects onto a tool (Pea, 2004). Englert et al. (2006) emphasized the wide range of tools used to enhance writing performance. Although the scope of tools addressed in this review are not as extensive as those identified by Englert et al. (2006), the 11 studies in this review used a variety of tools to scaffold writing composition such as diagrams, graphic organizers, text structures, and grammar and spell checkers. Three studies reviewed here made explicit references to the term *scaffold* while the other eight did not. Regardless of whether articles invoked the word scaffold, the studies characterized the use of all such technology tools as scaffolds.

Scaffolds were harnessed in a variety of ways and targeted several aspects of student writing. The first was to increase students with disabilities' production of written texts. Several interventions sought to achieve this goal by harnessing software features such as text-to-speech, word prediction features, and speech recognition to improve writing outcomes. Bouck et al. (2010) investigated the effects of pen top computers on the writing abilities of students with high-incidence disabilities (mild ID and/or LD). Findings from this study revealed audio prompts embedded within a digital writing exercise scaffolded the writing process for students and facilitated their writing production. The auditory cues provided students with prompts during the planning and drafting stages of the writing process, and suggested multiple gains were achieved in both writing quantity and quality.

Another way in which scaffolds were used aimed to help students plan and structure the content of their written work more effectively. Englert et al. (2005) examined the ability of digitally embedded scaffolds to enhance writing performance as measured by the inclusion of appropriate genre features such as topic sentences, detail sentences, and concluding sentences. Englert et al. (2005) found students with LD who used such scaffolds increased their ability to include the kinds of information required by narrative text structures. Of particular note was the authors' conclusion that improved writing was aided by students' ability to offload the text structure onto the software program, thus enabling them to focus on the details required by the writing exercise. This example illustrates how technology-based scaffolds can help students with disabilities focus on essential elements of a writing task, thereby improving the quality of their writing.

Higher Order Concerns and Lower Order Concerns.

One useful conceptualization of composition components divides writing skills into two categories: Lower order concerns, which relate to mechanics, syntax, and spelling, and higher order concerns, which focus on development of thesis, idea production, and organization (Keh, 1990).

Technology to facilitate lower order concerns. Addressing lower order concerns, which consistently present challenges to students with disabilities (Troia, 2006), is one way to improve student composition. Three studies examined the effects of multimodality on lower order concerns and found positive impacts on the writing performance of students with disabilities. Two studies focused on the effects of technology scaffolds on lower order concerns by examining software tools (i.e., text to speech, word prediction, and talking word processor) used alone and/or in combination (Cullen et al., 2009; Silió & Barbetta, 2010), while the other explored the effect of speech recognition on fluency (Garrett et al., 2011). A common focus for these studies was the accuracy with which students produced words. Across all three studies, the technology scaffolds appeared to boost the quantity of words students with disabilities produced during the intervention.

Silió and Barbetta (2010) examined the effects of word prediction software alone, and in combination with text-to-speech software, on student writing. The amount of writing produced by students increased during both interventions, although greater gains were realized when word prediction alone was used. Silió and Barbetta suggested that these low-cost programs help students focus on conveying their intended message as opposed to remaining preoccupied with concerns about spelling and syntax. Findings from Cullen et al. (2009) echo the positive results on the writing ability of students with disabilities. In their study of fifth grade special education students, Cullen et al. found that misspellings decreased markedly with the use of word prediction software alone and when used in conjunction with text-to-speech software. By comparing the effects of speech recognition software to word processors for students with physical disabilities, Garrett et al. (2011) discovered both fluency and length increased when students used speech recognition. Accuracy, however, was not improved. Overall, technology tools bolstered students' skills in lower order concerns areas.

In addition to targeting lower order concerns, Cullen et al. (2009) and Silió and Barbetta (2010) found that word prediction software and text-to-speech software also improved student writing as measured by holistic writing scores. These findings were of particular interest in that technology targeting lower order concerns also improved performance in higher order concern areas as well. As writers continue to struggle with the composition process, technology tools addressing higher order concerns have the potential to make a meaningful impact on students' writing.

Technology to facilitate higher order concerns. In the 11 studies from our literature review, eight directly addressed higher order concerns, which were facilitated through learners' use of multimodal writing supports and environments. The most common aspect targeted in these studies related to the organization of students' written work. Four studies utilized audio and/or text prompts designed to help learners structure their writing more effectively (Bouck et al., 2010; Englert et al., 2004; Englert et al., 2005; Englert et al., 2007). In these studies, student gains made during the interventions suggest the powerful impact such prompts can have when students compose written work.

The effects of technology scaffolds on higher order concerns were addressed in media-rich learning environments such as classroom blogging activities (McGrail & Davis, 2011), a technology infused literacy lab (O'Brien, 1998), and in multimedia-software composing activities (Faux, 2005; Rao et al., 2009). These technologically equipped environments were focused in large part on idea development, and emphasized the ways in which technology scaffolds helped students with disabilities convey their ideas. Two of these studies also emphasized how students benefited from the use of multiple modalities to transmit meaning (Faux, Rao et al.). The diversity of contexts in which higher order concerns were explored speaks to the flexibility of such technology supports and to the wide range of learning environments in which they can be applied.

Technology's Impact on Writing Quality

The final trend in the research findings deals with the role of technology in the quality of student writing. The ability to write effectively is not developed easily. Teachers of students with disabilities struggle to find ways to support their students with complex tasks. For students to be successful writers, they must approach composing with confidence, and it is the teacher's responsibility to aid in the development of this attitude (Pajares & Valiante, 2006). While attention to higher order and lower order concerns is necessary for effective compositions, the quality of writing also is steeped in two additional elements: that writers must have a measure of independence, and that they must understand the audience for whom they are writing.

Student independence. In reviewing the research, we found that technology influenced student independence, which increased students' confidence and motivation. Technology scaffolds decreased student reliance on teachers (Bouck et al., 2010; Englert et al., 2004, 2005, 2007; Faux, 2005) and increased student confidence (McGrail & Davis, 2011; Rao et al., 2009). This scaffolding allowed students with disabilities to create work of both higher quality and quantity with limited assistance from teachers (Bouck et al.; Englert et al. (2004, 2005, 2007); Faux, Rao et al). As students increased work production, they became greater self-motivators (Bouck et al.; Cullen et al., 2009; Faux; McGrail & Davis). Increase in motivation led to a greater willingness to take risks, moving students outside of their comfort zones to explore new possibilities in writing (Faux, McGrail & Davis). Allowing students to capitalize on their strengths, to leave behind the current limitations of traditional composing, and to work in a multimodal environment created feelings of autonomy and self-assurance in students (Faux).

Audience awareness. A key development in improved writing ability is the emergence of audience awareness (McGrail & Davis, 2011). Vygotsky (1997) maintained that learning was a social process, aided by interactions with teachers and peers. Thus, one approach to teaching composition would be to provide writing opportunities with authentic audiences. McGrail and Davis conducted a study of elementary level writing development in which students maintained blogs for one year. At the beginning of the study, students' composition was self-centered and written only to satisfy the teacher, whose primary role was evaluator. Lack of audience awareness led to hollow writing with evidence of little or no purpose. By the end of the year, the students' writing had been transformed; the blogs were full of meaning and purpose. The authors reported, "…having access to an audience through blogging motivated students to write for and engage this audience" (McGrail & Davis, p. 16). Providing readers that are free of evaluative responsibilities allowed students to write for an audience in a more authentic fashion, which improved the quality of their writing.

Emphasis on student writing independence and audience awareness—key components to quality written pieces—are supported through multimodal composition using technology. Research from the 11 reviewed studies indicates technology's infusion in the composition process contributed to the improved quality of student writing. While empirical research in this area is limited, other published nonempirical pieces offered advocacy for the benefits of multimodal composition.

Trends in Multimodal Composing Advocacy

Practitioner publications provide advocacy for the use of multimodal literacies, but because these articles were not research based, they were not included in our review. However, we found a number of valuable recommendations from those using multimodal composing in their classroom. Throughout these pieces, it is suggested that the use of a multimodal approach for students with disabilities provides a worthwhile approach to learning.

One way that technology has been integrated with written composition lies in the support it can provide for learning and interacting with text material. A range of multimodal tools for personal expression is supported throughout the articles, in what Gray & Silver-Pacuilla (2011) call "leverage[ing] a personalized learning experience" (p. 5). Internet-based tools such as Web Blogger (Edyburn, 2008a), Wikispaces (Levinsen, 2008), and advances of Web 2.0 (Edyburn, 2008b) are being used to transition students from reading to writing while completing a given task. These Web-based tools offer multimodal environments for students to display their composition skills for authentic audiences. Students with disabilities have benefited from such technology applications. Web 2.0 increased the level of exposure to knowledge for students with disabilities (Edyburn, 2008a). These technology-based tools are emerging topics for further research as they can provide assistance for students with disabilities to produce higher quality written compositions (Levinsen).

The use of technology support systems is growing in application. Technologically infused writing supports such as hypermedia text (Anderson & Anderson, 2008), digital concept maps (Ayres & Langone, 2008; Levinsen, 2008), Kidspiration (Barbetta & Spears-Bunton, 2007), Vivo (Crossman, 2010), and digitized text (Barbetta & Spears-Bunton) are a few specific examples that have received attention. Barbetta and Spears-Bunton presented various benefits of technology for students with disabilities, such as organizational tasks, reducing effort spent on spelling with word prediction software, and improving the fluency of the writing process. Levensen described how word prediction software also could enhance the subset of skills often found in higher order concerns by increasing the complexity of sentence structure. MacArthur (2009) stated that skills such as word prediction software, cognitive organizational skills, and scaffolding supports can assist students in producing written text.

The importance of writing development for students, particularly those with disabilities, has resulted in the examination of technology as a tool for improving composition outcomes. The articles discussed in this section offer support for the findings and implications from the 11 reviewed studies. Examination of these articles, combined with the reviewed empirical research, can provide researchers with promising directions for future investigations. The benefits of increasing exposure to knowledge, offloading lower order concerns such as spelling to allow for increased sentence complexity, assisting with the organization of writing, and increasing the amount of written text are just a few benefits mentioned. More research is needed to specifically address the avenues in which technology can assist students with disabilities with multimodal forms of composition.

Discussion

The implications that emerged from our review of the findings address: (a) the facilitating role of teachers, (b) the potential of digital video, and (c) a framework for future research.

The Facilitating Role of Teachers

The teacher is central in his or her guidance and participation in order to affect student outcomes. Teacher facilitation will be a factor in determining whether students are successful in their technology implementation (Bouck et al., 2010; Luce-Kapler & Dobson, 2005). For this reason, teachers must have a thorough knowledge of the technology they decide to utilize in their classrooms. They must know how to operate and troubleshoot the tools and how to train students to utilize them effectively. If teachers are unable to master the technology they expect their students to use, students will not achieve the desired outcomes.

Once students are able to employ technology effectively, they will have access to new avenues for self-expression. A multimodal environment allows students who are unsuccessful within the limitations of written expression to use other methods with which they are comfortable to express themselves (Faux, 2005). Multiple modes of expression and instruction have the ability to accommodate the range of student abilities in a single classroom. Based on the findings from our literature review, it is evident that technology-infused opportunities—led by capable teachers—could provide an effective method for increasing the quality of student composition.

The Potential of Digital Video

While the 11 studies explored a limited range of available multimodal tools, other effective forms of technology offering outlets for multimodal compositions have received little attention in empirical research with students with disabilities. One mode of representation increasingly found in "traditional" classrooms, but that has yet to be researched with students with disabilities, is DV. Miller (2007) purports, "Digital video composing is a quintessential multimodal literacy that allows orchestration of visual, aural, kinetic, and verbal modes electronically" (p. 66). Incorporating DV into the classroom is a feasible and acceptable practice in developing academic skills such as expository writing (Ohler, 2006). The creative vision of DV engages students in authentic learning activities (Kearney & Schuck, 2004) incorporating critical thinking and media literacy (Ohler) while strengthening their writing skills (Strassman & O'Connell, 2007). As previously discussed, written composition is often a challenge for students with disabilities. However an alternative teaching practice (i.e., digital storytelling) supports the nonconventional learner (Lacey, Layton, Miller, Goldbart, & Lawson, 2007).

DV composition has led to literacy gains for populations of general education students (Brass, 2008; Bruce, 2008, 2009; Figg & McCartney, 2010; Goulah, 2007; Henderson et al., 2009; Hull & Katz, 2006; Miller, 2007; Valkanova & Watts, 2007). Prior research found DV composition could improve writing outcomes in several ways. Students must make more composition choices, allowing them to draft a sequence multiple times to critically examine the effect of their choices (Bruce, 2009; Miller, 2007). Additionally, successful DV compositions require complex writing skills paralleled to print writing (Brass, 2008; Bruce, 2009; Figg & McCartney, 2010; Goulah, 2007; Miller); they support student reflection, an often overlooked component of the writing process (Bruce, 2010; Valkanova & Watts). Moreover, prior research indicates that DV compositions foster utilization of iterative compositional strategies (Bruce, 2009; Figg & McCartney; Miller). DV compositions can be a form of multimodal writing with multiple avenues for improved literacy gains.

Research in DV composition has shown promise with populations of low-achieving students as well as those from low socioeconomic backgrounds. Bruce (2008) found that low-achieving students engaged in higher order thinking through demonstration of complex composition strategies showed success with parallel composition skills in digital compositions. These students also engaged in peer-led discussions and complex conversations offering textual evidence for their ideas, skills not evidenced in their print-based compositions. Hull and Katz (2006) found similar results with students from families of low socio-economic status. Digital compositions were found to enhance the depth of the compositional structure. Additionally, students were more engaged and took greater ownership of their work compared to their print compositions. With the gains general education populations of students can make in creating DV compositions, its effects on students with special needs has yet to be fully explored.

Research involving DV composition use by students with disabilities should be studied to determine if similar literacy improvements could be made. Brass (2008) contended that digital video could be used to facilitate engagement and academic achievement for students whose knowledge could be displaced by conventional curriculum and typical instruction. Students with disabilities may demonstrate difficulties in the writing process, and DV composition could be a form of multimodal writing that may ameliorate these difficulties. More (2008) asserted that students with disabilities need to take ownership of their learning, and the power in involving students in the process of creating digital compositions may bestow this sense of ownership. Future research should explore the effects of DV compositions on the composition skills of students with disabilities.

A Framework For Future Research

In light of our review of studies exploring the ways in which multimodality is being harnessed to support the written composition of students with disabilities, a framework proposed by Graham and Harris (2009) offers a particularly useful conceptualization of composition development. Four primary building blocks of writing development include (a) strategic behavior, (b) writing skills, (c) knowledge, and (d) motivation (Graham & Harris). This review uncovered evidence that emphasizes the importance of these building blocks.

All of the reviewed studies examined at least one of the above mentioned elements. Some examined strategic behavior (e.g., Bouck et al., 2010; Englert et al., 2004; Englert et al., 2007). Others targeted writing skills (e.g., Cullen et al., 2009; Silió & Barbetta, 2010), while another explored knowledge of genre elements and process (Englert et al., 2005). Many of the studies focused on two or three of the primary components identified by Graham and Harris (2009). Authors of several studies in this review acknowledged the pivotal role that motivation can play for students with disabilities. This seems to support what Graham and Harris tentatively acknowledge as an important element of writing development, although they have urged continued research on the impact of motivation on the writing process. Lastly, the notion of teacher facilitation in developing writers' abilities runs throughout the primary building blocks of the writing framework.

While the reviewed studies did not frame their research on the work of Graham and Harris (2009), the themes emerging from this review align with their conceptualization of writing development as multifaceted. Graham and Harris's composition framework aims to address four primary building blocks of composition; the studies we examined narrowed their focus to two or three of these components. We view this building block notion of writing as particularly valuable because it embraces essential components of writing development. Another value lies in its applicability across modalities. That is, researchers might consider including all four primary building blocks of writing as a framework for future research on multimodal composition practices for students with disabilities.

While we find promise in the above mentioned framework in guiding multimodal composition, it is important to note the technologies harnessed for any given pursuit are likely to change, due to the constantly evolving nature of technology (Leu Jr. et al., 2004). The various capabilities of technology can allow teachers to support students with disabilities and their learning in new ways. Even though it is important to study new technologies and their impact on teacher use and student learning, research focusing on a specific technological device runs the risk of becoming obsolete as technology changes and evolves. As various technological applications are examined, it may be helpful to focus research on the features and functions of technology rather than on the programs and devices themselves.

Conclusion

There are growing demands in the classroom, specifically for the academic development of students with disabilities. Based on the results of our 11 reviewed studies, multimodal composition holds a host of potential benefits for students with disabilities. Multimodal composing through technological integration can increase the quality and content of compositions, an aim most teachers desire to achieve with their students—particularly those with disabilities. While prior research has explored these benefits to the composition process, it remains limited. To expand upon this, future researchers should examine the effects of multimodal composition on student performance across a variety of grade levels and disability categories. While there is a need to continue to explore how multimodal technology can aid in the composing skills of students with disabilities using small sample sizes, it will be helpful to have empirical studies with larger sample sizes contribute to the body of research. Moreover, empirical research using generalizable populations of students would be useful to guide future research. With these additions, research could better evaluate the impact of multimodal composition on the writing ability of students with disabilities with potential to become an evidenced-based practice. Consequently, the use of technology to foster multimodal composing deserves attention, and should be investigated further.

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Online Learning for Early Intervention Professionals: Transition Planning from Early Intervention to School

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Most states in the U.S. require that early intervention (EI) providers receive ongoing professional education and training. Unfortunately, few education and training programs exist for busy professionals who find it difficult to travel to attend traditional face-to-face classes. An alternative to traditional education is Internet-based online learning. This article describes the development and evaluation of an online learning course entitled Transition Planning from Early Intervention to School. Designed for professionals who provide EI services to children with developmental disabilities and their families, the course is available anytime, anywhere and is fully self-contained, which means it does not rely on an instructor for course delivery. Thirty EI professionals completed a field evaluation of the course in which they completed three modules on topics related to transition planning in EI. Learning was assessed through changes in pretest to posttest scores. Course satisfaction and usability were assessed using a Likert-type survey. Participants increased their pretest to posttest scores by an average of 43% and reported moderate to high overall satisfaction.

One the most challenging times for children with disabilities and their parents is the transition period associated with moving from early intervention (EI) to school-based services. Transitions for any family are difficult, but for the family of a child with special needs they may be particularly challenging. A family systems perspective suggests that most families anticipate and plan for common child transitions; however families of children with special needs experience a greater number of transitions from infancy forward than do families with children who are developing typically. Those transitions tend to be stressful due to the new and challenging roles parents must take on, and to a sense of uncertainty about what the future will hold (Turnbull, Turnbull, Erwin & Soodak, 2006), Quite often, parents find the transition from EI to preschool to be particularly difficult (Pang, 2010). Although it brings new opportunities for families, it also brings concerns and stress. Families may be reluctant to disrupt home-based and family-centered services as they shift to school-based services. A well-prepared EI provider can support the family through this transition by engaging in professional best practices that can reduce family and child stress and facilitate a smoother transition. Practices include establishing timelines for planning and preparation; involving the family in planning and decision making; establishing communication between the family, EI, and the receiving agency; and fostering a clear understanding of policies and procedures regarding transitions and Part B requirements (Bradley, Daley & Levin, 2011; Bruder, 2010; Malone & Gallagher, 2009). EI providers need professional development and training in these practices to ensure that all components of the transition process are followed effectively.

EI providers are mandated under IDEA to provide transition planning services and evaluations within nine months of a child's third birthday (U.S. Department of Education, 2010a). School districts often have transition information available to families and work closely with EI teams before transition occurs. Although transition planning between EI agencies and school districts is required by IDEA, data suggest that this is not occurring at the level it should (Rous, & Hallam, 2012). Recent studies have found that despite updated regulations that serve to make the transition process easier, parents' perceptions are that the process continues to be difficult (Branson & Bingham, 2009; Pang, 2010; Podvey, Hinojosa & Koenig, 2010; Rous & Hallam, 2012; Turnbull, Zuna & Hong, 2010). A review of research on the effectiveness of transition practices on early childhood school transitions for children with and without disabilities suggests favorable academic outcomes, but these outcomes are affected by factors such as level of parental involvement, quality of teacher-child relationships, and the number of transition practices implemented by the receiving teacher, among others (Rosenkoetter, Schroeder, Rous, Hains, Shaw, & McCormick,, 2009).

There are no nationwide guidelines specifying effective EI transition practices. Instead there exist differing sets of practices recommended from EI research, along with those put forth by individual states and agencies involved in transition planning. In addition to this lack of consistency, there is often no evaluation of practices, which if done could yield important information to help guide a more standardized process based on empirical data. One way in which states do try to promote optimal transition practices is through professional development opportunities for EI professionals, usually in the form of workshops and conferences. Unfortunately, many of these opportunities lack adequate measurement of outcomes, such as knowledge gained and knowledge subsequently applied in work situations (Campbell & Sawyer, 2009). This is a potentially serious shortcoming, given that the in-depth knowledge needed to guide effective transition practices may not be acquired in a relatively brief workshop or conference format.

While the demand for professional training in EI in general is great, there is a shortage of suitable programs (Campbell & Sawyer, 2009; Osofsky, 2005). In-depth learning experiences designed to foster complex knowledge acquisition and skill development are needed, but many EI professionals are too busy to spend the travel time to attend classroom-based courses, or the class schedule may be inconvenient. One alternative is to capitalize on the flexibility afforded by online learning, particularly when such Internet-based instruction is designed to be highly interactive and tailored to the needs of learners (Cook et al., 2012; Head, Lockee & Oliver, 2002; Kambutu, 2003). Access to online learning technology is widespread, and researchers are examining the benefits and effectiveness of online instruction, including its capacity to produce measurable increases in knowledge that extend to problem solving and critical thinking skills (Sanders & Morrison-Shetlar, 2001). Indeed, the U. S. Department of Education, Office of Educational Technology, recently produced the National Education Technology Plan 2010, entitled *Transforming American Education: Learning Powered by Technology* (U. S. Department of Education, 2010a). This plan is broad in its scope of how technology can be used flexibly to engage and in measurable ways meet the needs of diverse learners who have increasing access to media for delivery of educational content. The term "learners" in this case can refer to both educators and service providers. A meta-analysis, also sponsored by U. S. Department of Education (U. S. Department of Education, 2010b) concluded, "Students in online conditions performed modestly better, on average, than those learning the same material through traditional face-to-face instruction" (p. xiv); and, "Online learning appeared to be an effective option for both undergraduates (mean effect of +0.30, $\rho < .001$) and for graduate students and professionals (+0.10, $\rho < .05$) in a wide range of academic and professional studies" (p. xv).

Anderson and Dron (2010) described theoretical frameworks for distance learning pedagogy. One framework, cognitive-behavioral pedagogy, lends itself to the development of online courses that target knowledge acquisition and the potential for behavior change, even in cases where there is limited instructor presence. With an asynchronous course that has no instructor, the quality of learning is placed in the hands of the instructional design team. From a cognitive-behavioral perspective, under these conditions adult learning can be successful with careful prior consideration of learning objectives, the depth and breadth of content to be presented and its application, diverse and engaging methods of content delivery, and a means for assessing knowledge and satisfaction (Anderson & Dron). Resulting course development decisions will depend upon the needs of the target audience, e.g., EI personnel, the individuals they serve, and the systems in which they perform (Miltiadou & McIsaac, 2000; Sulzer-Azaroff, Fleming, Tupa, Bass, & Hamad, 2008). Research in adult learning suggests that adults are motivated to undertake learning opportunities for a variety of reasons (Merriam, Caffarella, & Baumgartner, 2007), one of which is to acquire practical knowledge that is applicable to their daily lives, including their work lives (McGrath, 2009). With this in mind, when designing an online course, the principles of instructional design for online learning need to be applied, including—for example—the need to develop problem- and case-based learning opportunities and to reduce extraneous material (Clark & Mayer, 2003). Courses should incorporate materials based on salient, real-life challenges experienced by members of the target population (McGrath). Equally important is that course navigation is simple and predictable (Horton, 2006), and that the look and feel of the course is aesthetically pleasing (MacPherson-Court, McDonald, Drummond, Kysela, & Watson, 2005).

The purpose of this study was to develop, implement, and evaluate an online course on transition planning for EI professionals who provide services to children with developmental disabilities and their families. The course was delivered completely online in an asynchronous manner to increase flexibility over scheduled classroom-based courses. This article describes the steps taken to design and develop the course, entitled Transition Planning from Early Intervention to School; presents data on participant knowledge acquisition and satisfaction from a national field evaluation; and discusses the strengths and limitations of the project, with suggestions for next steps for research and practice.

Course Design and Development

Transition Planning from Early Intervention to School was designed to help EI professionals address the processes involved in assisting families of children with developmental disabilities during the transition from EI to school-based services. Course development was guided by a common instructional design approach designed to: (1) assess the learning needs and expected outcomes of the target audience; (2) develop learning objectives; (3) specify critical content; (4) determine types of learning called for (e.g., synthesis, analysis); (5) identify instructional methods and technology to deliver content effectively; and (6) develop and implement an evaluation plan.

To assess needs and outcomes of the target audience for the course and to begin to identify key content we conducted a survey and a comprehensive literature review. The survey was conducted with leaders in the field of EI, including Part C coordinators and state directors of Title V-funded programs for children with special health care needs in 15 states, and directors of university centers on developmental disability programs with projects in EI. Each completed a survey in which they were asked to identify important EI-related topics. Key training areas were identified from the completed surveys. They included transition and transition-related areas, specifically service coordination, family-centered care, use of natural environments and routines, developmental screening, and assessment and intervention strategies. Course content also was guided by an extensive literature review on national transition planning practices. This began with an examination of IDEA and P.L. 99-457 for information related to transition planning and then moved to a review of government funded project reports on EI practices that included transition planning. The final step of the review examined peer-reviewed research on the effectiveness of transition planning and related practices.

Based on this needs analysis, it was ascertained that participants would need to learn about the roles and responsibilities of school personnel, how schools approach early childhood education, evaluation processes used by schools, and ways in which EI evaluation and transition processes are used to interface successfully with the school system. Additionally, participants would need to be taught strategies for helping families to acquire the skills and tools they need to prepare for transitions and to advocate effectively for the needs of their child within the school setting. Participants also would need to be taught to provide information on other community-based resources available to support families' needs when EI services were no longer available. These clear needs became the main learning objectives for the course and allowed for further specification of content to be covered.

In order to present content in a logical manner, the course was organized into three sequential modules, which are presented in Table 1. Each module utilized the same format: (1) introduction and learning objectives; (2) study questions to help students prepare for an assessment at the end of the module; (3) brief online lectures and supplemental readings, such as downloadable journal articles and links to open source websites; (4) application (case study) exercises to help students apply learning; and (5) frequent self-check assessments in the form of 10-item multiple choice and true/false quizzes that were presented and scored electronically, with feedback provided on individual questions.

Table 1

Transition Planning from Early Intervention to School-Based Services Course Modules

Module 1	**Roles and Responsibilities**
	• Rights and Entitlements of Children (transition from Part C to Part B) • Roles and Responsibilities of the Early Intervention Team • Roles and Responsibilities of the School: The IEP Process • Roles and Responsibilities of Parents/ Family
Module 2	**Stages of the Transition Process**
	• Benefits to Transition Planning • Development of a Planning Team • Setting Goals and Identifying Problems • Defining Roles • Developing a Written Transition Planning Procedure • Follow Up and Evaluation of Child's Adaptation to School-Based Setting
Module 3	**Effective Strategies for Transition**
	• Most and Least Common Practices to Preschool (research summary) • Barriers to Transition • Facilitators to Transition • Addressing Cultural and Linguistic Diversity in Transition • Helping Families Transition

Field Evaluation

EI professionals were recruited via email to LISTSERV members identified by leadership staff who participated in the survey. Forty-six professionals volunteered to participate and were enrolled in the course. Of these, 35 logged in, completed a demographic survey and course pretest, and began the course. Thirty participants completed the entire course, which included taking the posttest and end-of-course satisfaction survey. Upon completion of all course requirements, each participant received a stipend of $50.

Demographic and Descriptive Information

The demographic survey asked participants about their current employment, educational background, and their experience with technology. All information was kept confidential; no names or identifying information were revealed. All participants reported that they were employed while enrolled in the course, with 77% working full time and 23% part time. On average, they had been providing EI services for 6.5 years (range = 6 months to 20 years), and they represented several disciplines within EI, as shown in Table 2. Seven participants (23%) selected "other" when asked to identify their discipline. This subgroup was

Table 2

Percentage of Participants Representing Each Early Intervention Discipline (*n* = 30)

Professional Discipline	Percent Who Selected Option
Early Childhood Special Education	23%
Early Childhood Education	21%
Social Work	20%
Occupational Therapy	7%
Speech and Language Pathology	3%
Psychology	3%
Other	23%

comprised of four administrative and supervisory personnel, two nurses, and one Spanish language translator.

Participants also reported their education level, race, gender, and age. Half of the participants held bachelor's degrees (50%); the remaining participants held master's degrees (37%) or associate's degrees (13%). Participants reported their race as White (90%) or More Than One Race (10%). Seventeen percent of participants identified themselves as Hispanic or Latino. Nearly all participants who completed the course were female (97%). Finally, participants' average age was 44 years (range = 24 to 62 years).

Table 3 shows participants' goals for taking the course, which were primarily to improve their skills as early EI specialists. Data collected on participants' online experience indicated that access to and comfort with technology were likely to be important factors contributing to their success in the course. Nearly all participants (86%) said that they used a computer several times during the day on most days; the remainder (14%) said that they used a computer about once per day. Almost three-quarters of the participants (70%) said that they used the Internet frequently during the course of the day. Others reported using the Internet about once per day (20%), or once per week (10%). Table 4 shows participants' experience with computers, Internet browsers, email, and online discussion or chat groups.

Participants reported working on the course for a total of about 7 hours on average (range: 2–12 hours). Only two participants (7%) said that they were not always able to access the course. All of the participants said that it was helpful to be able to go through the course at their own pace.

Table 3

Participants' Primary Goal for Taking Course ($n = 30$)

Goals	Percent Who Selected Option
Generally improve my skills as an early intervention specialist.	33%
Gain complete understanding of transition planning.	13%
Learn about the stages of transition planning from EI to school.	11%
Learn about the roles and responsibilities of transition team members.	10%
Learn more about transition planning from EI to school, in general.	7%
Learn about the role of family members in transition planning.	0%
Learn about effective strategies for transition planning from EI to school.	0%

Knowledge Acquisition

In order to establish their baseline knowledge in transition planning as covered in the course, participants completed a 30-item pretest comprised of multiple choice and true/false questions that asked about the definition and goals of transition, the purpose and components of Individualized Family Service Plans (IFSPs) and Individualized Education Programs (IEPs), the meaning of evidence-based transition practices, IDEA and Part C stipulations, selected research findings on transition, communication strategies for use with parents about transitions, and barriers and facilitators of transitions, among others. Once the pretest was completed, the course was made available to participants. They were given three weeks to complete all three modules and then completed a posttest, which allowed a comparison with their pretest results to assess knowledge gained

Table 4

Percentage of Participants Who Reported Engaging in Relevant Computer and Internet Activities ($n = 30$)

Computer/Internet Activity	% of Students
Email	100%
Taking courses online	93%
Watching online video clips	77%
Browsing the Internet for information on transition planning	70%
Participating in online discussions or chat groups	40%

from the course. The pretest and posttest were identical in order to ensure that question/test difficulty was consistent. None of pretest and posttest items, or similar items, was presented in any of the self-check assessments delivered within the modules. This was done to avoid participant practice effects with the test items.

Thirty of the initial 46 participants completed the course in its entirety. The average score on the pretest was 40% ($\sigma = 7.56$), and on the posttest it was 83% ($\sigma = 12.18$). A paired-samples *t*-test was conducted on students' pretest versus posttest scores to determine the degree of participant learning. Results indicate a statistically significant increase in scores, $t(29) = 17.24$, $\rho < .05$. On average, participants' test scores increased 43 percentage points ($\sigma = 13.54$).

Course Satisfaction

Participants were asked upon course completion to respond to a 17-item survey to assess their satisfaction with the course content and format, the quality of their overall experience, and their perceived learning. The satisfaction survey utilized yes/no questions, 4-point Likert-style ratings, and open-ended questions. Data collected on participants' opinions on the design of the course showed that nearly all (97%) felt that the course was easy to navigate and that the design of the pages was visually appealing (97%). The one participant who rated the design as not appealing explained that she actually did not pay attention to the design.

Participants responded to a series of questions about online features designed to enhance learning. In general, participants were pleased, reporting that the self-check tests were a useful tool for learning (93%); the online text/readings were useful in helping them to understand transition planning as it pertained to EI (93%); and the links were helpful in directing them to useful websites that added to their understanding of transition planning pertaining to EI (90%). Furthermore, all of the participants reported liking the automated grading feature of the within module self-check assessments.

Data also were collected on participants' impressions about the difficulty, language, and organization of the course material. The majority of participants said that the course material was at the right level (90%), and that the language was easy to understand (90%). All participants felt that the information was presented in an organized and logical fashion. Participants also responded to a series of questions about the amount and quality of information presented. Participants' satisfaction with course content and activities, using a Likert-type scale in which 1 = very poor, 2 = needs improvement, 3 = satisfactory, 4 = good, and 5 = excellent, is shown in Table 5. Overall, participants' satisfaction was 3.80 ($\sigma = 1.00$).

When asked about their perceived competence when working on transition planning from EI to school as compared to before completing the course, the majority of participants said that they felt more competent. Sixty-four

Table 5

Average Ratings and Standard Deviations of Students' Satisfaction with Course Content and Activities ($n = 30$)

Content and Assignments	Sample Mean (μ)	Sample Standard Deviation (σ)
Amount of information provided by this course	3.20	.41
Quality of information in this course	3.20	.55
Relevance of information to the course objectives	3.48	.51
Usefulness of the course activities and assignments to the course objectives	3.30	.60
Usefulness of the course activities and assignments to your job	3.17	.70

percent reported being somewhat more competent, 18% reported being considerably more competent, and the remaining 18% reported no change.

Discussion

Professional development in EI, while mandatory, is a challenge to accomplish for many busy professionals who find themselves juggling their personal and professional lives. Internet-based online learning is one method that can be as effective as face-to-face courses (Carr, 2010; Kambutu, 2003; MacPherson-Court et al., 2005; Sulzer-Azaroff et al., 2008; U. S. Department of Education, 2010a). Participants in the current evaluation acquired knowledge from the beginning to the end of the course and reported that they enjoyed the ease and flexibility of the online format. One participant exemplified the experience of many, replying, "I really enjoyed this course and the content. I feel that it will benefit my overall EI knowledge base. The ability to complete the course at my own pace was something new for me and I am going to look for more online learning opportunities for staying up to date with topics in EI."

Data gathered from the course surveys also indicated that participants felt more competent in applying transition planning in their jobs as a result of taking the course. The significant positive change in pretest to posttest scores demonstrated that they successfully learned new material in an online format and at their own pace. Still, the resulting mean posttest score of 83%, as opposed to something closer to 100%, suggests that the instructional design and educational technologies used in the course could be improved to increase knowledge acquisition. Perhaps most important is the need to conduct research on the extent to which online courses such as this one, taken by EI professionals for preservice and inservice training, will result in improved professional practice on the job. It is promising that several participants in this study reported that they could apply course knowledge on the job, e.g., "…the information will help [me] when answering parents' questions regarding transition," and, "I can use this information when training new staff on effective transition processes." Still, data on transfer of learning from course to job are needed.

Participants reported that the course design and navigation features were satisfactory. All felt that the information was presented in an organized and logical fashion, and the majority (90%) thought that content and material was satisfactory. However, several participants provided feedback stating that they wished there was less emphasis on research findings in favor of more hands-on information applicable to their own work. While hands-on information was presented in the form of application exercises (case studies), research article readings also were included to present evidence-based information relating to the steps involved in transition planning.

Future studies should continue to explore not only important components of transition planning to be presented in online courses, but also the efficacy of instructional media technology, Web-based supervision, and mobile device applications (Zwang, 2011) applied as mechanisms for professional development. The U. S. Department of Education (2010b) meta-analysis and review of online learning research concluded that online learning is enhanced when blended with face-to-face instruction or instruction that in other ways involves the support of an instructor. Research to further test the efficacy of the current course could include variations of these blended learning features in addition to increased interactivity using media-based simulations, which have been found to be effective in online training health researchers (Aggarwal, et al., 2011).

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JSET

Technology in Action

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Visual Supports for Individuals with Autism Spectrum Disorders

Visual supports are identified by the National Autism Center (2009), Twachtman (1995), and Myles, Grossman, Aspy, Henry, and Coffin (2007) as an effective evidenced-based strategy for individuals with Autism Spectrum Disorders (ASD). Visual supports is a collective term referring to items that are perceived via the eyes and that increase understanding of a particular environment and/or expectations in that environment and/or contribute to an understanding of communication by making auditory information available in a visual manner (Smith, 2007).

Environmental visual supports are encountered frequently in our everyday lives. Flight schedules on airport monitors direct travelers to the appropriate gate; roped off areas at construction sites convey the message to stay out; and lines on the floor at motor vehicle offices indicate in which line we should stand for service. These are all examples of visual supports provided for the general public. They are understood easily and replace the need for lengthy text-based explanations or oral presentations of the rules or procedures. Environmental visual supports are especially beneficial for individuals with ASD. The use of visual supports has been shown to increase these individuals' ability to complete tasks independently; learn more rapidly; demonstrate decreased levels of frustration, anxiety, and aggression related to task completion; and adjust more readily to changes in their environments (Smith, 2007).

Communication visual supports address the problem of speech and gestures being fleeting (once spoken or demonstrated, they disappear). Visual supports offer a static form of communication that remains present. This static message can remain as long as the individual requires it in order to understand the message or to serve as a reminder of a message that might be forgotten. Visual supports may provide an analysis of a complex task, a label showing where to find or place materials required to complete a task, or a schedule to help a student understand where to go or what to do next. For example, a student who comes home from school and wants to watch TV might benefit from a visual schedule that shows which chores must be completed before having free time to watch TV. The use of a visual schedule can help the student avoid anger and frustration at being told that he cannot watch TV until he completes his chores. The visual schedule also can help to build independence, because in the presence of visual prompts the student will need fewer verbal reminders from adults.

Handheld Assistive Technology for Visual Supports

Traditionally, visual supports have been constructed using photographs, pictures, or line drawings that have been printed on paper; these often are laminated for increased durability. The process of constructing these low-tech visual supports can be time consuming and can result in large notebooks containing pages of printed symbols that may be cumbersome to carry and/or stigmatizing to use. Low-tech visual supports also are difficult to adapt when teachers are faced with sudden unexpected schedule changes, environments, or social situations. In addition, low-tech visual supports may be too abstract for some students with ASD to process. High-tech visual supports created and presented on handheld devices such as iPhones and iPods are a promising alternative that overcomes the limitations of traditional visual supports.

Visual support apps running on handheld technology have the potential to allow teachers to more effectively and efficiently address the needs of individuals with ASD. These visual supports can be created in less time and with less effort, thereby increasing the likelihood that they will be available and that they will be used. Changes can be made to these supports easily, even at the last minute, to adjust to unexpected circumstances. The portability of handheld devices accommodates the need for using the supports in multiple locations within the educational setting. Multiple types of visual supports can be created and stored on a single handheld device, and they can be customized to meet the individual needs of different students. Additionally, providing visual supports through apps running on a handheld device are less stigmatizing for students with ASD because these mobile devices also are used and valued by their typically functioning peers.

Whether using a handheld Apple device such as an iPhone or a device running the Android operating system, there are a plethora of apps for creating visual supports. Picture schedulers, timers, to-do lists, calendars, and more are readily available for free or a fee. Table 1 provides a sampling of currently available visual support apps.

Despite the ready availability of visual support apps, little has been done to analyze the utility and appropriateness of providing visual supports via high-tech assistive technology. Research has validated the use of low-tech visual supports (National Autism Center, 2009); now, research is needed to determine the feasibility and/or effectiveness of using high-tech, handheld devices to provide visual supports.

Pilot Study Description and Results

To evaluate the feasibility and promise of using handheld technology in authentic educational delivery settings, a pilot study was conducted using the iPrompts v.1.2.1 app on the iPhone. The iPrompts app allowed participants to create and present a variety of customizable visual supports—visual schedules, visual timers, and visual choice-making among objects. Twenty-five certified teachers completing a practicum requirement in the master's level autism concentration at Southern Connecticut State University (SCSU) used the iPrompts app with 88 students with ASD in a Connecticut public school. The students ranged in age from 5 to 16 years of age. Practicum participants, under the supervision of SCSU faculty members, were responsible for providing social skills training and working on functional communication skills for three weeks during the school district's extended year program.

The practicum teachers were grouped into 11 teams of two and one team of three and provided with a 90 minutes of training. The first part of the training focused on how to use the iPhone. The second part of the training focused

Table 1

Visual Support Apps

App	Developer	Available from	Compatible Device(s)
iPrompts	HandHold Adaptive	iTunes, Google Play, BarnesandNoble.com	iPhone, iPod touch, iPad, Android devices, Nook
Picture Scheduler	Petr Jankuj	iTunes	iPhone, iPod touch, iPad,
First Then Visual Schedule	Good Karma Applications	iTunes, Google Play, BarnesandNoble.com	iPhone, iPod touch, iPad, Android devices, Nook
Visules	Dean Huff	iTunes	iPhone, iPad
U-Sync Video Scheduler	Agile Disability Solutions	Google Play	Android devices
TASUC Schedule for Android	Info Lounge	Google Play	Android devices

on how to use specific features of iPrompts. After the training, each team was provided with one iPhone with the iPrompts app preinstalled. The teams were asked to incorporate the use of the iPrompts app with their students.

Multiple measures and data collection techniques (e.g., observation, focus group) were used to evaluate and analyze the teachers' use of the iPrompts app. Data from the focus group revealed that all teachers believed the iPrompts app was not too complicated to set up and that they knew how to use it. A majority of the participants indicated they preferred using high-tech visual supports rather than traditional low-tech methods due to the ease of use, the amount of time and effort that was saved, and the ability to use the application quickly when unexpected needs arose. Several participants commented on the effectiveness of the app's features in helping with group transitions, keeping individual students engaged in their work, and helping individual students stop one activity in order to begin another. In the focus group, additional stories of the positive impact that the app had on their students' behavior were shared, and the majority of teachers indicated they would like to continue using the iPrompts app.

Observational data showed that teachers were able to use the handheld device and the iPrompts app correctly. Teachers were able to use graphics from the picture library within the app, and some used pictures taken with the iPhone to further individualize the visual supports. All the visual supports available in iPrompts—visual schedules, visual timers, and visual choice-making among objects—were used by the teachers; the visual timer was the most widely and frequently used visual support.

Lessons Learned

The results of this pilot study lend support for high-tech options as a feasible and effective method of providing visual supports for students with ASD. The data also helped to identify additional aspects that must be addressed during training to improve the chances that the technology will be implemented effectively and that students will receive the greatest benefits.

Although the teachers felt they had received sufficient training and had the knowledge necessary to use the iPhone and the iPrompts app effectively in their teaching, the observational data and focus group data highlight the need for additional training. Several teachers expressed concern about a problem of the image on the screen disappearing and the screen turning black. One participant commented that she did not realize this happened until she watched a video of herself using the app with her students. She was talking to her students about what they were seeing, and when she saw the video she realized they were not seeing anything but a blank screen. These comments indicated that they thought this was due to the iPrompts app, when in actuality it was due to a screen saver setting on the iPhone. Therefore, instruction related to the general settings and features of the handheld device as well as differentiating between features of the device and features of the app is warranted.

In addition to needing training related to the general implementation of high-tech visual supports, this pilot study revealed that training is needed on how to pair assistive technology uses with specific classroom situations. Observational data reveal that, at times, some teachers opted to use handheld technologies with students even when it was not appropriate to do so. During one observation, a teacher presented choices and encouraged a student to make a selection on the handheld device even though the student already had verbalized his choice clearly. Rather than presenting a visual schedule prior to a transition, another teacher presented the visual schedule while a student was already experiencing a meltdown. Emphasis needs to be placed on the fact that best practices related to the use of visual support strategies must be utilized regardless of whether the visual supports are low-tech or high-tech.

Influencing the Field—A Happy Accident

Teachers' focus group input included numerous comments about the viewing screen needing to be bigger so groups of students could see it better. These comments stemmed from an inappropriate use of the app. The iPrompts application was developed to support individual students; it was not intended to be used for groups of any size. For example, the scheduler tool is designed to help a particular student through a difficult transition from one activity, situation, or environment to another. It was not designed to be used for a group picture schedule. Upon receiving this feedback, however, HandHold Adaptive, Inc., the developer of the iPrompts app, responded by developing iPrompts XL for the iPad, thus providing the bigger view screen and expanding the ways in which the app could be used to support students with ASD.

Looking Forward

The handheld technology presented to the teachers in this pilot study was embraced with enthusiasm, which is not always the case when assistive technology is delivered to teachers' classrooms. In many instances, high-tech assistive technology is not mainstream technology. It often is viewed as more work for the teacher, as it is necessary to either put in extra time at school or lug the technology home to learn how to use it. The iPhone, on the other hand, had a cool factor at a time when smart phones were not yet quite so ubiquitous. The training provided for the teachers before receiving the iPhone with the iPrompts app meant they could immediately start using the assistive technology. If they wanted to explore more on their own or set up visual supports in advance, transporting it was easy due to its small size. The iPhone and iPrompts app were available whenever and wherever the teachers had time to work with them. The question of which of these factors (alone or in combination) or what other factors made the teachers so eager to use the assistive technology was not examined. What factors influence teachers' acceptance and use of handheld technology remains a question worth exploring.

The iPrompts app running on the iPhone allowed teachers to create visual supports more efficiently, to customize them easily to meet the needs of individual students, and to meet the needs of more than one student with the same handheld device and app.

This pilot study demonstrated that training on how to access the iPrompts app on the iPhone and how to use the app is not enough. Teachers need more in-depth training to learn about the settings and features of the device on which visual support apps are running and the strategic use of high-tech visual supports. There may well be other training needs and supports that did not become evident in this short pilot study. This leads to an additional question for future research: What are the supports necessary for successful implementation of visual supports on handheld technology in the school setting?

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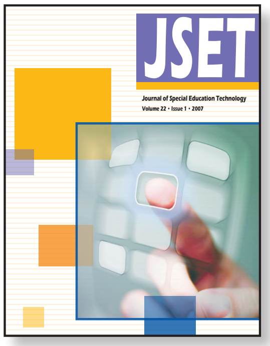

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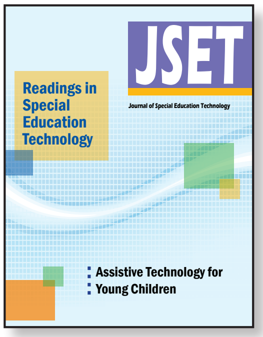

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