RESEARCH BRIEF

Use of Assistive Technology to Support Emergent Literacy for Young Children with Disabilities

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The Head Start Center for Inclusion provides research briefs that summarize the findings of research studies on topics important to Head Start and early childhood education.

Introduction

Early childhood educators play a vital role in supporting young children's emergent literacy development by engaging them and their families in early literacy experiences in natural learning settings (Shonkoff & Phillips, 2000; Pierce & McWilliam, 1993). High quality early literacy experiences are critical to future school success, yet research suggests young children with disabilities sometimes have limited access to meaningful early literacy opportunities (Erickson & Koppenhaver, 1995; Pierce & Porter, 1996; Trudeau, Cleave, & Woelk, 2003).

Universal design for learning (UDL) is a systematic approach to designing environments, curricula content, learning activities, and materials to accommodate the needs of young children with the widest possible range of abilities (National Early Childhood Technical Assistance Center, n.d.). UDL provides children with a range of functional abilities access to everyday learning experiences, including early literacy opportunities (DEC/NAEYC, 2009). While the adoption of UDL might meet the needs of many young learners, some children require additional individualized supports to promote access to and participation in early literacy activities. The effective use of assistive technology (AT) by early childhood educators can support young children with disabilities to participate in early literacy activities. The purpose of this brief is to discuss UDL and the research evidence about the use of AT to support emergent literacy for young children with disabilities.

Background

High quality early childhood programs demonstrate successful inclusion when *all* children are provided access, participation, and appropriate supports for learning. UDL principles and practices ensure access to typical routines and activities, and to early literacy curricula and experiences (DEC/NAEYC, 2009). The Individuals with Disabilities Education Act (IDEA) of 2004 adopts the definition of universal design used in the Assistive Technology Act of 1998. *Universal design* is defined as "a concept or philosophy for designing and delivering products and services that are usable by people with the widest possible range of functional capabilities." UDL includes products and services that are compatible with assistive technologies (National Early Childhood Technical Assistance Center, n.d.). For example, an "off-the-shelf" storybook that includes both written words and electronic voice narration when a button is pressed makes the storybook universally designed and accessible to young children with a wide range of abilities. While UDL can support learning opportunities, some children will require additional accommodations, adaptations, and modifications to promote their access, participation, and engagement in learning (DEC/NAEYC, 2009). The terms accommodations, adaptations, and modifications are often used interchangeably to refer to strategies that facilitate a child's meaningful access to and participation in daily activities, routines, and transitions. These strategies might include changes to the learning environment or modifications to learning materials and instructional practices (Milbourne & Campbell,

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2007). Some types of accommodations, adaptations, and modifications can also be considered assistive technology (AT). UDL, AT, and modifications can be used simultaneously to support the access and participation of all young children in early literacy experiences.

IDEA of 2004 defines *AT* as "any item, piece of equipment, or product system, whether acquired commercially off-the-shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of a child with a disability." For the purposes of this research brief, AT refers to a device, item, or piece of equipment that is used to support a child's access and participation in early literacy activities (National Early Childhood Technical Assistance Center, n.d.; Cook & Hussey, 2002; Merbler, Hadadian, & Ulman, 1999; Mulligan, 2003).

Description of the Practice

Assistive technology can be used to support meaningful access to and participation in early literacy experiences for young children with disabilities. AT includes low- and high-technology supports (Erickson & Koppenhaver, 1995; Lane & Mistrett, 1997; Pierce & Porter, 1996). Low-technology supports are often simple and easy to create. An example of a low-technology support might be a physical modification to a book that would facilitate a child to turn the pages with a gripping device (e.g., a button or pull tie). High-technology supports are frequently manufactured and individualized for a child. Examples of high-technology devices include an electronic communication device or specialized computer software (Mulligan, 2003). In addition, augmentative and alternative communication (AAC) is a type of AT. AAC refers to "the use of special strategies, methods, and techniques to *augment* and/or serve as an *alternative* to natural speech and/or writing" (Blischak, Lloyd, & Fuller, 1997, p. 38). This can include sign language and communication that requires electronic and non-electronic devices. AAC devices can be low- or high-technology supports.

The continuum from low- to high-technology supports offers early childhood educators a variety of options to support the early literacy development of young children with disabilities. It is recommended to consider low-technology options before choosing high-technology supports (Stremel, 2000). For example, a child might be able to communicate effectively using a low-technology communication system, such as picture cards, and not need a high-technology communication system, such as a voice synthesizer (Mulligan, 2003). When considering low- and high-technology options, it is important to assess what level of AT support (i.e., low to high) will most effectively meet a child's learning needs in a particular context (Wilcox et. al, 1999). It is also recommended to consider family and cultural preferences when planning for the use of AT in early literacy activities with young children (Binger et. al, 2008; Mueller & Hurtig, 2009; Scherer, 1998).

Search Strategies

Primary and secondary literature searches of the ERIC, EBSCO, Web of Science, and Medline databases were conducted. The primary literature search terms included "early or emergent literacy," "technology," "assistive technology," "augmentative and alternative communication," "AAC," "universal design," "shared book reading," "adaptations," "computers," "young children," and "Head Start." The secondary literature search terms were "beginning reading," "computer software," "technology integration," early childhood education," "accommodations," and "computer assisted instruction." The use of these search terms resulted in 570 hits. In addition, a hand search of the reference lists of included studies was conducted. Criteria for inclusion of studies in this research brief were the following: (a) an empirical study that involved an early literacy intervention; (b) inclusion of technology-based early literacy adaptations or supports; (c) inclusion of children with disabilities; and (d) children birth through 5 years of age at study entry.

Results

Of the 570 articles identified through the primary and secondary searches, a total of eight studies published about the use of technology to support emergent literacy development for young children with disabilities met the criteria for inclusion in this brief. Identified articles were published between 2000 and 2009. A hand search of the reference lists of included articles was conducted and no additional articles were identified that met the inclusion criteria. Table 1 summarizes the characteristics of participants, methods, and the salient findings of the studies reviewed.

Demographic information revealed the participation of parents, teachers, and young children with diverse needs. Table 2 shows the demographic information of child participants, including disability classification, race, ethnicity, age, and gender. The spectrum of mild to significant disabilities was represented in the children who participated in the interventions. Demographic information on race and ethnicity showed a range of representation of children and parents from African-American, Caucasian, Filipino, Latino, and Pacific Islander populations. The age of the child participants ranged from 24 to 71 months at entry to the studies. Sixty-five percent of the child participants were males.

The early literacy technology interventions were conducted in various settings, including early childhood special education classrooms, inclusive preschool classrooms, and community- and home-settings. None of the reviewed studies indicated the interventions were implemented in Head Start settings. Three studies included parents in the intervention and the remaining studies involved teachers delivering the intervention. The interventions targeted varying early literacy goals for young children with disabilities.

Interventions With AAC

Three studies focused on the effects of early literacy interventions for young children who required AAC. The first study (Binger et al., 2008) measured the effect of an instructional program on the multi-symbol utterance productions of children who use AAC during storybook reading sessions. The instructional program involved teaching parents to use a turn-taking strategy to support their children's use of multi-symbol utterances. Two of the children used a speech-generating device and one child used a low-technology communication board. When compared to the use of multi-symbol utterances before the instructional program was implemented, all children increased their use of multi-symbol messages after the instructional program was implemented. Parents were able to continue to use the strategy when reading novel storybooks with their children in the 8 weeks after the intervention.

A second study (Johnston et al., 2009) investigated the effect of a naturalistic instructional strategy focused on sound-letter correspondence and spelling of consonant-vowel-consonant (CVC) combinations with two young children who used AAC. The naturalistic instructional strategy involved an interventionist engaging two children at the literacy center. She added four activities at the literacy center that would support adult-child interaction and used these as reinforcement for correct responses (e.g., children could throw a sponge ball into a basketball hoop after a correct response). The interventionist created a book with letters and CVC words. She used this book each day during the intervention. She prompted the children to identify a letter and then provided consequences based on the child's response. If the child was correct, the interventionist provided the materials needed to engage in a selected activity and provided verbal reinforcement (e.g., You're right, that is /l/). If the child was not correct, the interventionist said no, repeated the prompt, and then modeled the correct response. After the children demonstrated that they mastered letter identification, the interventionist introduced CVC combinations. Researchers measured the effect of the intervention by measuring how many correct letters and CVC combinations the children were able to identify correctly before, during, and after the intervention. Results indicated that children made gains in letter identification and CVC combination skills. Although children made gains during the intervention, only one child was able to identify letters on a computer keyboard. Computer keyboards are frequently part of AAC systems.

A third study (Trudeau, Cleave, & Woelk, 2003) described the use of an interactive book reading program which used AAC techniques and adaptations to promote the participation of all children. Parents of children with and without disabilities were invited to participate in training sessions. Mother-child dyads participated in group sessions and were taught to use adaptations and technologies to promote their child's participation in interactive book reading. AAC supports used in the training included: adapted books, picture communication systems, voice output communication aids, and props such as puppets or three-dimensional objects. Both children with and without disabilities made use of the AAC supports, suggesting that typically developing children can model how to use adaptive devices. Books and related materials were found to be effective tools for supporting literacy and language development. It was found that some parents needed on-going support to use the adaptations and AAC technologies at home.

Interventions With Computers

Two studies identified in the literature search made specific use of computers and software programs. One study (Hitchcock & Noonan, 2000) compared two types of support for assisting children to learn shapes, colors, numbers, and letters. The researchers compared the effectiveness of (a) teacher instruction and (b) teacher instruction paired with use of a computer program. The computer program used animation, color, and sound to increase the appeal to young children. The computer was equipped with an adaptive keyboard. A teacher helped the young children to use the computer program and guided the computer learning activities. The study found that children who received teacher instruction only, and children who received teacher instruction paired with the computer program both made gains in their learning. However, the children who received teacher instruction with the use of a computer made greater gains towards individual goals.

A second study (Mueller & Hurtig, 2009) used a computer program featuring children's books accompanied by a fluent sign language narrator. The computer program also included a parent-training component. The program was designed for mothers and their children who were deaf or hard of hearing to increase their knowledge of sign language during shared book reading. A small increase in engagement with shared book reading was found with the provision of a fluent signing narrator. Mothers showed a mixed pattern regarding time spent with parent training on electronic books. It was hypothesized that time spent on training related both to mothers' familiarity and interest to learn sign language. Both the children and the mothers acquired new sign language vocabulary with and without the presence of the fluent signing narrator. It was concluded that the use of a signing electronic book might be an effective tool when combined with other interventions to augment the literacy experiences of young children who are deaf and hard of hearing. However, the use of this technology support must be situated in the context of parent or caregiver needs.

Interventions With Embedded Technologies

Two longitudinal studies implemented comprehensive technology systems with young children with disabilities. The first study (Hutinger & Johanson, 2000) implemented a technology system that was accompanied by a teacher-training component. Integrated assistive technologies appropriate for children with mild to severe disabilities were provided throughout the day and across the curriculum. There was an increase in teacher use of computer software to promote emergent literacy development and child engagement, as well as the integration of assistive devices and adaptations across activities and routines.

The second study (Hutinger et al., 2006) was a replication of the aforementioned study, with an increased focus on early literacy. The training model was guided by an integrated curriculum approach that involved providing activities and experiences around a common theme. This involved collaboration among professionals to plan for experiences that developed concepts, skills, and language meaningful contexts. Literacy activities were customized when needed to meet individual needs, and low- to high-technology adaptations were provided. The data showed mixed results between control and intervention groups, highlighting the challenge of establishing and maintaining a new curriculum and changing practice.

A third study (Koppenhaver & Erickson, 2003) integrated emergent literacy opportunities with AT supports into naturally occurring classroom activities for three children with autism. During baseline observations, none of the children engaged in self-selected literacy behaviors. Teachers expressed their belief that the three children were not developmentally ready to engage in pre-literacy behaviors. The children had limited access to literacy activities. In addition, low teacher expectations for literacy development were reflected in individualized educational goals. The intervention included: adding literacy tools and materials throughout the classroom, providing time for children to interact with materials, and increasing teacher support around early literacy. Some examples of AT supports included: an electronic writing center, books with sound effects, touch and feel books, homemade picture books, and communication cards. It was found that children engaged in emergent literacy behaviors with the increased high-interest materials, supports, and writing technologies.

Implications for Practice

As suggested by the intervention studies reviewed, early childhood educators and program directors should plan systematically for all young children to have access to early literacy opportunities. Young children with disabilities frequently do not have meaningful access to early literacy experiences. Barriers to access and participation in early literacy activities can be addressed by considering UDL and the use of AT when necessary. The effective use of AT in early childhood classrooms and other settings might provide support to young children with disabilities in order to foster their emergent literacy development. The use of AT to support young children with disabilities requires consideration of the needs, interests, and abilities of each child in the context of the activities and learning goals. It is important to use AT supports that children find motivating and engaging, and to provide support using a least-to-most support approach. Parent and teacher training is also essential to support the effective use of AT. Additionally, it is important for early learning practitioners to consider how technology-facilitated early literacy interventions will meet the needs of families from diverse ethnic, racial, linguistic backgrounds and abilities. The eight studies reviewed suggest low- to high-technology supports can be used to engage young children with a range of disabilities in early literacy experiences that promote their learning.

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* *References preceded with an asterisk indicate the intervention studies included in this review.*

Table 1. Intervention Studies of the Use of Technology to Support the Emergent Literacy for Young Children with Disabilities

REFERENCE AND DESIGN	PARTICIPANTS	SETTING	INTERVENTION	MEASURES	RESULTS
Binger et al. (2008) Mixed Methods: Focus Group used to determine cultural appropriateness of existing educational program; Single subject multiple probe design across participants to measure implementation of the strategy & child outcomes	2 Latino mothers & 1 Latino father participated 1 male child, age 4 years 1 month with a profound phonological process disorder; 1 female child age 3 years 4 months with suspected Velocardiofacial Syndrome, profound velopharygeal insufficiency, & suspected childhood apraxia of speech; 1 female child age 2 years 11 months with subpalatal cleft & profound velopharygeal insufficiency	Not stated	First author taught Latino caregivers to use an instructional strategy to facilitate expressive symbol combinations during story reading & with each child's aided AAC system. AAC systems used by 2 of the children included a speech-generating device and one child used a low-tech communication board	Dependent measures were the accuracy of caregivers' implementation of strategies & frequency of children's multi-symbol utterance production Caregivers completed a questionnaire about the perceived benefits of the intervention	Parents implemented the instructional strategy during book reading sessions at rates of 80% or higher after they were instructed. The percentage of non-overlapping data points before and after intervention was 100%, indicating the intervention resulted in children using more multi-symbol messages following intervention Parents reported high levels of satisfaction with the intervention.
Hitchcock & Noonan (2000) Adapted Alternating Treatments Design	3 males aged 3 years, 3 months, 4 years, 2 months, and 3 years, 10 months respectively. 2 females aged 3 years, 2 months and 3 years, 10 months respectively. All children were identified as having an "early childhood learning impairment, a broad disability category defined as significant delays in cognitive, language, or adaptive behavior skills" (p. 147). 1 child was reported to be Filipino and 4 were part Hawaiian	Special education preschool classroom in a rural public school	Teachers facilitated use of computer programs that included a picture library (including shapes, colors, numbers and letters), sound, and movement. An adaptive keyboard was provided.	Percentage of correct matches (shapes, colors, numbers, and letters)	Percentage of correct matches was higher with computer-assisted instruction than teacher assisted instruction, although children in both conditions showed gains.

REFERENCE AND DESIGN	PARTICIPANTS	SETTING	INTERVENTION	MEASURES	RESULTS
Johnston et al. (2009) Multiple baseline probe design	1 male child aged 5 years 3 months with cerebral palsy & severe developmental delay; 1 female child age 4 years 2 months diagnosed with pervasive develop-mental disorder & developmental delays.	All sessions occurred during free-choice play activities in 2 private & inclusive preschool classrooms in an urban area.	Adult presented a response prompt with an instructional cue to engage in a target behavior (either learning to identify the sound a letter makes or spelling a CVC word). As criteria for mastery of target behavior were met, new skills were introduced. During generalization phase, keyboards were used with letters of the alphabet.	Percentage of correct responses Maintenance and generalization probes were also conducted.	Sound letter correspondence & spelling of CVC words: both children's correct responses increased. During maintenance, both children maintained strong accuracy percentages for sound letter ident-ification & CVC combinations. The first child showed strong generalization (80- 100% accuracy) when presented with both the lowercase & uppercase keyboard layouts. Second child showed strong generalization when presented with the lowercase keyboard layout (60- 100% accuracy) but no generalized responding (0% accuracy) with the uppercase layout. Some generalization was observed for spelling of non-trained CVC combinations (21% to 60% accuracy)

REFERENCE AND DESIGN	PARTICIPANTS	SETTING	INTERVENTION	MEASURES	RESULTS
Koppenhaver & Erickson (2003) Mixed methods	3 children (3 years of age) 2 of the children were Caucasian (1 male, 1 female) & diagnosed with Autism; 1 male African-American child with Pervasive Developmental Disorder.	Full-day, self-contained special education class housed in a public elementary school	Intervention focused on increasing natural opportunities for emergent literacy learning in the classroom by providing emergent reading & writing supports in print-rich environments with increased interaction supports. The intervention provided print-rich environments, a variety of reading and writing tools, & time for children to explore their use. Low to high technology supports and devices were provided in the classroom (e.g., electronic writing center, video-painting toys, whiteboards, recordable buttons, picture communication system)	Percentage of time children chose literacy activities during free choice time Examined children's signatures produced during sign-in time using an adapted version of Sulzby's (1989) categories of writing Qualitative observations	All children spent 0% of their time in self-selected literacy activities during unstructured time. This increased to 96%, 35%, and 39% for each child, respectively, during intervention phase Researchers observed increased interest in writing, one child learned to write his name conventionally and with a word processor. Researchers observed behaviors and interactions evidencing the children's growing interest and under-standing of print

REFERENCE AND DESIGN	PARTICIPANTS	SETTING	INTERVENTION	MEASURES	RESULTS
Mueller & Hurtig (2009)	4 children participated. 1 male child (age 2 years, 0 months) with mild to moderate hearing loss at birth, wore hearing aids. 1 male child (age 4 years 8 months) with moderate to severe hearing loss at birth, wore hearing aids. 1 female child (age 2 years 3 months) with moderate hearing loss at 14 months of age, wore one hearing aid. One male child age 4 years 10 months identified with moderate hearing loss at age 2 years 5 months. Child received cochlear implants at age 4.	Participants were seen in their homes.	Technology as well as parent training based on the Shared Reading Project were provided to enhance the shared reading experiences with children who are deaf and hard-of-hearing. Intervention included use of an e-book with a signing narrator.	Time on task Sign vocabulary as measured by the Carolina Picture Vocabulary Test (Layton, & Holmes, 1985)	Children & parents showed increased reading times during the signing phases, but the difference was small for most children. Children and mothers all learned new signs throughout the 5-week study. There was no effect of the presence of a signing narrator on two of the children's sign vocabulary.
Trudeau, Cleave, & Woelk (2003)	4 mother and child dyads. Children ranged in age from 3 years 10 months to 5 years 11 months. 2 of the children were typically developing. 1 child had severe speech, physical, & cognitive impairments with no specified diagnosis & 1 child was diagnosed with Down syndrome.	Children participated in shared book reading in a group setting. Individual sessions in the home were observed before & after the group sessions.	Interactive 6-week book reading program was taught in a group setting using AAC techniques & adaptations to promote the participation of all children. Researchers provided communication symbols, communication boards, & props as well as voice output communication aids.	On-line observation checklist & coding system for the group context Individual sessions coding system Observation of video taped group & individual sessions to observe the proportion of use of the various modes by each child	"All children used the adaptations in both contexts (group & individual) showing an interest in these kinds of materials." This supports the "notion that these adaptations can scaffold participation of young children with disabilities" (p. 198). Support was also found for use of the adapted books to foster emergent literacy skills.

Table 2: Child Participant Demographic Information Across Studies

CHARACTERISTIC	% (*n*)
GENDER	
Male	65 (15)
Female	35 (8)
AGE	
24 to 35 months	18 (3)
36 to 47 months	47 (8)
48 to 59 months	29 (5)
60 to 71 months	6 (1)
RACE/ETHNICITY	
Latino	43 (6)
Pacific-Islander	29 (4)
Caucasian	14 (2)
African American	7 (1)
Filipino	7 (1)
DISABILITY CLASSIFICATION	
Speech or Language Impairment	35 (70)
Developmental Delay	31 (62)
Other[a]	18 (36)
Autism Spectrum Disorder	3.5 (7)
Cerebral Palsy	2.5 (5)
Down Syndrome	2 (4)
Hearing Impairment	2 (4)
Learning Disability	2 (4)
Visual Impairment	1.5 (3)
Behavior Disorder	1.5 (3)
Attention Deficit Hyperactivity Disorder	1 (2)

[a] Other includes classifications such as Early Childhood Learning Impairment, Multiple Systems Disorder, Low Functioning.