Using a Tablet Application for the Enhancement of Early Literacy Skills and Assessments: A Literature Review

The development of strong early literacy skills is viewed as a foundational base from which all future literacy is built. Children start building this foundation very early in life and bring the acquired skills to the task of learning to read (Justin & Pullen, 2003). Research shows that early literacy skills and learning to read are some of the most robust indicators of later literacy and academic achievement (Snow, Burns, & Griffin, 1998; Spencer, Spencer, Goldstein, & Schneider, 2013). In order to move towards being adept readers, children must have gained functional knowledge of the early literacy skills (Snow et al., 1998). In alignment with existing research, we define early literacy as the possession of pre-reading and writing skills during the pre-Kindergarten years (Justice, Chow, Capellini, Flanigan, & Colton, 2003; Justice & Pullen, 2003; Storch & Whitehurst, 2002) which includes (but is not limited to) the precursory skills of: (a) phonological awareness, or the ability to detect and manipulate phonemes and auditory aspects of language independent of meaning (National Early Literacy Panel [NELP], 2008; Wackerle-Hollman, Schmitt, Bradfield, Rodriguez, McConnell, 2015); (b) alphabet knowledge, or the knowledge of and ability to produce letter names and sounds (NELP, 2008; Wackerle-Hollman et al., 2015); (c) oral language, or the ability to comprehend and produce language (NELP, 2008; Wackerle-Hollman et al., 2015); and (d) early comprehension, or the ability to understand spoken and written language (Snow et al., 1999; Wackerle-Hollman et al., 2015).

Early Literacy Skills

Early literacy skills, as studied in preschool and kindergarten, are robust predictors of later literacy success (Goldstein, et al., 2013). Evidence suggests children who read well excel on a trajectory of success as a result of vocabulary, phonological and comprehension skills acquired through frequent reading (Lonigan et al., 2011a; Lonigan, Purpura, Wilson, Walker & Clancy-Menchetti, 2013). Children who do not frequently engage in reading or who struggle to read well in comparison to peers may practice less and therein receive less opportunity to build their vocabularies and expand comprehension (Lonigan et al., 2011a; Lonigan et al., 2013; Marulis & Neumann, 2010). While acquiring emergent literacy skills is a process that occurs over time, what children learn depends on the amount of and type of exposure to language and literacy they receive (Schryer, Sloat, & Letourneau, 2015). These findings are not only disconcerting, as research consistently shows that children who struggle with reading during their early formative years of school continue to struggle as readers throughout their educational career (Phillips, Norris, Osmond, & Maynard, 2002; Pullen & Justice, 2003), but also serve to highlight the shortage of appropriately applied intervention strategies for students who struggle with reading.

When looking at factors beyond the individual, demographic factors also contribute to early literacy acquisition. Research suggests differences in vocabulary knowledge exist among children from different socioeconomic groups (Marulis & Neuman, 2010). Children of low social-economic status (SES) as well as children who are learning English as a second language tend to have lower word counts in comparison to higher income peers and are at increased risk for reading difficulties (Justice et al., 2003; Justice & Pullen, 2003; Marulis & Neuman, 2010; Spencer et al., 2012). Furthermore, scholarship indicates that children who arrive at kindergarten with depressed literacy skills are not likely to benefit from reading instruction in elementary grades unless they receive targeted interventions (Lonigan et al., 2011b). These important findings have resulted in significant efforts focusing on how we can best support early literacy in the preschool years so that early intervention and instruction will lead to literacy success (Justice & Pullen, 2003). Given the clear and present challenges in supporting and intervening with

preschool age children on early literacy skills, one approach that makes use of the current educational climate is the integration of technology resources to support early literacy assessment and intervention. Indeed, educators, policymakers and researchers are asking how technology can best be integrated into early childhood curriculum design to maximize student outcomes (Zomer, 2015).

Research literature points to the use of developmentally appropriate technology to enhance young children's learning, particularly in the area of early literacy (Zomer, 2015). To date, advances in technology have culminated in tablet-based devices that can be accessed by adults and children of young ages alike (Willobough et al., 2015). Furthermore, early literacy assessment and intervention tools housed within a technological interface may improve the user's ability to differentiate instruction for preschool age students.

Access to technology in the classroom

Cheung and Slavin, (2012) define educational technology as materials that support the learning process and that are delivered via electronic tools and applications. Using technology for educational purposes is increasing and bringing with it advancements to assessment and intervention practice. In particular, children's use of screen-based technologies (e.g., television, computers, smartphones, tablets, and other mobile devices) have been increasing in recent years (Vatalaro, 2015). In a national survey conducted in 2009, 3150 teachers were asked about their access to computers in the classroom. Findings illustrated 97% of teachers had access to computers with 96% of the computers having internet access (Blackwell, Lauricella, Wartella, Robb, & Schomburg, 2013). However, despite this demonstrated access to computers in K-12 settings, actual use of technology within each classroom remains inconsistent. This is especially true in early childhood settings in which only 59% of classroom teachers report access to computers (Blackwell et al., 2013). While research on technology in the K-12 setting provides information and context for educators implementing technology in preschool settings, it's important to note the differences in technology administration, functionality and purpose between preschool and elementary settings. The paucity of research investigating technology applications in early childhood is a substantial challenge for the field, and even less is known about how such technology can be used to leverage existing or current early childhood resources to support early literacy and language skills.

The Present Study

The purpose of this literature review is to demonstrate the utility and unique capabilities of integrating an early-literacy technology platform into preschool education by systematically reviewing extant literature. Leveraging these findings, we will then describe how a new tablet-based application, IGDI-APEL (Individual Growth and Development Indicators: Automated Applications for Performance Evaluations for Early Literacy), offers innovative resources in the provision of assessment and data-based decision making to support early literacy development through technology.

To establish the context for early literacy technology platforms we first provide an overview of three early literacy skills found to contribute to reading ability; phonological awareness, oral language, and alphabet knowledge (Fischel, Katz, Shaller, Spira, & Storch-Bracken, 2007; Pullen & Justice, 2003; Whitehurst & Lonigan, 1998). We then present how technology has been integrated in early literacy assessment and instructional practices targeted at these three domains (oral language, phonological awareness, and alphabet knowledge). Finally, we bridge these two literature bases by presenting and discussing how the real-time data collected from a new technology platform, IGDI-APEL, may aid teachers in instructional

planning and data-based decision making within a multi-tiered system of support to improve student early literacy and language outcomes.

Method

Selection Criteria for Early Literacy Research

Considering our focus on early language and literacy, a study was included when it met all of the following criteria: (a) it addressed early literacy for students of preschool age and or the use of educational technology in promoting emergent literacy; (b) the article investigated or reported on early literacy and or technology use for typically developing or struggling beginning English readers (i.e., preschool students under age 6); (c) the report, dissertation, or published peer-reviewed journal article was written between 1990 and 2015. Duplicate articles and articles written prior to 1990 were rejected. Articles included in this review were diverse, including randomized control trial studies, curriculum reviews, quasi-experimental studies, dissertations, and literature reviews.

Literature Search Procedures

With the selection criteria in mind, a literature search was conducted using electronic educational databases (PsychINFO, Academic Search Premier, JSTORE) as well as a web-based repository (Google Scholar). Database searches were completed using different combinations of keywords: 'phonological awareness' or 'oral language' or 'alphabet knowledge' or 'early literacy' or 'preschool' or 'early literacy skills', 'assessment', AND 'iPad' or 'computer applications' or 'educational technology'. Boolean operators (i.e., AND, OR) were used to appropriately narrow the search. Studies were identified using a four-step search: (a) electronic databases were searched using established search terms, (b) the title and abstract of all results were screened for relevance and those deemed relevant were saved, (c) the articles that were saved from the screening process were read and compared to the pre-established search criteria, (d) articles matching the criteria were included in the review while the articles not matching criteria were discarded. The database searched yielded a total of 5,904 articles. The title and abstract of these articles were then screened for inclusion. A total of 69 articles, reports, and dissertations were identified and read in entirety. Duplicate articles were eliminated as well as articles that failed to meet the pre-established inclusion criteria. Of the 69 articles, 10 were removed because they did not focus on early literacy for preschool aged children (i.e., 3-5 years of age); 17 articles were removed because they did not examine the effect of technology on early literacy skills or they failed to examine early literacy skills; 5 articles were removed because the children in the studies exclusively had disabilities; 2 articles were removed because they examined early literacy development in a language other than English; and 6 duplicate articles were removed. This resulted in a total inclusion of 29 articles. Results are clustered by the three domains of early literacy: 1) phonological awareness; 2) alphabet knowledge; and 3) oral language; as well as by the role of technology in preschool classrooms.

Results

Phonological Awareness

In 2002 the National Institute of Literacy assembled a panel to synthesize evidence for practices that affect early literacy development. The National Early Literacy Panel (NELP) identified early literacy skills that best predict later reading success as well as instructional practices that support and contribute to the development of such skills. The results from this massive undertaking outline the following moderate to large predictors of later reading success; alphabet knowledge, phonological awareness, rapid automatic naming of letters, rapid automatic

naming of objects and colors, writing and/or name writing, and oral language (Shanahan & Lonigan, 2010).

Knowledge about print and phonological awareness play critical roles in early literacy as pre-readers are just beginning their reading instruction and just beginning to crack the code of reading. Research demonstrates a strong linkage between phonological awareness and early reading (Fielding-Barnsley & Hay, 2012; Pullen & Justice, 2003). In order to become successful readers, children must grasp the concept that letters correspond to sounds. Once children understand that sound units can be manipulated, they may begin to recognize words that rhyme, words that begin with the same sounds, or they may grasp that adding or removing a sound changes words (Goldstein, 2011).

Speech itself is comprised of phonological units such as large words and syllables, as well as small sound units of morphemes and phonemes (Pullen & Justice, 2003). Typically, beginning readers become aware of phonology at the larger level first and increase their sophistication to the point of mastering individual phonemes (Pullen & Justice, 2003). In alignment with research demonstrating that phonological awareness develops from shallow understanding to more heightened levels of awareness, phonological awareness interventions should start broad and become more specific (Pullen & Justice, 2003). For example, students should learn to manipulate larger elements of sound, such as syllables and matching words that rhyme before learning to manipulate the smaller units of phonemes (Ziolkowski & Goldstein, 2008). Once children have a good grasp of phonological awareness, they may begin to distinguish or segment individual words, syllables or even phonemes. One theory that describes the development of phonological awareness is the lexical restructuring model (LRM: Lonigan et al., 2013).

According to LRM, as children grow and develop, so too does their mental representation of words. Children begin to shift their mental representations of words from a holistic view to a more segmented form and this shift allows learners to access smaller and smaller segments of speech sounds (Lonigan et al., 2013). In alignment with research, children's performances on phonological awareness tasks are significantly correlated with oral language skills (Storch & Whitehurst, 2002). Based on the theory of LRM, the implementation of an effective vocabulary intervention will facilitate improved segmentation of children's mental lexicons which can increase the effectiveness of a phonological awareness intervention (Lonigan et al., 2013).

Despite its complexities, research findings indicate phonological awareness may be one of the most important contributions to literacy development. The ability to successfully segment and blend different phonemes has a substantial impact on overall phonological awareness skills (Yeh, 2003). In fact, a larger effect was found amongst preschool children who were instructed with phoneme segmentation and blending activities as opposed to rhyming and alliteration activities (Yeh, 2003). Additionally, among the segmentation treatment group, phoneme substitution demonstrated the greatest effect. These results suggest that phoneme segmentation and blending (e.g., /c-at/, /p-at/, /m-at/) were more effective phonological awareness activities than rhyming and alliteration alone (Yeh, 2003).

Teachers in early childhood education settings can assist children in the acquisition of phonological awareness skills through a variety of explicit instruction, and dynamic activities such as songs and rhymes. Skill work that encourages phonological awareness development includes recognizing and producing rhymes, hearing and identifying individual syllables, initial sounds of words and ending sounds of words, and blending and isolating sounds (Pullen & Justice, 2003).

Technology and Phonological Awareness. Phonological awareness skills are constrained, indicating they have a clear trajectory that ends in mastery after a brief period of development (Paris, 2005). Constrained skills are contrasted by unconstrained skills such as vocabulary that continually develop over the duration of learning and lack a point of infinite mastery (Paris, 2005). Given there is a clear continuum of development for phonological awareness skills, they have strong potential for use in technology applications. Macaruso and Rodman (2011) recently studied how Computer Assisted Instructed (CAI) can be used to teach emergent literacy skills to preschool students. As part of the study, students in the experimental group completed 10-15 minutes of CAI, via the program Early Reading, 2-3 times a week over a period of 4 months. Although both the experimental and control group experienced gains in pre-literacy skills, there were significant group differences in gain scores in the phonological awareness skills of rhyming and sound matching for the experimental group (Macaruso & Rodman, 2011). The findings show accelerated growth in early literacy skills during CAI use.

Similarly, Schryer et al. (2015) measured the extent to which a 5-week educational screen-based intervention improved preschoolers' emergent literacy alphabet knowledge, oral language and phonological awareness skills. Fifty-one preschool children, measured for equivalent baseline through the use of Early Language and Literacy Classroom Observation Pre-K (ELLCO Pre-K), were included in the quasi-experimental pretest and posttest nonequivalent group design study. Classroom assignment to experimental or control condition was determined by teacher self-selection based on access to a television and DVD player. The intervention consisted of pre-teaching the "letter of the day", direct instruction and a 15-minute read-along lesson presented via video. In total, children viewed 5 hours of video over a 5-week period of time. Researchers used the Picture Naming and Rhyming assessments from IGDIs as well as the Phonological Awareness and Alphabet Recognition subtests from PALS-PreK. There were statistically significant interactions between groups on vocabulary, phonological awareness, and oral language. Findings indicate that children in the experimental group who received a 5-week screen-based early literacy intervention demonstrated greater gains on measures of vocabulary, alphabet knowledge, and rhyming than children who did not receive the intervention.

While an abundance of research demonstrates the importance of phonological awareness in early reading, this skill alone is not sufficient to develop strong readers (Fielding-Barnsley & Hay, 2012). As outlined by NELP (2002), alphabet knowledge and, oral language and comprehension skills are also key indicators of early reading success.

Alphabet Knowledge

Alphabet knowledge is the ability to accurately name all the letters of the lower and uppercase alphabet as well as identify their individual sounds before beginning first grade (Drouin et. al., 2012; NELP, 2008; Shanahan & Lonigan, 2010), and is an important skill in the development of early literacy. Alphabet knowledge is a strong predictor of reading success and has thus become an important learning goal for young students (Hall et al., 2014; Piasta & Wagner, 2010; Pullen & Justice, 2003). The NELP report identified alphabet knowledge as a specific outcome of interest and by synthesizing the results of 24 code-focused early childhood interventions, found an overall average effect size of .38 (95% confidence interval=0.18 to 0.58) (Piasta & Wagner, 2010). Additionally, standards imposed by the U.S. Department of Health and Human Services & Administration for Children and Families onto the federal program of Head Start require children demonstrate awareness of letters as individual and unique symbols as well as the ability to correctly identify 10 letters by name (Piasta & Wagner, 2010).

Research shows that preschool students who have a poor grasp on letter names and sounds during the early literacy stage are more likely to struggle with learning to read as they progress through school (Piasta & Wagner, 2010). These findings highlight the need to uncover and utilize effective instructional techniques preschool teachers can employ to help develop alphabet knowledge skills.

By reporting on the importance of alphabet knowledge, NELP contributed to its salience as a primary objective of preschool instruction. However, the NELP report did not distinguish between the various components of alphabet knowledge such as letter names, letter sounds, or letter writing but instead reported one effect size for the skill (Shanahan & Lonigan, 2010). Interestingly, current research demonstrates support for NELP's rational. Research assessing a sample of preschoolers (n=335) asserts that alphabet knowledge tasks such as letter recognition, uppercase and lowercase letter names, and letter sounds are indicators of a single ability and do not in fact, measure distinct skills (Drouin et al., 2012). When exploring the relationship between alphabet knowledge and age, studies show the average five-year-old child has the ability to correctly name all uppercase letters and also possesses a 50% chance of correctly naming 13 or more lowercase letters (Drouin et. al., 2012). In comparison, the average four-year-old has the ability to correctly recognize all uppercase letters, name approximately 6 uppercase letters, as well as name the lowercase letters of 'x' and 'o' (Drouin et. al., 2012). These findings demonstrate the great amount of growth early learners make towards the mastering of this early literacy skill and the importance of starting to work on this skill early on in the preschool experience. Furthermore, the results from this work suggest some components of alphabet knowledge previously identified as separate constructs may more appropriately belong to a single underlying construct of alphabet knowledge. Therefore, alphabet knowledge may be best taught and assessed as a collection of skills that represent sounds and letters that represent a single underlying construct (Drouin et al., 2012).

Interactive Writing and Alphabet Knowledge. While current literature demonstrates the utility of writing as a manner of building literacy skills in kindergarten and older grades, there is a dearth of evidence exploring the effectiveness of writing in preschool (Hall et al., 2014). Therefore, researchers conducted a pretest-posttest randomized control group design with 73 Head Start students in order to examine the effectiveness of interactive writing with this population (Hall et al., 2014). Students in the intervention group worked with teachers 3-4 days a week for 10-15 minutes a session for 13 weeks to: (1) discuss the writing topic; (2) talk about letters, letter sounds, and how letters make up words; (3) read and re-read sentences together as the text was written; (4) after completion, decide together where to keep the text so it could be read later, while the control group received "business as usual" literacy lessons. After 13 weeks, all children completed the Letter Identification task (a subtest of the Observation Survey of Early Literacy Achievement), which measured their upper case, lower case, and letter sound identification knowledge. Results revealed statistically significant results for the intervention interactive writing group for both lower case and upper case identification.

Technology and Alphabet Knowledge. Given advances in technology, research has begun to explore the differential effects of paper alphabet books and electronic books with preschool children (Willoughby et al., 2015). Researchers examined how children interacted with electronic alphabet books and how these interactions afforded benefits to their early literacy development (Willoughby et al., 2015). Willoughby et al. (2015) compared letter-name and letter-sound scores between the intervention group (i.e., ebook) and the control group (i.e., alphabet book) and found no significant differences. However, significant gains were made from

pre to post-test for both experimental and control groups indicating no particular condition offered increased benefits and that paper and e-book alphabet perform equally well in promoting alphabet knowledge skills. Due to the overall rise in young children's access to technology, research examining differential effects between printed and electronic books is important (Castle et al., 2013).

In a similar line of work, Castle et al. (2013) explored the association between four-year-old children's computer use and early literacy skills. Researchers drew from a large-scale community cohort to examine the relation between alphabet knowledge and computer use among preschool children. Parents completed surveys measuring their children's formal literacy and informal literacy experiences in the home. Parents answered formal literacy questions, including: During a typical week, how often do you help your child read letters and words? and informal literacy questions, including: For how many minutes does your child enjoy being read to at a sitting?. Parents also answered items about their children's television watching and computer use in the home, such as: How many hours on a typical weekday would you say your child watched TV at home?, and How many hours on a typical weekday would you say your child uses a computer while at home?. Researchers then assessed children's letter knowledge by asking them to name each of the 26 letters of the English alphabet. The item was scored as correct if the child was able to either accurately name the letter or produce the correct letter sound. A statistically significant positive correlation between letter knowledge and computer use was found (r=0.214, $p < .01$). While the results indicate a positive relationship between computer use and alphabet knowledge, the survey did not differentiate between general computer use and educational computer use. These findings stop short of analyzing specific aspects of computer interaction and their relation to early literacy skills. As a result, additional research is needed to further examine the particular aspects of computer interaction that are associated with early literacy.

Oral language

A foundational component of mastering language is understanding the words that comprise spoken and written language and that contribute to successful reading comprehension (Shanahan & Lonigan, 2010; Pullen & Justice, 2003). Oral language is described as the ability to understand and produce spoken language (Shanahan & Lonigan, 2010). Children expand their vocabularies through one of three common avenues: incidentally through the natural course of verbal and written language interactions, embedded instruction such as direct instruction, and extended instructional activities (Zucker, et al., 2013). Incidental vocabulary acquisition occurs when children and adults engage in shared reading and the children may be exposed to novel vocabulary in its natural context. Embedded instruction employs child-friendly definitions of words that arise within the natural context of shared reading. Once the book is completed, the children are given opportunities, or extended instructional activities, to discuss and practice the novel words (Zucker, et al., 2013). This is important to consider as preschool students may not explicitly or outwardly demonstrate their oral language ability (e.g., familiarity with and comprehension of vocabulary words) in a typical reading environment unless prompted (Pullen & Justice, 2003; Zucker, et al., 2013).

The NELP discovered that when the complexity of oral language was broken down into distinct skills and then measured with a composite measure of grammar, ability to define words, and listening comprehension, it played a larger role in later literacy achievement. The NELP panel found that more challenging measures of oral language (e.g., word definitions and listening comprehension) demonstrate larger predictive power of later literacy achievement than less

demanding measures such as receptive or expressive vocabulary (Justice et al., 2003a; Shanahan & Lonigan, 2010; Spencer, et al., 2012).

Research points to oral language difficulties as early manifestations of reading disabilities (Pullen & Justice, 2003). Generally, preschool age students who struggle with vocabulary and grammar are more likely to experience literacy problems (Pullen & Justice, 2003), which highlights the importance of early intervention. Results from the National Reading Panel (National Reading Panel [NRP], 2000) found that students with limited vocabulary typically benefit from a variety of instructional approaches as opposed to a single approach. The NRP states some approaches that have been found to be most successful for increasing a student's vocabulary include: reading aloud to children, modeling new words, building time into the day for explicit vocabulary instruction, and employing the use of technology. More specifically, in their review of promising emergent literacy interventions, Justice and Pullen (2003) identify adult-child shared storybook reading as one such strategy. Shared storybook reading is viewed as such a powerful strategy because of its interactive, authentic, interesting, and motivational context. The authors also highlight the flexibility and potential for modification teachers can make to optimize literacy achievements (Justice & Pullen, 2003). Shared book reading holds promise for teaching code-based skills as well as meaning-focused skills to children and can be approached in a variety of ways (Goldstein, 2011) not the least of which could include a technological interface.

Technology and Oral Language. Currently, scholarship is emerging that examines how advances in educational technology can positively contribute to children's development (Vatalaro, 2015). Recent research demonstrates the use of a screen-based intervention aimed at increasing receptive and expressive vocabulary of preschoolers. Head Start children who took part in a direct instruction vocabulary app intervention scored significantly higher on an iPad receptive vocabulary assessment than children in the control group demonstrating that when technology is used to support learning, it can increase early literacy achievement (Vatalaro, 2015). Similar research has examined the efficacy of a screen-based app in promoting early literacy in young learners.

In their review of the current literature, Bus, Takacs, and Kegel (2014) found devices such as tablets contain a combination of enhanced capabilities that change the way children experience books. Smeets and Bus (2014), as cited in Bus et al., (2014), found that animated electronic storybooks not only offered more opportunities for vocabulary growth but also resulted in a 6% rise in word learning compared to computer books offering static pictures alone. Results from their synthesis highlight the importance of quality and design when incorporating tablets into early literacy activities. Animated pictures used within tables may be promising for young learners as well as language-delayed learners as animated pictures facilitate word learning and story comprehension (Bus et al., 2014). However, the type of visualization is important as extravagant content may draw children's attention away from the meaning of the text may lead to diminished performance (Bus et al., 2014).

Results are mirrored in the systematic review conducted by Salmon (2014). The purpose of her review was to identify factors that affect the efficacy of electronic books as a means of supporting early literacy development (Salmon, 2014). Findings suggest that while repetitive exposure to electronic storybooks increased students' ability to connect story events, acquire vocabulary, and elaborate the story due to the synergistic effect of multimedia features, some graphics can actually cause disruption or distraction (Salmon, 2014). Similar results are found in Willoughby et al. (2015). In this study, 94 preschoolers were assigned to one of three groups

(i.e., the eBook condition, the paper alphabet book condition, and the storybook condition). The intervention lasted 8 weeks and was comprised of 16 sessions. Students completed pre and post-tests that assessed their letter-naming, letter-sound, vocabulary, and phonological awareness skills. Results showed that emergent literacy score gains were significant for all groups as measured by the post-test. However, results were not significantly different between groups. One possible reason the findings were not different between groups could have been the age of the participants (e.g., 3 and 4 years). The authors posit more intense activities may have been needed above what was provided. These results suggest the need for more adult supervision or modeling with very young children. Results from these studies highlight the need for early literacy app developers to consider content when designing technology targeting oral language.

Further research examining the effect of technology on early literacy skills was conducted by Fletcher-Finn and Gravatt (1995). Fletcher-Finn and Gravatt (1995) reported CAI to be more effective than traditional instruction for skills such as reading and writing with an average effect size of .24. Furthermore, effectiveness of CAI has been demonstrated across grade levels with the largest effect size (.55) reported for the preschool group (Vernadakis, 2005). Likewise, results from Shute and Miksad (1997), in which pre and post-tests revealed cognitive differences after an 8-week CAI program among preschool children, suggested CAI had a greater effect on increasing verbal as well as oral performance (Vernadakis, 2005). Parallel findings by Reitsma and Wesseling (1998) indicated that a CAI teaching method resulted in greater word production by preschool students (Vernadikis et al., 2005).

In sum, the preschool years are crucial to the development of the prerequisite early literacy skills of phonological awareness, alphabet knowledge, and oral language that help prevent reading difficulties (Pullen & Justice, 2003). Results outlined above provide a solid starting point for understanding the early literacy skills of oral language, phonological awareness, and alphabet knowledge and how technology has been used to leverage existing early childhood resources to support these skills. Findings suggest children may experience gains in oral language and phonological awareness when technologies such as tablets are effectively used as part of a classroom curriculum (Lyons & Tredwell, 2015).

Educational Technology's Evolving Landscape

Given the findings discussed above, it is important to further explore how and why technology is uniquely positioned to enhance preschool instruction and intervention on early literacy skills. The use of tablets and tablet applications in the classroom has become increasingly more universal. As such, technology is found in most children's educational environments. The debate on using technology has transitioned from whether or not to use technology, to a discussion on the best way to utilize it for successful student development (Flewitt et al., 2015). We now live in a time when children are exposed to screens and technological devices (e.g., computers, tablets, and smartphones) almost from infancy (Northrop & Killeen, 2013). Increasingly, children are exposed to technologies at home as well as at school.

In their paper synthesizing work on computers as learning tools to enhance linguistic and literacy skills in preschool children, Vernadakis et al. (2005) state the enormous growth of technology in education yet lambaste the minimal integration of computers into preschool education. Given the similar findings described in this review, it is clear that scholarship is only emerging that examines how CAI can be used to support literacy acquisition (Macaruso & Rodman, 2011). Given the steady and increasingly concentrated integration of technology into daily life, it seems necessary to develop an early literacy measure that utilizes the benefits

technology has to offer. While CAI is not likely to replace traditional children's books, it can offer interactive pictures and sound that may increase accessibility for young children (Vernadakis et al., 2005).

Educational Technology, Policy and Practice. As this review illustrates, there is a growing need to attend to CAI approaches in early childhood early literacy domains. This necessity stems from the changing landscape of technology accessibility and mounting evidence that CAI can be effective in improving early language and literacy skills not only for K-12 students but for preschool children as well. Therefore, it's only logical that national, state, and local agencies have developed policies on access to educational technology in early childhood settings.

In 2012, the National Association for the Education of Young Children (NAEYC) and the Fred Rogers Center (FRC) issued a joint position statement on the use of technology in early childhood programs (Lyons & Tredwell, 2015). The statement suggested that the manner in which teachers use technology in early childhood mediates its impact; namely, to ensure effectiveness, the same developmentally appropriate principles used with print materials should be employed with technology (Lyons & Tredwell, 2015). This suggests the need for careful and planned implementation. Through a standardized process of implementation, early childhood educators may begin to understand children's background knowledge of technology and use this knowledge to design a technology curriculum that is sensitive to the learning experiences of all children (Lyons & Treadwell, 2015).

Taking this into account, Lyons and Tredwell (2015) developed a five-step process teachers can follow to implement technology in early education; 1) assess children's knowledge of technology, 2) develop rules around technology, 3) apply judgment and policy, 4) implement technology into the curriculum, and 5) collect data for decision making. Step one involves asking students questions such as: what technology can you use at home and what is your favorite app. The answers to such questions can be used to assess children's knowledge of technology. Step two seeks to involve children in the development of classroom rules for the technology (e.g., I will touch the iPad gently). This process helps them take ownership and helps with accountability. Step three recommends teachers integrate technology that is developmentally appropriate and responsive to the unique needs of each student. Step four encourages teachers to consider the amount of exposure time, whether all children are getting equal access, and the use of technology as a way to support hands-on learning. Step five encourages teachers to use technology in order to engage in ongoing and regular data collection. Progress monitoring data helps depict progress toward short and long-term goals and can be easily and efficiently collected via a variety of tools and applications (e.g., tablet devices, apps; Lyons & Tredwell, 2015). This model highlights the importance of intentional planning and programming by teachers.

Technology Use in the Classroom. As noted, integration of technology into the classroom has become a common practice. One method of technology in particular, computer applications, is a tool educators can use to facilitate individualized instruction within the general education setting (Coufal, 2002). We know from leading scholarship that the existence of technology alone does not create active learning environments or necessarily encourage the development of language skills; instead it is how the educator chooses to implement technology within their classroom that critically impacts student level success (Coufal, 2002). Johnson et al completed a study in 2010 to examine the effects of CAI on early reading skills. In this study, the intervention group consisted of varying levels of computer interaction for 13 weeks while the control group functioned as a business as usual condition with no CAI. However, post-test results

of reading ability did not indicate significant differences between groups; instead findings suggested that the method of presentation must fully engage the student in order to produce effects (Johnson et al., 2010).

When examining how educational technology might enhance reading outcomes, adhering to the QAIT model (Slavin, 2009) may prove helpful. In this model, effective teaching is comprised of four factors: quality of instruction, appropriate levels of instruction, incentive, and time. In sum, the manner in which technology is used can impact quality of instruction. Individualized computer instruction is best utilized when the content is varied, well-designed and compelling (Slavin, 2009). Technology has the unique capacity to illustrate key concepts presented by the teacher, as well as individualize the pace and level of instruction in order to enhance reading outcomes (Slavin, 2009). Cheung and Slavin (2012) describe computers as endlessly patient devices that provide infinite opportunities to practice literacy skills.

One benefit of technology is that while students can be given direct instruction on how to use it, it can also be utilized as a supplementary teaching tool to augment other traditional curricular goals (Northrop et al., 2013). Computer-based activities can be visually stimulating and motivating for students (Macaruso & Rodman, 2011). The novelty and excitement of educational technologies can have an effect on young learner's enthusiasm. Technology appears to not only motivate young learners, but it has been found to increase the amount of time a child will spend practicing a certain skill (Mandel Morrow, Barnhart, & Rooyakkers, 2002). Most touch screens contain icons or symbols that are visually attractive and as children develop fine motor skills, they start to use their hands and fingers to manipulate and interact with the devices that house these icons. As opposed to traditional computers that function through manipulation of a computerized mouse attached to a screen, tablets function with finger-based operating systems more intuitive for a child (Neumann & Neumann, 2014). Tablets have features reminiscent of books that may help facilitate emergent literacy skills. Tablets, like books, are light-weight, mobile and handheld. Similar to how they interact with books, children may hold tablets on their laps, use them while laying down on the floor, or use them in collaboration with peers and adults (Neumann & Neumann, 2014). Tablets hold much potential for supporting early literacy development because of the many ways in which children may interact with them. Through tapping, pressing, tracing, stretching, and/or scrolling children are easily able to write and draw. This tactile interface allows young learners to successfully interact with technological devices much earlier than ever before (Neumann & Neumann, 2014). Beyond the benefits of being exciting, intuitive, as easy to use for children, tablet devices employed as educational tools also offer benefits to teachers.

Flewitt et al (2015) examined teacher use of iPads to support their classroom curriculum over a two-month period. Results showed teachers valued iPad-based literacy activities that were well-planned and stimulated children's motivation and concentration and the teachers valued the opportunity to deliver curriculum in novel ways (Flewitt et al., 2015). Researchers interviewed the teachers on using technology as a tool to deliver early literacy lessons both before and after using the iPads in class. After their time with the iPads, teachers listed numerous benefits of using an iPad for educational purposes; namely: (a) independence, or student autonomy made possible through device mobility and touch screens; (b) motivation, enhanced by the immediacy of results and responsive nature of the iPad; and (c) increased communication and collaboration between students when working together on the iPad (Flewitt et al., 2015).

Early Literacy Assessment and Multi-Tiered Systems of Support

Quality early childhood education is shaped by the knowledge that the formative years before kindergarten can be used to ameliorate later language and literacy risks (Greenwood et al., 2011). The employment of tablet devices as educational tools has greatly expanded learning possibilities. One specific benefit of technology in the classroom is that it is able to provide individual instructional activities and reinforcement of skills through adjustable levels of difficulty (Mandel Morrow et al., 2002).

Children arrive at preschool with greatly varying levels of literacy, yet the end goal for children, is that they all leave preschool with the required early literacy skills to become successful readers (Lonigan et al., 2011a). In order to address this disparity, research recognizes the importance of individualizing the level of instructional support in order to address each learner's unique set of needs (Lonigan et al., 2011a). Therefore, tools and frameworks used to identify the children in need of additional support are warranted. Based on the critical need for the development of strong early literacy skills, effective literacy instruction must be complemented by robust assessment in order to accurately identify students needing more intensive services than the universal curriculum can offer. Taken together, accurately identifying students who need early literacy intervention (potentially with the support of technology) and delivering appropriate and differentiated instruction form the basis for multi-tiered systems of support (MTSS; Buzhardt et al., 2012).

Students who struggle to acquire early literacy skills may continue to experience difficulty with literacy in later school grades unless they receive appropriate instruction and intervention (Phillips et al., 2002). However, screening is the starting point for successful implementation of a MTSS model as the data serves as the driver for both instruction and intervention. Once children are screened, interventions and next steps should be considered. In their report, Justice and Pullen (2003) emphasize the need for early literacy interventions to: 1) be highly contextualized, 2) meaningful, and 3) use objects that occur within their environment.

Adopting a data-based decision making model which employs data collection on student performance in order to drive universal curricula and intervention practices for students in need can be used to enhance early literacy instruction in the preschool educational setting. Universal screenings of early literacy skills, in which every child is assessed, allow teachers to identify children in need of additional instruction as well as children currently at risk for developing difficulties (Goldstein et al., 2013). Research demonstrates that preschoolers who perform well on early literacy measures are generally found to have higher literacy outcomes as compared to children whose performance levels are lower (Justice et al., 2003a). Early literacy assessments serve to identify children who are lacking early literacy skills and offer educators opportunities to address these risks with high quality instruction and individualized interventions. The Get Ready to Read! Revised Screening Tool (GRTR-R) and the Individual Growth and Development Indicators (IGDIs 2.0) are two screening tools developed to measure children's early literacy skills (Lonigan et al., 2011a). The benefits of employing effective early literacy assessments are many; namely, they measure student progress and status and offer valuable information that can be used to provide appropriate interventions (Goldstein et al., 2013). A high-quality screening assessment should accurately identify students in need of support; with high levels of sensitivity and specificity, limiting the identification of false positives (i.e., children identified by the screener as at risk who are not actually at risk) and false negatives (i.e., children at risk who were not identified by the screener) (Lonigan et al., 2011a).

To appropriately attend to the individual needs of all children's early literacy skills, assessment practices must be linked to tailored, or multi-tiered, intervention practices that map onto the need of each individual learner (Spencer et al., 2012). MTSS is a framework used to identify, intervene, and monitor students based on their individual needs (Fuchs & Fuch, 2006). The base of a multi-tiered approach, Tier 1, is a high-quality evidence-based core curriculum that is provided to all children in the classroom (Diamond et al., 2013). High quality and high fidelity universal curricula is an assumption of successful Tier 1 intervention. When this generalized instruction is not sufficient to the learners, they receive supplemental or targeted instruction in Tier 2. This instruction, typically provided in small groups, tends to be more explicit and intensive. Supplemental instructional activities in Tier 2 may include repeated practice opportunities for students and increased instructional time (Spencer et al., 2012). Tier 3 interventions tend to be highly intensive, explicit, and individualized (i.e., one-on-one support). Enlisting the help of a teacher with specialized skills or changing the format of instruction can modify the intensity at Tier 3 (Spencer et al., 2012). As a framework, it is important to note that MTSS functions bi-directionally. In this way, the level of instruction increases as a student's skill becomes more discrepant from the Tier 1 expectation, and the level of instruction is scaled back as a student's skills align with being functional at a Tier 1 level.

Assessment approaches within an MTSS framework function in two distinct ways; the measures used must appropriately identify children in need of additional support (screening) and appropriately track the progress of such children (progress-monitoring; Wackerle-Hollman et al., 2015). In order to identify those requiring more intensive levels of intervention, children are screened at established points throughout the academic year. Screening data can be used to alert teachers to children not making adequate progress and who subsequently may benefit from differentiated instruction (Greenwood et al., 2011).

To appropriately address the literacy and language needs of all students, assessment and intervention practices must be individually tailored to match students' skill level with instruction (Wackerle-Hollman et al., 2015). Many educators look towards MTSS as a means of delivering interventions and monitoring student response to them (Fuchs & Fuchs, 2006). While early childhood resources are not as well developed as K-12 resources for use in MTSS, there are efforts to apply such frameworks in early childhood settings through implementation of both assessment and intervention (Wackerle-Hollman et al., 2015).

Technology to Support Data-Driven Decision-Making. It is important to consider how we identify children who are "at-risk" and who might benefit from higher levels of targeted instruction in order to make gains required for reading success. While traditional pencil-paper assessments provide equally valuable information, their delivery can be cumbersome and time consuming. Using a tablet based assessment system reduces the burden pencil-paper assessments have become by reducing the length of time needed to complete the assessment and increasing the accuracy and speed of scoring. However, it is important to go further than merely assessing students; of greater importance is an instructional decision framework from which to use these tools.

The goal of data-based decision making is to use information in order to individualize services and interventions that address each child's unique needs (Buzhardt et al., 2012). In their report, Buzhardt et al. (2012) question how technology can help remove barriers to successful data-based decision making. The benefits of employing computer-based tools as facilitators of data-based decision making are (a) earlier identification of students in need of intervention; (b)

time saving practices; (c) improved instructional decision making, and (d) the ability to easily compare individual student performance (Buzhardt et al., 2012).

In their study, Carson et al. (2011) investigates whether the use of a computer-based administration of phonological awareness skills could generate equivalent results to a paper-based administration of phonological awareness skills. In this study, 33 preschool aged children were given either a paper-based or computer-based assessment and then re-assessed two weeks later using the opposite assessment modality. Results show that computer-bases assessments generate comparable scores while taking 20% less time to administer. These findings suggest computer-based assessments not only garner comparable assessment results, they are more time efficient. In educational settings where teachers are required to do more and more within the school day, efficiency is vital. Parallel findings by Kao (2015) indicate that children's performance on an electronic Concepts About Print (CAP) test are not significantly different from children's performance on the original paper and pencil CAP. These findings have shown the electronic tests have potential to be a valid measures of assessing children's performance on print awareness (Kao, 2015). While studies conducted by Carson et al. (2011) and Kao (2015) demonstrate the equivalence of scores between paper-and-pencil and technology-based assessments, studies on the potential for early childhood data-based decision making via technology have yet to be fully explored (Buzhardt et al., 2012). This is unfortunate, as tablet-based technologies serve as an ideal platform for supporting teachers in making data-based decisions via time saving assessment administration, automatic scoring, data storage and dissemination, and instruction and intervention suggestions. Therefore, IGDI-APEL is in a unique position to bridge the gap between assessment and intervention by housing both processes together in one educational tool in order to support the use of data-based decision making.

Making Improvements in Early Childhood Technology use: IGDI-APEL

At present, early childhood educators interested in implementing a MTSS model are faced with numerous challenges. These challenges start with the assessment system that drives MTSS. To identify students for services in different tiers and in order to monitor progress within tiers, teachers need to (a) collect and manage every student's performance data using paper-and-pencil measures; (b) score, store, sort, and analyze data to identify appropriate services for each student; (c) ensure classroom time accommodates changes in interventions for students; (d) manage and share data with administration and families for use in monitoring intervention effectiveness. In contrast, consider an early childhood classroom where teachers use tablet devices for the assessment of early literacy skills and in order to support instruction and intervention. One effort to develop a comprehensive model for technology-based assessment and intervention in early childhood classrooms is Individual Growth and Development Indicators-Automated Application for Performance Evaluation of Early Language and Literacy (IGDI-APEL).

The Individual Growth and Development Indicators are a set of early literacy and language screening and progress monitoring tools designed to assess early language and literacy skills for preschool-age children and subsequently provide information on early intervention decisions (McConnell, Bradfield, Wackerle-Hollman, & Rodriguez, 2014). IGDIs are part of a class of assessment tools described as general outcome measures (GOMs). GOMs are characterized by their brevity (i.e., 1 to 2 minute measures), their ease of administration and interpretation, their link to long-term goals as well as their sensitivity to growth over time (Wackerle-Hollman et al., 2015). More specifically, IGDIs help support early literacy instruction

by mapping onto three early literacy domains: phonological awareness, comprehension, alphabet knowledge, and oral language. IGDIs have demonstrated utility as tools that can help teachers determine which students are in need of additional early language and literacy support, as well as to identify students who are on track to becoming successful readers.

IGDI-APEL extends the IGDI measures by placing them in a tablet-based application, complemented by additional features that support the implementation of a MTSS. In IGDI-APEL teachers and students use tablet devices to assess ability. The teacher delivers each item while the child interacts with visually appealing images. In receptive tasks (i.e., Which one Doesn't Belong, Rhyming, Sound Identification, and First Sounds), the child selects the answer by touching the image on the screen. IGDI-APEL is being carefully designed in an iterative and dynamic manner that elicits teacher feedback to ensure the interface is user-friendly and intuitive so teachers can easily move from assessment data to instructional practices that make meaningful differences in student outcomes. Indeed, IGDI-APEL facilitates teacher tracking of individual student progress as well as class-wide progress. Immediately after data is collected the application suggests evidence-based intervention based in real-time, allowing teachers to tailor instruction to meet each student's unique set of needs.

IGDIs were developed to accurately differentiate between children who are performing at an appropriate and expected level and those children who are not. IGDI-APEL specifically addresses this by offering teachers the ability to screen all students, immediately see a visual depiction of the student's ability level via real-time data graphing and furthermore see children assigned to tiers based on previously established scores. Further IGDI-APEL incorporates computer adaptive testing, which tailors the assessment protocol to map onto the child's unique ability level. In sum, IGDI-APEL provides teachers with an easy to use application that facilitates standardized data collection as well as data-based decision making.

This new tablet-based application employs many of the concepts presented in this review. For example, in alignment with Northrup and Killeen's (2013) instructional framework, teachers use sample items A and B to model how to use and respond to items on the iPad before gradually releasing that responsibility to the student. Additionally, IGDI-APEL follows Justice and Pullen's (2003) suggestion for early literacy interventions to: 1) be highly contextualized, 2) meaningful, and 3) use objects that occur within their environment. Consequently, IGDI-APEL represents a notable advance in early childhood technology and education integration. Through inclusion of such features as identification, progress monitoring and intervention suggestion, IGDI-APEL provides teachers with a robust early literacy assessment and real-time data-based decision making tool. Technology can provide immediate feedback regarding student response (Johnson et al., 2010). This added component reduces the latency between administering the assessment to a child and formulating data-based decisions. IGDI-APEL not only brings technology into the preschool classroom, it enhances individualized learning.

Discussion

The purpose of this review was to evaluate and discuss the integration of phonological awareness, oral language, and alphabet knowledge and technology in the early education setting as it relates to the tablet-based early literacy assessment IGDI-APEL. The literature base on technology and early literacy within the preschool setting continues to expand. The findings from this review suggest iPad/tablet devices used for early literacy instructional and assessment purposes offer promising opportunities within a preschool MTSS framework. More specifically: (a) the touch-responsive interface of iPads allows children to easily interact with them and teachers report high levels of student engagement; (b) research on electronic based interventions

shows positive effects on phonological awareness, alphabet knowledge, and oral language skills; (c) careful planning and on how to incorporate tablet based learning within preschool early literacy settings is essential when considering a move to an electronic interface; and (d) more research on how technology can improve data-based decision making among preschool teachers is warranted.

In an attempt to promote teachers' attention to building the foundational skills of oral language, phonological awareness and alphabet knowledge and at the same time leverage the benefits of tablet-based technologies, new technologies, such as IGDI-APEL, are being developed. IGDI-APEL promotes data-based decision making and intervention selection in real time through a highlight intuitive and engaging application designed for use between a student and a teacher. IGDI-APEL provides teachers a unique platform for assessment and data-based decision making by featuring empirically robust measures, evidence-based intervention suggestions, and a reduced latency between interaction with data and implementation of interventions. Students in classrooms where IGDI-APEL is employed are systematically monitored to allow for data-based decision-making based on their performance. Results of this review indicate there is significant promise in using technology to support early literacy skills with preschoolers, and IGDI-APEL aims to contribute to this area of research.

Limitations

The present study shares limitations inherent in any systematic literature review. Namely, the literature search may have failed to identify all relevant studies due to incomplete search terms or restricted databases. Another limitation is the search criteria. Technology is an ever-advancing field. Suggestions for specific technology programs or applications may quickly become outdated as newer versions and technology platforms are developed and released to the general public. Articles written prior to the year 1990 were discounted in an effort to localize the most relevant and up to date information. While this may have limited results, a more relaxed search (e.g., a year limit prior to 1990) may have compromised the ability to generalize results to present classrooms.

Another limitation is that most of the existing literature focuses on technology use within the K-12 setting; with only 17 articles focusing on technology use within the population of interest (i.e., preschool). Early literacy marks a distinct phase in the overall process of gaining literacy and therefore articles exploring technology use in the education of early literacy skills was strictly restrained to preschool. By doing so, numerous articles were removed and our results may have been limited.

Directions for Future Research

One major future direction in research is to conduct more studies about the use of technology in assessing early literacy skills in preschool classrooms in order to develop recommendations for best practices. Given the dearth of articles with preschool populations, it is clear more research in this area is warranted. Surveying preschool programs in order to explore their use of technology in the literacy curricula is one proposed method of doing this. Such an investigation would shed light on how technology use varies among programs as well as regions in the nation.

Another direction for research is to examine how technology can facilitate administration of early literacy assessments specifically for phonological awareness, alphabet knowledge, and oral language. Information from research such as this could help provide direction to technology developers as well as educators.

Research is also needed to investigate the differences of gender, socioeconomic status, native language, and amount of exposure to electronics on technological assessments administered via tablets (Kao, 2015). While technology use in general is increasing and more children grow up accustomed to multiple technological interfaces, exposure time to devices is variable (Kao, 2015). The literature on educational technology exposes a digital divide in which some children are exposed to technology through supported activities at home while other young children either do not have access to technology at home or have reduced opportunity to engage with media at home or in educational settings (Flewitt et al., 2015). Exploring how various socio-economic factors correlate with technology use may offer researchers valued insight into how educators may better use technology to support early literacy and language.

While research on MTSS has expanded to early childhood settings, resources are not yet as well developed as they are in the K-12 setting. Therefore, research is needed on how preschool teachers use data with the support of technology to make data-based decisions. More specifically, research is needed to investigate the extent to which: a) technology improves teacher capacity to make data-based decisions, b) the scaffolding provided in technology frameworks improve intervention selection and instruction, and b) technology reduces latency between assessment and intervention.

Future Implications

The current review offers merits that should stimulate future investigation of tablet-based programs as mediums of early literacy interventions within preschool classrooms. The current study provides information about important pre-requisite literacy skills (e.g., alphabet knowledge, oral language, and phonological awareness) and synthesizes findings from studies that explored the use of technology in developing these skills with preschool aged children. Moreover, the findings from this literature review highlight the need to further investigate the utility of employing technology to assist in an early literacy MTSS framework. By informing educators of the link between early literacy skills, educational technology, and MTSS, children needing more intensive language and literacy supports than the universal curriculum provides can be effectively identified and supported through technology-based interactions.

Conclusion

Successful early language and literacy development is crucial in providing the foundation for children to learn to read. Ensuring children grasp the pre-requisite skills of alphabet knowledge, oral language, and phonological awareness is an important component of this developmental trajectory. Research illustrating the continued struggle of children who fail to develop solid early literacy skills speaks to the importance of developing successful instructional and intervention practices. Research exploring the use of educational technology in the K-12 setting as a way to assist struggling students is useful but overlooks the preschool population. Therefore, this paper searched the literature to demonstrate the utility and unique capabilities of integrating an early-literacy technology platform into preschool education and then leveraged these findings to describe how a new tablet-based application, IGDI-APEL, offers innovative resources in the provision of early literacy assessment and data-based decision.

Findings demonstrate (a) positive effects on electronic based interventions targeting phonological awareness, oral language, and alphabet knowledge; (b) ease of student use highlighting the feasibility of incorporating in an early childhood classroom; (c) the need for careful planning and on how to incorporate tablet based learning within preschool early literacy settings; and (d) the great need for more research on how technology can improve data-based decision making among preschool teachers. IGDI-APEL offers easy to use, empirically robust

assessment and progress monitoring tools for teachers to assess development of early literacy skills, monitor students identified as needing additional support, and use the data collected to inform data-based decision-making in the classroom. In sum, IGDI-APEL facilitates data-based decision making within an MTSS framework by easing the burden associated with early childhood's current method of data collection, management, and interpretation.

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* denotes inclusion in systematic review

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