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Assistive technology for students with learning disabilities: A glimpse of the livescribe pen and its impact on homework completion

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Abstract This research investigated the effectiveness of an assistive technology tool, the Livescribe Pen (LSP), with an elementary student identified with dyslexia. Using interview and focus group methodologies over the span of one academic year, the study probed the perceptions of teachers, parent, and child. While the LSP was primarily utilized for curriculum accessibility and an audio tool to promote academic independence, the study's findings reveal its impact as an assistive technology on both academic success for children with disabilities as well as non-academic gains. These included an increase in independence, more time for social activities, and the ability to develop strategies for homework success. Most importantly, the academic team and the parent reported a sense of higher aspirations for this student; ones they had not thought possible previously. Finally, the study revealed two elements critically important for students with disabilities. Those are the importance of fostering communities of support and the importance of self-determination.

Keywords Assistive technology · Livescribe pen (LSP) · Homework · Learning disabilities · Home-school connection · Universal design for learning (UDL)

With approximately 2.4 million of American public school students identified with a learning disability (LD) under the Individuals with Disabilities Education Act (IDEA), the nature of particular needs and neurological differences continues to be better understood (Cortiella and Horowitz 2014). Transformation efforts that lead to wider success in all aspects of children's lives who live with a LD sometimes involve the

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adoption of instructional technologies or the introduction to assistive technologies. The Livescribe Pen (LSP), for example, sometimes referred to as "the pen that never forgets" (Thompson 2010) is a smartpen equipped with a removable ballpoint ink cartridge, a microphone to enhance audio recording, a playback speaker, an infrared camera, and internal flash memory that can store handwritten notes, audio and images. The LSP, founded by Jim Marggraff in 2007, was initially introduced to the market in 2008, and has since undergone four versions that currently has the capacity to store one hundred hours of audio per gigabyte. This model, the Livescribe 3, can be synced with iOS and Android devices where notes synchronously appear and can be stored for future reference. LSP as an assistive technology utilizes Anoto digital paper that stores audio recordings respective to the notes taken. As an example, handwritten science notes and diagrams in the Anoto digital paper notebook can play back audio recorded when the notes were taken with just a tap of the pen. Students can, therefore, listen to their 'teacher' over and over again at their convenience and request. Apps such as a calculator, or word translator in multiple languages can be downloaded among many other features this smartpen offers. In a study conducted by The Yale Center for Dyslexia & Creativity six students were followed, five at the high school level and one in eighth grade for six weeks. Findings suggested that most students found the LSP to be a powerful study aid especially given that more time could be spent listening and learning than on note taking with the playback feature (Frankenberger 2016). The University of Michigan, among many other universities, promote the LSP as an assistive technology to aid with listening and notetaking (Ryan 2016) (Fig. 1).

The LSP integrates advanced, technological features including the ability to record audio synchronized with pen strokes written on paper, into a wireless pen. The pen strokes written on paper, when tapped with the tip of the pen in playback mode, provide the audio recording captured while writing. The LSP can be utilized by students across all levels to provide supports when completing academic tasks such as writing lecture notes synched with audio capturing the lecture. Students can devise personalized techniques and strategies to maximize the LSP's unique features that are integrated into the practical, everyday tool of a pen. A benefit of using the LSP within the classroom is, to those unaware of the device, students appear to be writing with a typical pen while taking notes or completing coursework. After recording audio, two options are available for playback. The internal speaker built into the pen amplifies the audio or a headset can be plugged into the LSP for individual playback. Additionally, the audio playback feature enables the student to slow down or speed up the recorded audio. This ability to differentiate the rate of audio accommodates for a student's individual learning needs. When the LSP is utilized as assistive technology, academic activities can be enhanced for a student within inclusive classroom environments. After learning how to use LSP's features, a student can adapt and use the pen's functions to address individual and specific areas of need. For example, a student struggling with expressive writing skills can utilize the pen to elaborate on and add verbal responses to written answer questions recorded on paper. A teacher can then replay the audio while

Fig. 1 Livescribe 3 Smartpen. The Livescribe 3 Smartpen utilizes Bluetooth technology to sync everything with a smartphone or tablet. (www.livescribe.com 2016)

reviewing the student's written work, reviewing the audio verbal responses to assess the student's level of comprehension.

Dyslexia, a learning disability whose features vary from person to person, i.e. difficulty with phonological processing or phonemic awareness or decoding, is the most prevalent and commonly recognized of the subtypes of LD (Cortiella and Horowitz 2014). An empirical study led by Brante (2013), included seven individuals with dyslexia currently or formerly in higher education. All seven were interviewed about their reading experiences and none could identify any strategy for overcoming dyslexia other than investing much time into their homework and studying. Across all participants, in fact, time investment was considerable and the time-consuming nature of reading expended much of their energy levels. Brante (2013) also concluded that each of the participants had individual strengths, and weaknesses signifying the diversity of impairments found under the common diagnosis of dyslexia.

According to Eide (2016), the K-12 educational landscape for children with dyslexia resounds the higher education scene. The *Dyslexia at School Survey* conducted by Dyslexic Advantage (2016) found that an overwhelming majority, 76 %, reported that homework they were routinely assigned, they could not complete. Half of the students surveyed across the United States were of elementary age. Parents were given the opportunity to respond as well noting their children took three times as long to complete their work compared to their peers, their after school hours were consumed with completing homework, and anxiety and frustration levels built after school. "Lack of adequate teacher training and best practices for dyslexia leads to unrealistic homework and other work expectations as well as a cascade of negative consequences for dyslexic students" (Eide 2016). A review of the related literature that follows examines the value of home-school partnerships, parental aspirations and the benefits of a Universal Design for Learning (UDL) environment that can contribute to the overall academic program in addition to assistive technology that supports students with special needs.

1 Review of the literature

1.1 Home-school connection

The benefits of home-school collaboration have been documented for many years with a variety of positive outcomes. Research has shown that family involvement can have a significant effect on their children's achievement. In fact, according to Epstein and Sheldon (2006), family and community influences may account for as much as 40–65 % of children's learning. Partnerships between home and school can have a positive influence on children's engagement in their school work as well as their enthusiasm toward learning (Brooking 2007). The more extensive the parent involvement, the higher the student achievement (Teale and Yokata 2000). Brooking (2007) defines home-school partnerships as "…ideas and initiatives schools have implemented that involve parents, families, in their child's learning, in an effort to form closer relationships between school and home" (p. 14). Along similar lines, Christenson et al. (1992) describe the home-school partnership as a relationship between families and schools that promote the academic and social development of children.

In 1987, the Research and Policy Committee of the Committee for Economic Development (1987) promoted policy development that targeted the whole child with intervention strategies to be implemented in the context of school, family, and community. However, Ryan and Adams's (1995) analysis of the empirical research from the 90's decade showed home and school as independent rather than as an integrated and overlapping system in children's lives. Similarly, the Goals 2000: Educate America Act, recognized the importance of partnerships between schools and families and the involvement of parents in promoting their children's academic, social and emotional growth (Cox 2005). To that end, Brooking (2007) argues that parents need to be educated about their children's curriculum and ways they can support learning on the home front. Furthermore, Crozier and Reay (2005) assert that schools also need to be proactive in recognizing ways to circumvent barriers to parental involvement.

Cox's (2005) meta-analysis of evidenced-based interventions of home-school collaborations highlighted two noteworthy studies that were among the most successful: Morrow and Young (1997) and McConaughey et al. (1999). Both studies utilized interventions where schools not only collaborated with families but treated them as equals that led to the families feeling more empowered to help their children and more comfortable participating in their child's education. Additionally, Pryor and Church (1995) highlights strategies and techniques to promote family- school partnerships and describes elements that foster relationships including effective communication, equality among partners, and school support of home activities. Patton et al. (2001) discuss types of home-school collaboration, as well as challenges and solutions through recommended practices regarding homework. Morrow (1995) stated that when rich literacy home environment provides experiences that simulate the school environment, they will be more successful with reading and writing. Baker (2003) describes findings indicating home influences on reading motivation and provides suggestions to teachers to enlist parents to motivate struggling readers.

1.2 Parent and child aspirations

Pryor and Church (1995) examines the relation between parent educational aspirations and the educational aspirations of students with learning disabilities. Findings indicate that parent aspirations for their children did affect the educational aspirations of their children, regardless of learning disability status. The higher the parents' aspirations for their children, the higher the aspirations children held for themselves. Further, Pryor and Church (1995) asserts that although learning disability status did not affect parent or student educational aspirations directly, it did have an indirect influence on academic performance, consequently decreasing parent and student aspirations. Along similar lines, Cosden et al. (1999) hypothesized that increased knowledge about their learning disability would also increase the self-esteem of children who had LD. Rather, their findings indicate that the children's understanding of LD was associated with actual and perceived scholastic competence while their global self-esteem was associated with perceptions of competence in nonacademic domains. LiveScribe, a tool primarily utilized for curriculum accessibility as well as an audio tool that promotes academic independence, has the potential to garner a greater understanding of one's LD and subsequently enhance metacognitive skills and strategies. Cortiella and Horowitz (2014), for example, finds it critical to pair unique needs with modifications or accommodations that are designed to result in optimal success.

1.3 Use of Universal Design for Learning

Strobel et al. (2007) outlined market research on how to identify critical technology needs for people with learning disabilities. Findings indicate the underlying context of these technology needs is Universal Design for Learning (UDL). These authors assert increased knowledge and awareness of the need for UDL environments is critical to the success of students with LD. Wehmeyer et al. (2008) meta-analysis on the efficacy of technology use by people with intellectual disabilities revealed most empirical studies did not employ universal design features to individually meet the needs of students with different learning disabilities and more empirical studies that examine 'cutting edge' technology and its impact on student learning is critical. Maor et al. (2011) argue that assistive technology has the potential to enhance the performance of children with special needs and the investment in assistive technology known to exist should be more visible in the scholarly literature. Kennedy and Deshler (2010) recommend that educators select or design multimedia materials for use in literacy instruction that (a) logically extend existing pedagogy; and (b) explicitly help students build skills necessary for literacy-related success, including meeting individual needs, along with demands of local and state standards. Thus, the LSP as an assistive technology has the potential to allow students to build these necessary literacy skills.

2 Purpose of the research

Although the LSP is becoming more widely recognized in the higher education communities, the empirical research remains limited. The authors sought to examine the LSP's utility in supporting learning and instruction, as well as accessibility for students with high incidence disabilities.

Throughout the course of the school year, we systematically pursued pedagogical insight from faculty into how this assistive technological tool may have influenced the lives of their students with special needs across the cognitive and social-emotional domains. While capitalizing on what is currently known about best practice, the purpose of this research was to further explore how this assistive technology could be utilized. Specifically, the objectives were to document the impact of the LSP for (a) curriculum accessibility, (b) how it could be employed as an audio tool to promote increased academic independence, and (c) how it could be utilized as a tool for promoting academic study skills, among other instructional purposes.

The research investigated the effectiveness of an assistive technology tool, the LSP, for children with disabilities. More specifically, this case study evaluated the use of the LSP to support one fourth-grade student who was labeled as having dyslexia consistent with the definitions in the New York State Education Department (NYSED) Part 200 Regulations.

3 Description of the intervention

Teachers who participated in the intervention and subsequently the study, worked at a partnership school the college collaborated with for student teaching placements and other initiatives. The investigation began when one of the teachers requested assistance

in supporting one of her students with significant learning disabilities. After conferencing with the authors who then conducted a literature review to choose a tool, the LSP was chosen as a potential intervention.

The teachers including the fourth-grade classroom teacher with fifteen years of experience, the special education consultant teacher who had twenty-five years of experience and the Academic Intervention Services (AIS) teacher for English Language Arts (ELA) with twenty years of experience, were currently working in fourth-grade and were trained in the use of the pen. The mother and her fourth-grade child were also main participants in the study. The child was eager to utilize the pen while the adults' reactions were a bit more cautious as they were not familiar with the new technology. Once trained, the teachers embraced its use and the mother became more familiar through her daughter's lead.

At first, the teachers agreed to utilize the pen for assignments; especially those required for ELA homework. The teachers recorded required reading passages with the pen. This included everything from Scholastic newspaper articles to content area textbooks, to word problems in mathematics. The student was then able to read along while listening to the narrative at home. She was also able to record (rather than write) her responses to writing prompts that followed each passage. As the team found success, the pen's use was expanded. After a short while, it was used daily in ELA and mathematics, for all assessments in school, and daily for homework.

4 Methodology

Qualitative data were collected utilizing interview and focus group methodologies. Kvale (1983) defines the primary purpose of the qualitative interview as "gathering descriptions of the life-world of the interviewee with respect to interpretation of the meaning of the described phenomena" (p. 174). The interview and focus group questions invited conversation that could highlight each constituent's unique perspective. According to Kvale (2006), qualitative interviewing techniques often result in receiving rich in-depth details about the participants' experiences.

All participants received informed consent forms prior to the interview and were allowed to ask relevant questions regarding their role. Each was assured that confidentiality would be respected and that their information would be reported with anonymity. Further, the researchers employed member checking during the interview and at the end of the analysis increase the credibility and validity of the study. The researchers built rapport with the participants in order to obtain honest and open responses. During each interview, the researchers restated or summarized information and then questioned the participant to determine accuracy. Each was provided with the findings section and allowed to question any part of the report. These member checking strategies (Lincoln and Guba 1985) provide trustworthiness to the analysis and ensure content validity. Data were coded individually by the three researchers and then themes created provided the framework for subsequent analysis. Findings reflect data that were triangulated in a variety of ways.

Interviews were conducted throughout the school year. The researchers met with the teachers on a regular basis (monthly) to provide support, trouble shoot any challenges encountered, and brainstorm solutions. At each meeting, teachers reported on the pen's

use and their experiences related to the new technology. Through the interview process, the researchers ascertained and explored views from the staff, parent, and student perspective of their experience utilizing the LSP in their own terms and framework of understanding. School personnel were interviewed as a group on multiple occasions throughout the year and in one final follow-up session. The mother was interviewed one time alone, and another with her daughter. At this second interview, the student's perspective served as the main focus and the mother elaborated on the student's response. The researchers systematically evaluated data throughout the year using thematic coding. Iterative analyses of the data identified important and sometimes unexpected themes that emerged.

5 Data sources

Data were derived from structured and unstructured interviews with higher education faculty and the practitioners, the parent, and the student. Data collected also included anecdotal notes from the practitioners (i.e., email correspondence), student data from progress monitoring tools, and a review of student's work and relevant student records. Participants were provided a list of questions before each structured interview and were allowed to elaborate on their answers in subsequent meetings. The practitioners and the mother were provided with similar questions. These included: What was the student's receptivity toward the pen? How did you implement the pen at first? Did the school communicate with you why they thought it would be useful for you to use? Codes that emerged included: (a) initial thoughts about the pen, (b) receptiveness to the pen, academic uses of the pen, and (c) outcome of its use (self-directed learner, ownership of work, academic gains, and non-academic gains). These codes surfaced as a result of the collective qualitative interviews empowering the participants to 'tell their story.'

6 Data analysis

After all interviews were transcribed and checked for accuracy, the three researchers read them individually. Each developed a list of themes identified during this first reading. Next, they shared lists to ascertain similarities and differences. Codes were agreed upon by all three, some were combined that were synonymous, and an outline with multiple levels emerged. Finally, they re-read the transcripts and coded data adhering to the outline. Again, similarities and disagreements were addressed, codes were narrowed, and various sources considered. Themes were included in the final analysis if they represented unanimous agreement, were evident across multiple sources, and were triangulated across data sources. No apriori design was defined, that is, themes emerged as a result of data analysis.

7 Findings

This case study research examined the role the LiveScribe technology played in the academic success of one fourth grade student with dyslexia. Utilizing the LSP for this

specific purpose is different from what we currently know about best practice in meeting the needs of students with this disability. Specifically, the study sought to reveal its impact on three areas: curriculum accessibility; its use as an audio tool to promote independence; and academic study skills. Findings indicate much more in terms of impact. The LSP seemed to increase the quality of life (overall happiness, increased independence, more free time for leisure activities, etc.) for the child with disabilities from an academic and social standpoint.

7.1 Curriculum accessibility

Use of the pen allowed the student more access to the curriculum. For example, nightly homework that included an extensive amount of reading proved futile prior to the pen's use. The LSP provided an audio of the printed text (recorded by the teacher during the day), thus allowing the student to listen while she read the narrative. Further, other forms of accessibility included test taking (also recorded), and word problems in mathematics.

The team also reported the LSP's ability to remove barriers for the student. The teacher recorded story problems in mathematics, for example, and the student could listen for keywords that prompted the appropriate operation(s) utilization to solve the problem. Suddenly, she had access to material and subject matter that was previously inaccessible because of her disability. Now, utilizing the UDL principles of multiple means of representation, engagement, and expression, the child was able to engage in the material as she needed, and express what she knew by using the pen.

7.2 Increased independence

In terms of non-academic gains, both parent and child reported increased independence that influenced other feelings of success. The mother reported that the child began to return home and immediately begin her homework; a routine that frequently resulted in tears and frustration in the past that on average lasted four hours. This increased independence also allowed the mother to spend time on other household duties that included paying more attention to her younger children. As a result of the increased independence, the student was also able to complete her work more quickly, on average one hour. That is, the mother and child both reported the extensive number of hours it used to take to complete homework. The mother also described the frustration and tears that resulted in exhaustion by the end of the tasks assigned prior to the pen's use.

7.3 Academic study skills

Changes in study skills were not revealed upon interviewing the adults. Unknown to the adults, the student explained how the pen helped her study. When interviewed, she described in detail, a method she had developed using the pen that improved her ability to express herself in writing. While the teachers reported the same, they were not aware of any reason *why* she was writing better and attributed her success to other factors (increased word recognition, availability of more time). The adults were all surprised to learn of the strategy the child had created. When required to write a long passage (student's words), the child would create bullet points in her (often illegible)

handwriting. Then she would record her thoughts in an organized manner to create the writing piece. Since no one else was able to decipher the handwritten words, the pen facilitated the student's success as she was able to 'write' in a more comprehensive manner. She often listened to her own work and made changes as appropriate, thus implementing the editing process in an auditory manner. The strategy use also fostered better time management, enhanced her auditory skills, and deepened the connection between reading and writing. The child had advice for both children and adults who may be considering the LSP's use:

> "You should use it because it can help you a lot with reading and it can help you a lot with your homework because sometimes reading can be really hard for you."

For example, the child, her mother, and the teachers all reported an increase in sight word vocabulary and increased efficiency in completing homework. Before the LSP, the child would begin homework shortly after arriving home from school that would lead well into the evening hours. Socially, all reported increased independence, the mother reported more time for social activities (dance lessons, for example), and all described a student who seemed to be happy more often. It has raised the level of practitioners' expectations of literacy gains, as well as the level of communication of ideas from the student who demonstrates her knowledge commensurate with her otherwise untapped abilities through features of the LSP.

While the findings related to the teachers and parent provide a great deal of insight into the pen's use, those perceptions from the child lend themselves to feelings of transformation for this student. Further, the objectives of the study were to document the impact on academic and social domains in school, yet, the findings reveal a much deeper impact. Changes in the child included non-academic gains, ownership of her learning, and thoughts of her future.

7.4 Non-academic gains

Ownership of her learning With the pen, the child was not only able to begin homework independently, but she found she was able to finish earlier, thus having time for other activities (i.e., social activities such as clubs, sports, etc.) or continued work on flash cards and other learning tools she utilized. She took charge of her own knowledge.

Increased happiness Over time, all involved reported seeing a child who was always happy. The increased independence, success, and time for "more important" tasks (from the student's perspective) simply resulted in a child who was happy. By eliminating barriers described above, the child not only became more independent but became a self-directed learner. Her ability to take ownership of her learning, have time for her priorities, and the feelings of success she now enjoyed supported the feelings of increased happiness.

Elevated aspirations The most significant finding of the study was the notion of higher aspirations the entire team had for this student. The teachers were able to see how intelligent she was and looked beyond her disability to see the girl within who

wanted so badly to learn and 'could' learn. Further, the mother reported that in the past, each September she was simply hoping that her child would 'get through' the grade level she was assigned. Reporting the multiple hours of tears, frustration, and painful completion of homework each evening, she said she was content if her child simply made it to June. Now, she saw her child in a different light and realized that the LSP allowed her to achieve and find success like her peers. The mother reported her current dreams for the child to succeed in high school and even college. For her, this was the most profound result of the LSP's use. Finally, the child had new dreams and aspirations for herself she previously felt impossible. Her goal for the summer was to read a chapter book (like her peers) and when asked about the future, her response inspired the entire team:

> "I want to do something important. I want to help other children with reading and stuff like that. "

8 Discussion

8.1 Understanding disability and self-determination

An unexpected finding of this study was the influence assistive technology had on a student's personal life, improving her quality of life by increasing personal happiness and success. Data analysis revealed the integration of the LSP within the student's academic day extended beyond the classroom to her everyday life. Through observation and reflection of the student's experiences, the findings indicate the LSP enabled the student to develop metacognitive skills to address cognitive deficits characteristic of dyslexia. The student took ownership of her learning and was empowered with the technology of the LSP. The daily challenges of dyslexia had a profound impact on the student and her family beyond the classroom, including limiting her time to participate fully in after school leisure activities. In identifying the positive outcomes of using the LSP to support self-determination and positive emotions such as happiness at home. This compelling finding highlighted the importance of school and family partnerships to integrate assistive technology into daily practices and routines.

8.2 Fostering communities of support

Interviews with the teachers and parent revealed the importance of developing partnerships to support the student's personal utilization and self-discovery of assistive technology. This study revealed the integral team approach needed to support and self-empower the student to develop metacognitive study skills to address some of the academic challenges of dyslexia. Reflective practice and ongoing dialogue with faculty enabled a network of support to emerge for the student. The ongoing support and collaboration of the parent, teachers, and support providers enabled the researchers to gain insight into the discovery period of trying out new methods and strategies to accommodate the barriers she was experiencing daily in the classroom and at home completing homework. Implementing and supporting the use of the LSP was an

ongoing learning experience for all stakeholders involved. The use of the LSP was continually reviewed and evaluated. Barriers and problems were addressed as the student persistently used the LSP at a supported level at first and later progressing to an independent level.

The findings of this study indicate other students with similar challenges may utilize the LSP as a personal tool to address academic skill deficits. The researchers have continued to provide a framework for support to enable students to self-discover and develop techniques on an individualized basis. In correspondence with the special education mandate of an individualized education plan addressing individual needs on a one-on-one basis, the LSP has implications to be a transformative form of assistive technology, improving academic outcomes for learners with specific learning goals. The researchers found key to successful implementation of the LSP was the student taking ownership of technology integration and recognizing its utility. Future research will build upon these findings to further understand the implications assistive technology such as the LSP has on addressing disabilities in inclusive general education settings. The themes that emerged from this case study raised more questions about the potential of assistive technology addressing deficits in academic skills and fostering opportunities for self-determination.

9 Limitations

The qualitative methodology of this study revealed the student's perseverance and determination as an outcome of using assistive technology. The findings suggest assistive technology may have positive implications on the quality of life extending beyond the classroom to home and happiness, motivation through empowerment fostered from experiencing success. A limitation of a one-year study is the inability to fully conceptualize the long-term implications of happiness, motivation and self-determination have on student success in later years. Positive emotions and empowerment may extend to success in later years of education into high school and post-secondary experiences. Over the one-year period of data collection methods for this study, the long-term implications of using the LSP and its impact on the quality of life and future academic success have yet to be fully understood, however, research suggests there are notable, benefits for students with learning disabilities.

This case study revealed the LiveScribe Pen individualized supports for a child with dyslexia to address her everyday challenges and make connections that extended beyond the classroom into everyday life. Given the opportunity in her classroom, the student utilized the LSP to devise personalized techniques and strategies to overcome skill deficits related to dyslexia. Three distinct features afforded to the student when utilizing the pen included the ability to voice record audio, sync the audio with visual representation, and connect literacy-based tasks with the tactile stimuli such as printing, drawing, and turning pages. The active integration of audio, visual and tactile learning techniques utilized with the LSP had positive, observable outcomes on the student's homework. Assignments including greater detail in comprehension responses and there was a significant reduction in time to complete assigned tasks. For educators, the findings indicate the utilization of technology enhanced practical devices such as the LSP, have the potential to improve the metacognitive and literacy skills of students with

learning disabilities. As depicted in the case study, providing a student with a technology-enhanced practical everyday tool, a pen, helped address skill deficits by offering audio, visual and tactile modalities to learn new content and material. Further, it appears to extend a student's ability to effectively communicate in response to academic tasks. Thoughts in a student's mind can be articulated and recorded before developing the skills to construct written responses. The audio playback feature enables a student to listen and self-assess responses. Teachers have the ability to view written work with the audio, providing a dual means of assessment to evaluate individual levels of comprehension and task completion. The audio, visual, and tactile functions of the LSP promote comprehension skills and self-determination offering students with avenues for self-expression and greater inclusion in grade-level academics.

10 Implications for future practice

The LiveScribe Pen is a relatively new(er) technology and the empirical research on its use is limited. The insight gained from how this assistive technology can impact academic success for students with high incidence disabilities will become a critical component of our teacher preparation program. We find it is imperative that our teacher candidates familiarize themselves with tools such as the LSP so that they may utilize it in their field experiences and come to personally know the benefits it provides students who have accommodation and modification needs. In summary, the researchers continue to support the use of LSPs in inclusive elementary classroom settings to address disability. The current model for the LSP research initiative includes LSP training paired with an action research workshop for teachers. This model of professional development provides a foundation of knowledge for technology integration and the framework of action research to enable the progression of the LSP implementation in the classroom to be monitored addressing students' identified needs. Interviews, observations, and data analysis of classwork are concurrently analyzed to understand the impact of assistive technology on student outcomes. From this study, several fruitful areas for future research have emerged including assistive technology for students with disabilities, teacher inquiry to improve student outcomes, and action research implementation in the K-12 classrooms.

References

Abadiano, R., & Turner, J. (2003). Home-school partnership: what works? *The Nera Journal, 39*(3), 58–62.

Baker, L. (2003). The role of parents in motivating struggling readers. *Reading & Writing Quarterly: Overcoming Learning Difficulties, 19*(1), 87–106. doi:10.1080/10573560308207.

Brante, E. (2013). 'I don't know what it is to be able to read': how students with dyslexia experience their reading impairment. *Support for Learning, 28*(2), 79–86.

Brooking, K. (2007). Home-school Partnerships. What are they really? *Teaching and Learning*, 14–17.

Christenson, S. L., Rounds, T., & Franklin, M. J. (1992). Home-school collaboration: effects, issues, and opportunities. In S. L. Christenson & J. C. Conoley (Eds.), *Home-school collaboration: enhancing children's academic and social competence* (pp. 193–214). Washington, D.C.: National Association of School Psychologists.

Cortiella, C., & Horowitz, S. (2014). *The state of learning disabilities: facts, trends and emerging issues* (p. 2014). New York: National Center for Learning Disabilities.

Cosden, M., Elliott, K., & Noble, S. (1999). Self-understanding and self-esteem in children with learning disabilities. *Learning Disability Quarterly, 22*(4), 279–290.
Cox, D. D. (2005). Evidence-based interventions using home-school collaboration. *School Psychology Quarterly, 20*(4), 473–497.
Crozier, G., & Reay, D. (Eds.) (2005). *Activating participation: parents and teachers working towards partnership*. Stoke on Trent: Trentham Books.
Eide, F. (February 24, 2016). Too much homework for students with dyslexia. Retrieved from http://dyslexicadvantage.org/too-much-homework-for-dyslexic-students/
Epstein, J., & Sheldon, M. (2006). Prospects for change: preparing educators for school, family and community partnerships. *Peabody Journal for Education, 81*(2), 81–120.
Frankenberger, C. (2016). Technology: livescribe pen. In *The Yale Center for Dyslexia & creativity* .Retrieved from http://dyslexia.yale.edu/TECH_livescribe.html
Kennedy, M., & Deshler, D. (2010). Literacy instruction, technology, and students with learning disabilities: research we have, research we need. *Learning Disability Quarterly, 33*, 289–298.
Kvale, S. (1983). The qualitative research interview: a phenomenological and a hermeneutical mode of understanding. *Journal of Phenomenological Psychology, 14*, 171–196.
Kvale, S. (2006). Dominance through interviews and dialogues. *Qualitative Inquiry, 12*(3), 480–500.
Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage Publications.
Livescribe.com (2016). Livescribe 3 Smartpen. Retrieved from: https://www.livescribe.com/blog/noteworthy2/wpcontent/uploads/2014/03/Livescribe3StandardPenSideview.jpg
Maor, D., Currie, J., & Drewry, R. (2011). The effectiveness of assistive technologies for children with special needs: a review of research-based studies. *European Journal of Special Needs Education, 26*(3), 283–298.
McConaughey, S., Kay, P. J., & Fitzgerald, M. (1999). The achieving, behaving, caring project for preventing ED: two year outcomes. *Journal of Emotional and Behavioral Disorders, 7*(4), 224–239.
Morrow, L. (1995). *Family literacy: connections in schools and communities*. Newark, DE: International Reading Association.
Morrow, L., & Young, J. (1997). A family literacy program connecting school and home: effects on attitude, motivation and literacy achievement. *Journal of Educational Psychology, 89*(4), 736–742.
Patton, J. R., Jayanthi, M., & Polloway, E. A. (2001). Home-school collaboration about homework: what do we know and what should we do? *Reading & Writing Quarterly: Overcoming Learning Difficulties, 17*(3), 227–242. doi:10.1080/10573560152121010.
Poelma, J. (2002). Do parent educational aspirations affect the educational aspirations of adolescents with learning disabilities? Dissertation Abstracts International: Section B: The Sciences and Engineering, 62(8-B), p. 3851.
Pryor, E., & Church, B. (1995). Family-school partnerships for the twenty-first century. *Reading & Writing Quarterly: Overcoming Learning Difficulties, 11*(3), 297–303. doi:10.1080/1057356950110307.
Ryan, M. (2016). *The number one way to succeed on the job is to use technology.* The University of Michigan Dyslexia Help .Retrieved from http://dyslexiahelp.umich.edu/tools/software-assistive-technology
Ryan, B. A., & Adams, G. R. (1995). The family-school relationship model. In B. Ryan (Ed.), *The family-school connection: theory, research, and practice* (pp. 3–28). Beverly Hils, CA: Sage.
Strobel, W., Arthanat, S., Bauer, S., & Flagg, J. (2007). Universal design for learning: critical need areas for people with learning disabilities. *Assistive Technology Outcomes and Benefits, 4*(1), 81–98.
Teale, W., & Yokata, J. (2000). Beginning reading and writing: perspectives on instruction. In D. S. Strickland & L. M. Morrow (Eds.), *Beginning reading and writing* (pp. 3–21). New York: Teachers College Press.
Thompson, C. (September 16, 2010). The pen that never forgets. The New York times magazine. Retrieved from http://..nytimes.com/2010/09/19/magazine/19Livescribe-t.html?_r=1
Wehmeyer, M., Palmer, S., Smith, S., Davies, D., & Stock, S. (2008). The efficacy of technology use by people with intellectual disability: a single-subject design meta-analysis. *Journal of Special Education Technology, 23*(3), 21–31.