Literacy Studies: Perspectives from Cognitive Neurosciences, Linguistics, Psychology and Education

Adina Shamir
Ofra Korat *Editors*

Technology as a Support for Literacy Achievements for Children at Risk

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LITERACY STUDIES

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While language defines humanity, literacy defines civilization. Understandably, illiteracy or difficulties in acquiring literacy skills have become a major concern of our technological society. A conservative estimate of the prevalence of literacy problems would put the figure at more than a billion people in the world. Because of the seriousness of the problem, research in literacy acquisition and its breakdown is pursued with enormous vigor and persistence by experts from diverse backgrounds such as cognitive psychology, neuroscience, linguistics and education. This, of course, has resulted in a plethora of data, and consequently it has become difficult to integrate this abundance of information into a coherent body because of the artificial barriers that exist among different professional specialties.The purpose of the proposed series is to bring together the available research studies into a coherent body of knowledge. Publications in this series are intended for use by educators, clinicians and research scientists in the above-mentioned specialties. Some of the titles suitable for the Series are: fMRI, brain imaging techniques and reading skills, orthography and literacy; and research based techniques for improving decoding, vocabulary, spelling, and comprehension skills.

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Chapter 1
Introduction: Technology as a Support for Literacy Achievements for Children at Risk

Adina Shamir and Ofra Korat

Being a well-integrated person in contemporary technologically oriented society requires more than the mastery of traditional reading and writing skills. While essential mainly for acquiring knowledge, occupational success, and improvement in socioeconomic status worldwide, the computer age demands broadening application of these skills and the integration of the accompanying new literacies. In parallel, these same technologies are providing access to new tools that may make basic literacy more readily available to the groups that are widely being known as populations at risk (Marsh 2005; Neuman 2009).

The concept "at risk," originating in the world of medicine, refers here to any group or individual in danger of suffering from difficulties in acquiring literacy. In complex, multicultural societies, these difficulties arise from socioeconomic gaps, bureaucratic categorization, as well as ethnic diversity. Students, of any age and belonging to any risk group, may also lack proper learning and teaching environments at home or in school. Some students may also have special needs that require highly individualized teaching methods and learning curricula.

Educators and researchers throughout the world are therefore increasingly concerned with the growing gaps between the disparate groups found in the same classroom. They are seeking ways to narrow gaps in school performance while focusing on traditionally underserved groups of children, such as low-income students, students with disabilities, and students belonging to major racial and ethnic subgroups.

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Evidence of the growing priority of these concerns is found in the passage, in the USA, of the No Child Left Behind Act of 2001 (NCLB), which aimed at improving the education of broad groups of children at risk attending public schools. The act requires schools to rely on *scientifically based research* when formulating curricula and teaching methods, specifically "research that involves the application of rigorous, systematic, and objective procedures to obtain reliable and valid knowledge relevant to education activities and programs." Such research is expected to result in "replicable and applicable findings" to generate persuasive, empirical conclusions. The need for research-based intervention was also noted. As a sign of the government's seriousness regarding this program, we need to simply note that the US Congress has since increased federal funding of education from $42.2 billion (2001) to $54.4 billion (2007). Importantly, funding targeted at reading acquisition quadrupled from $286 million in 2001 to $1.2 billion.

Research in the application of new technologies to literacy instruction is also being indirectly encouraged by its beneficiaries – students. Today's children tend to be fascinated by advanced technology rather early. Children as young as kindergarteners are increasingly exposed to and enjoying electronic media in the form of television and DVDs, video games, computer software programs, electronic books, Internet, mobile phone applications, interactive toys, and similar products (Marsh 2005). This exposure has motivated a growing body of research into just how children respond to these technologies beyond the level of entertainment. In a survey conducted by Vandewater et al. (2007) in the USA, they revealed that children aged 5–6 spend about 50 min a day on a computer, 10 min of which were devoted to e-book reading.

In a broader survey among more than 1,000 households with children aged 6 and under, again conducted in the USA, Rideout and Hamel (2006) found that in a typical day, 83% of the children participating used some type of screen media. Twenty-seven percent of the parents surveyed reported that their children used a computer at least several times a week, and 69% indicated that they felt computers helped their children learn.

This reality poses a significant challenge to researchers in the field of education. With the entry of computers into the class and the home, new opportunities are now provided for the improvement of learning skills in different subject areas; the need to ascertain the educational quality of existing computer tools has arisen. Researchers have therefore begun to look to the new technologies that characterize the modern age as opportunities to investigate and improve literacy acquisition for wide-ranging populations around the world.

Several studies have uncovered some of the main reasons why computerized and multimedia learning environments promise to promote literacy. Van Daal and Reitsma (2000), for instance, suggest that when compared to regular classroom instruction, computer-based learning is more structured and thus easier to absorb. Hutinger et al. (2002) show that in the area of emergent literacy, interactive technologies are particularly effective. These technologies appear to replicate a child's typical learning encounters more naturally than do standard tools (e.g., workbooks) while being sufficiently flexible to incorporate new curricula. Other research confirms that computer-assisted learning does promote children's language and literacy development (de Jong, and Bus 2003; Marsh et al. 2005; Reinking 1997; Shamir et al. 2012; Snyder 2002; Underwood and Underwood 1998; Valmont 2000; Yelland et al. 2006) in addition to arousing children's motivation to learn. Eshet-Alkalai (2004) reports on the multiple representations (text, voices, pictures, and animations) of similar content that multimedia platforms can provide, an approach that enables alternative means of learning the same material. In research attending to the content of multimedia presentations, Moreno and Duran (2004) cite the mutually referring information that each type of media makes available. Generally speaking, all the findings locate some literacy-promoting benefits in the dynamic multisensory environment available to the technologically attuned contemporary student population.

What remains open to investigation is computer technology's benefits for different types of children at risk, whether resulting from their young age (Lankshear and Knobel 2003), their belonging to low SES, ethnic groups, or the presence of special needs (Shamir and Margalit 2011; Zucker et al. 2009).

Within this body of literature, we consider the theoretical work of two researchers to be especially important for explaining why multimedia technologies can support emergent literacy among children at risk. We begin with Mayer's cognitive theory of multimedia learning (Mayer 2003; Mayer and Chandler 2001). Mayer (2003) has drawn our attention to the impact of design features (e.g., spatial contiguity, temporal contiguity, coherence, modality, and redundancy) on the quantitative as well as qualitative improvement of children's performance. He argues that multimedia platforms make several symbolic systems available simultaneously; this synchronization promotes cognition more effectively than does exposure to monomedia (exclusively visual) platforms. Hence, multimedia tools provide children with multiple opportunities to learn based on the special communicative and logical characteristics of each of the different media. Taken together, they support the cognitive transfer and retention of information. Neuman's (2009) theory of the synergetic effects of multimedia learning builds on these and other insights. She points to the benefits of combining different types of presentation – computers, television, and radio in addition to printed materials – each of which differentially contributes to stimulating and sustaining a specific learning capacity. The core of her argument thus stresses that the very combination of platforms produces improved interpretive and emergent literacy development.

To conclude, additional research is required to empirically support the theories promulgated regarding the effectiveness of multimedia technologies in promoting literacy and enhancing literacy-related outcomes among different groups at risk, working in different settings.

It is in this spirit that we have compiled the studies offered in this collection, which is designed to shed further light on some of the gaps in this important literature. The book focuses on studies investigating whether and how multimedia learning tools can instill and support literacy skills and thus prevent isolation of these children in the classroom, a condition often predicting their later marginality in the twenty-first century society. The book is one outgrowth of the international research conference held in 2010. The conference, supported by the Israel Science Foundation (ISF), brought together well-known researchers involved in cutting-edge research on technology as a support for the literacy development of students at risk. We believe that the results of the international research reported here can offer much to education systems around the world in their efforts to help these children, whatever their age, become active and contributing members of society.

The chapters in this book are grouped into three parts: (1) Early Childhood, (2) School Children, and (3) Special Education Needs. Part I, Early Childhood, examines the possible contribution of new technologies for the acquisition of language and early literacy skills among preschool-aged children. The majority of the chapters in this part focus on children from low-income families. In Chap. 2, Adriana G. Bus and Cornelia A. T. Kegel question about whether a computer program can stimulate early literacy skills. How is computer tutoring among low SES kindergarteners and does susceptibility to computer programs vary? The study's findings indicated that the effects of the software used (a computer game) were moderately strong only when a built-in tutor was available. Children's susceptibility to the program was found to be associated with a genetic predisposition to dopamine-regulated reward- and attention-related mechanisms, independent of cognitive ability. The authors' conclusion, that a computer intervention's efficacy is stunningly variable across program qualities and across children's characteristics, points to areas in which new research is needed. In Chap. 3, Susan B. Neuman presents a study applying an intervention designed to accelerate 3- to 4-year-old children's vocabulary knowledge and conceptual understandings. Participants included 1,200 children enrolled in Head Start. The intervention used an embedded multimedia curriculum known as the "World of Words" (WOW) developed by the authors. The chapter presents the data on the progress made by the children and shows how this multimedia intervention can influence their learning.

Chapter 4 presents research conducted by Maria de Jong and Marian J. A. J. Verhallen, who tested whether a digital technology can be used to stimulate early literacy skills in kindergarteners at risk. The chapter describes a series of randomized experiments that demonstrated the surplus value of video storybooks for understanding storyline (e.g., the story's actions and the internal responses of the story's main characters) and vocabulary. Another promising finding brought forth is that interactive features such as multiple-choice questions can add to the learning effects of video storybooks. The authors conclude their chapter with remarks related to what they call the "level-up effects" of multimedia.

Cathy Roskos and Karen Burstein present in Chap. 5 a unique four-component model focusing on the e-book instructional environment. The components include e-book quality rating, physical space for e-book browsing/reading, the child's engagement with e-books, and shared e-book reading instruction. Qualitative analytic techniques were used to formatively assess the model's functionality in the preschool learning environment and to gauge its potential usability in early literacy practice. The study's results reveal the model's promise for e-book pedagogy in early childhood settings.

Chapter 6 is devoted to kindergarten children aged 5–6. In the research described, Ora Segal-Drori, Ofra Korat, and Pnina Klein asked what medium can better support low SES kindergarteners' reading. They examined e-book and printed book reading with and without adult mediation. The young participants were assigned to four research groups: (1) independent e-book reading, (2) e-book reading with adult mediation, (3) printed book reading with adult mediation, and (4) receipt of the regular kindergarten program (control). The authors found that the group reading the e-book with adult mediation exhibited the greatest progress in letter name recognition, emergent word reading, concept about print (CAP), and general emergent reading among all the groups.

Part I closes with Chap. 7, contributed by Victor van Daal and Jenny Miglis Sandvik. They present a meta-analysis of 35 studies conducted to review and analyze the effect of multimedia on the early literacy development of children at risk. van Daal and Sandvik note that large effect sizes were found for phonological awareness, concepts of print, vocabulary, and reading. Medium effect sizes were found for comprehension, nonword reading, and alphabet knowledge. However, large effect sizes for vocabulary, reading, and alphabetic knowledge were also found for children at risk who did not participate in a multimedia intervention. The authors suggest that multimedia literacy applications can be beneficial for children at risk of literacy underachievement, especially with respect to phonological awareness, concepts of print, comprehension, and nonword reading.

Part II presents three studies discussing the effects of technology on school children. Carol Connor claims, in Chap. 8, that effective instruction can be supported by linking assessment and instruction. She describes online software that uses algorithms to translate assessment results into specific recommendations for amounts and types of literacy instruction. Her finding shows the greater the amount of time that third-grade teachers spent using the software, the greater were their students' reading comprehension gains. The findings also revealed that software use positively predicted the precision with which teachers provided the recommended amounts to each student in their classroom.

In Chap. 9, William H. Teale, Katie Lyons, Linda Gambrell, Nina Zolt, Rebecca Olien, and Donald J. Leu present a project including an online learning environment, In2Books, and a literacy-based eMentoring program. The program brings together 9- to 12-year-old at-risk students in American elementary schools with adult mentors for the purpose of reading, responding to, and writing about children's books in order to promote thinking and literacy. The series of studies conducted by the authors explores the program's impact on student achievements and engagement, together with the range of factors involved in constructing an online environment designed to be user-friendly and educationally effective. Analysis of the students' book discussions suggested that authentic literacy tasks – reading books, exchanging letters, and engaging in small group discussions – represent viable tools for creating a learning context reflecting student accountability to the community, content, and critical thinking.

Chapter 10 presents Bracha Kramarski's study comparing 80 seventh-grade students (low and high achievers) who were exposed to either forum discussion supported by self-regulated learning (SRL) with self-guided questions (the SRL group) or to no direct SRL support (the no SRL group). In her study, she investigated mathematical literacy by means of (a) authentic problem-solving performance and (b) forum discussion (mathematics and metacognition). The research findings indicated that the SRL students showed greater gains in mathematical literacy than the no SRL group students. They used mathematical language more frequently and were more flexible in their strategy use.

The book's Part III focuses on children with special education needs and how the new technology can enhance their language and literacy. In Chap. 11, Adina Shamir, Ofra Korat, and Renat Fellah present two recent studies initiated to test the potential of Hebrew educational e-books for enhancing emergent literacy among Israeli preschool children at risk for learning disabilities (ALD). Their findings show that despite the initial disadvantages exhibited by ALD children in vocabulary, phonological awareness, and CAP when compared to typically developing (TD) children, ALD children are clearly capable of making strides in these emergent literacy skills following exposure to an educational e-book of the type employed.

Eliane Segers, in the research described in Chap. 12, examined the use of mnemonics in learning grapheme-phoneme connections among children with specific language impairment (SLI). She asked if these children could benefit from mnemonics use within a computer-supported environment especially when the mnemonic picture is used in a fading condition, similar to the way that typically developing children learn language. Three conditions were tested: (a) a fading condition (letters are taught using a picture-supported first-sound mnemonics procedure in combination with a fading procedure), (b) an embedded condition (no fading), and (c) a pictureless condition. SLI children exhibited higher learning gains in the two mnemonic conditions but – contrary to typically developing children – showed no differences in the fading versus the embedded condition. Segers thus concluded that an integrated-picture mnemonics procedure is beneficial for children with SLI.

Chapter 13 reports research conducted by Sigal Eden, Adina Shamir, and Maayan Fershtman on the effect of laptop use on the spelling capabilities of teenaged pupils (aged 13–16) with learning disabilities. Ninety-three Hebrew-speaking pupils with LD, studying in ten special education classes, participated in this study. The participants were randomly assigned to two groups: the experimental group, which used laptops ($N=54$), and the control group, which did not use laptops ($N=39$). The findings indicated that participants in the experimental group significantly improved their spelling capabilities as opposed to the control group. It appears that the use of laptops in special education classes can enhance the targeted capability.

In Chap. 14, Orit Hetzroni describes research that investigated the effect of using an augmentative and alternative communication (AAC) program that includes a graphic and orthographic symbol processor for enhancing language, communication, and literacy skills. The program is meant to be used by teachers and students in schools for children with communication difficulties. Eighty children studying in six such schools participated in this study. The results demonstrated significant increases in language and communication skills measured across all schools, with the most significant gains in vocabulary. Teachers reported that they increased their use of the assistive technology (AT) for teaching literacy and communication skills.

In the closing Chap. 15, Nira Mashal reports the results of a study focusing on the use of an advanced brain imaging technique (functional magnetic resonance imaging (fMRI)) to improve understanding of metaphor-comprehension deficits in children with learning disabilities. Children with learning disabilities manifest considerable difficulties in understanding nonliteral language, expressed by 3-year delays in metaphor comprehension. The chapter shows how fMRI techniques can enlighten brain functioning in addition to the cognitive mechanisms underlying nonliteral language processing. Mashal also shows how fMRI contributes to our understanding of the specific language impairments observed in children with learning disabilities.

We would like to thank to all the contributors to this book for their scholarship and hard work. We hope that the studies presented here will stimulate thinking and research in this important area and contribute to the integration of technology with pedagogy for the purpose of benefiting all those at risk with respect to literacy development.

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Part I
Early Childhood

Chapter 2
Effects of an Adaptive Game on Early Literacy Skills in At-Risk Populations

Adriana G. Bus and Cornelia A.T. Kegel

Introduction

Early interventions to prevent reading problems address concerns that an unacceptably large number of children are already, by 4 years of age, lacking in competencies fundamental to their school success. It seems therefore essential to develop effective and efficient intervention programs targeting not only competencies in the area of spoken language (Chap. 3 by Neuman, this volume) but also in the area of alphabetic knowledge. Programs targeting alphabetic knowledge aim at stimulating the understanding that letters refer to sounds and which letter relates to which sound. A subsample in each kindergarten classroom lacks this nascent awareness due to sparse experiences in the early years or inability to take advantage of their environment. The early delays in code-related skills translate into marked limitations in literacy and school readiness upon entrance to first grade, and this group's capacity to benefit from beginning reading instruction may be compromised. Research-based curriculum-level interventions narrow in noticeable ways the skills gap at school entry (Byrne et al. 2000; Duursma et al. 2008; Silva and Alves-Martins 2002; Snider 1995) but involve a considerable investment of resources. Moreover, they are adapted to the class and not to the individual though it is only a subsample that is in need of an additional or more intensive whole class program in preparation to reading instruction in primary education.

Computer-aided instruction may hold particular promise, especially for children disadvantaged by learning difficulties or socioeconomic status (Wilson et al. 2009). They can provide individualized feedback by responding consistently and adaptively to children's answers. In the mathematics field, this approach has successfully

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been used to train children on a core aspect of mathematical cognition: number sense (Wilson et al. 2009). From a Finnish study appeared that a computer application designed for remedial reading training in first grade can enhance letter knowledge, reading accuracy, fluency, and spelling of at-risk children (Saine et al. 2011). *Living Letters* is an analogous adaptive game designed to improve code-related skills that are required at school entry. The benefits of *Living Letters* were scrutinized in junior kindergarten children with compromised pre-reading skills. Well-controlled research was carried out with a threefold purpose:

1. Can *Living Letters* stimulate the development of early literacy skills?
2. Which features of the program are vital to boost development and school-entry skills?
3. Who benefits from the remedial computer program?

Living Letters: An example of a Computer Program to Remediate Lags in Early Literacy Skills

The program *Living Letters* is an example of computer-aided instruction in early literacy skills. The program modeled after spontaneous activities of young children who grow up in a literate environment may be a useful tool in preschool and kindergarten. Although a variety of skills resort under early literacy skills, most researchers and educationalists would agree on the importance of understanding that letters relate to sounds. *Living Letters* starts with the proper name because from developmental research in preschool age has appeared that the name is the starting point for code-related knowledge (Levin et al. 2005; Levin and Bus 2003). Close inspection of children's emerging name letter knowledge, phonemic awareness, and invented spellings supports the hypothesis that the initial letter of the proper name serves as an early decoder illuminating how sounds relate to letters. Most children can name the initial letter of the proper name earlier than other letters, most can locate the sound of the first letter in other words preceding other sounds (Tom, for instance, will recognize/t/in "tiger" prior to/p/in "pat"), and most children can use the first letter of the proper name first of all in their invented spellings (Both-de Vries and Bus 2008, 2010).

Familiarity with the written form of the proper name is an incentive for new activities that stimulate the development of code-related knowledge: children start talking about letters in the name ("that's my letter"), adults target children's attention to letter-sound relations in the name ("the word begins the same way as your name"), and children start playing games with the sound of the first letter of their name ("he has the same letter as I have"). The program *Living Letters* imitates this kind of natural activities with the proper name that take place in the homes from a very early age and that make young children pay attention to print as an object of investigation (Levin and Aram 2004). There are games that require recognizing the written form of the name, naming the first letter of the name, and identifying the sound of the first letter in words. The program thus alludes to surface perceptual knowledge of the proper name that most young children develop naturally when they encounter their name on personal belongings such as mugs and artwork (Levin et al. 2005; Levin and Bus 2003).

Efficacy of Living Letters

The software was designed as a remediation tool for reading disabilities but may also be useful in other populations associated with lags in early literacy skills, such as low-socioeconomic status (SES) children. Hereafter, we describe the first test of the program *Living Letters* during the junior kindergarten year in a low-SES kindergarten population. In this study participated 312 kindergartners (60% male) from 15 Dutch schools that served large numbers of low-SES families. Seventy percent of the parents in our sample had attended senior secondary vocational education at most (about 15 years of education). Only children who were about 4 years old ($M = 52.9$ months, $SD = 3.2$) at the beginning of the year in which the intervention was carried out and who spoke Dutch as their first language qualified for participation in the experiment.

We compared children who played the *Living Letters* games with children playing another computer game that did not include letters and sounds during a 3-month period. Stratified assignment guaranteed that in each classroom, the same number of children was submitted to the experimental condition and to the treated control condition. The software used in the treated control group allows us to conclude that improvement could not have been solely due to computer use in general or to extra attention from the teacher. In both conditions, children played the games at school with minimal supervision by the teacher. The computer program was programmed in a way that, when the child had made an error in an assignment, the game was not only repeated in the same session but also in the next session, with a maximum of two repetitions per game. Children thus received a variable number of sessions ranging from 7 to 17, with a mean number of 11.2 sessions ($SD = 1.88$), each lasting about 10 min.

After 3 months in which they played the games in total about 2 h, the children that received the target program outperformed the children in the treated control condition. On a series of tasks that assessed emergent writing, name letter knowledge, and phonemic sensitivity, experimental children scored higher than the control children. After aggregating the three scores into one factor score, control and intervention groups scored on average $-.06$ ($SD = .96$) and .20 ($SD = 1.01$), respectively. The autoregressor (pretest scores on emergent writing, name letter knowledge, or phonemic sensitivity) was a significant covariate, and working memory and inhibitory control were marginally significant, whereas other background variables (age, maternal educational level, PPVT, and nonverbal intelligence) were nonsignificant covariates. The intervention showed moderate-sized gains ($d = .68$), an effect that is large enough to enable a move from the 30th to the 50th percentile.

Results demonstrate that children can achieve substantial gains when they receive computer-aided reading instruction that specifically teaches target skills in a manner that matches children's skill level.

Foundational Features of Remedial Programs for Early Literacy Skills

Even when games provide instructions and practice just as curriculum-level interventions, they may coax children into habits of responding that are nonproductive when viewed from the perspective of practicing code-related skills: instead of solving the assignments, they may just click and enjoy the animations. The *blind eye* of computer-aided instruction can leave children to their own devices, opening the door to *free play* rather than playful engagement with the content (De Jong and Bus 2002). Children may complete the computer assignments without seriously attempting to solve the problems they pose with the result that the potential benefits of computer-aided instruction strongly reduce (Kegel et al. 2009). In line with this theory, we expect that computer programs that include continuous correction or confirmation of the child's responses modeled on human tutors reveal fewer errors in the computer assignments and more growth in target skills (Anderson et al. 1985; Graesser et al. 2012; Van der Kooy-Hofland et al. 2011).

As a critical test, the study probes the differences in error levels in completing program activities by comparing two versions of *Living Letters*. In one version, children received adultlike feedback that becomes more supportive as more errors are made in an assignment: (1) After the first error, the oral instruction is repeated, and children are encouraged "to listen carefully" to promote more thoughtful responses. (2) After the second error, the program provides oral cues to solve the task correctly (e.g., "Which sound do you hear first in your name?"), thus enabling engagement in other similar tasks independently. (3) A third error is followed by the correct solution with an oral explanation (e.g., "Listen; in that word you can hear the/p/of peter"). The program thus provides not only feedback to the accuracy of answers, but it also offers oral cues to correct and optimize children's responses (Wild 2009).

A randomized controlled trial (RCT) design was used to compare this version of *Living Letters* including feedback with a version of the target program in which children did not receive feedback (Kegel and Bus 2012). In both versions of the program, games and instructions were the same, and children received an identical number of trials and repetitions. The two programs differed only on the presence of an online tutor to provide oral reactions to children's responses. The feedback group outperformed the group without feedback by far. After correction for background variables and the autoregressor, children in the feedback condition scored on average more than one standard deviation higher than children who received instruction and assignments but no feedback. Mean scores of the feedback and no-feedback group on the factor score were .20 ($SD = 1.01$) and $-.13$ ($SD = 1.00$), respectively.

Moreover, when the program did not provide feedback, children made more errors in assignments. Both findings are well aligned with prior research (Azevedo and Bernard 1995; Meyer et al. 2010; Vasilyeva 2007) showing that instructions and assignments lose a lot of their impact when children do not receive immediate and personalized feedback to their responses to games. Overall, these results suggest that an intelligent tutoring system should be preferred to playing simple games. A vital element of computer-aided instruction is a computer tutor providing immediate corrections and explanations after each reply to an assignment, thereby imitating instruction through positive, responsive interactions with the teacher.

Regulatory Skills

It seems a plausible assumption that feedback may be vital in particular for children who are easily distracted by irrelevant stimuli. It is typical for the latter group of kindergarten children that they do not succeed to concentrate on a task and stay focused especially when their behavior is not continuously corrected. These children with underdeveloped regulatory skills score low on tests where they have to suppress spontaneous reactions and impulses that interfere with carrying out a task. It seems not too far-fetched to expect that in particular children with underdeveloped regulatory skills are more dependent on feedback to stay on task and benefit from computer-aided instruction. They may only succeed when the program corrects random choices and reminds children of knowledge and procedures for solving the computer assignment. Built-in feedback may therefore be especially useful when children experience problems in regulating their own learning and when they are easily distracted by details or environmental influences. To test this hypothesis, we assigned eligible pupils randomly to experimental conditions stratified for children's level of regulatory skills (Kegel and Bus 2012). To assess regulatory skills, we applied Stroop-like tasks among other tests. In the Stroop-like tasks, children had to switch rules by responding with an opposite, i.e., saying "blue" to a red dog and "red" to a blue dog (based on Beveridge et al. 2002).

Our findings do not corroborate the hypothesis that feedback is especially vital when children's regulatory skills are underdeveloped. Actually, both groups of children, with high and low inhibitory control, perform far better in the condition with feedback. However, especially in the condition without feedback, children scoring low on executive functions lag further behind those scoring high. Results thus indicate that all children benefit less from a program without feedback, but that especially a low inhibitory control group is less able to benefit from computer games when they do not provide correction and confirmation in reply to children's responses to games. In line with the hypothesis that a program without feedback may reward low inhibitory control children's tendency to respond randomly instead of strengthening thoughtful replies, the low inhibitory control children made significantly more errors in the assignments than high inhibitory control children.

Actually, all outcomes evidence a "dual risk" model (Belsky et al. 2007): Children with some risk (here: low inhibitory control) lag further behind when they are exposed to a less supportive environment (here: no feedback).

Differential Susceptibility

Effects of early literacy programs including *Living Letters* are moderate even though programs target foundational literacy skills and present very systematic instruction. By focusing on the whole group, we may overlook higher effects in susceptible subgroups as a priori defined. For instance, in evaluating experimental interventions in the domain of emotional and physiological development, researchers have found differential effects of their manipulations. Children with a fearful temperament appear to suffer most from persistent family conflict or low quality of day care but also to benefit most from supportive environments. Blair (2002) found that a comprehensive early education program significantly lowered the level of internalizing and externalizing behaviors of 3-year-old children with more negative emotionality but not in children with less negative emotionality. From this finding, it can be concluded that fearful temperament or temperamental emotionality is a "risk" under less supportive conditions but a susceptibility factor in a supportive environment. This is the essence of the novel hypothesis of "differential susceptibility." Some children may be more susceptible for the environment and learn more from instruction and less from a control condition.

Likewise, interventions may cause differential effects in the cognitive domain. If children do not practice name writing spontaneously and hardly elicit adult comments because they do not succeed concentrating on such activities, they might be dependent on a program that trains code-related skills and offers abundant practice and personalized feedback. The mainstream classroom environment is an obviously unsatisfactory environment for at-risk children. Overcrowded early literacy settings are likely to challenge at-risk students, who need abundant repetition for acquiring code-related skills. Regular education may fail to provide the kinds of intensive, closely monitored, and individualized practice that children at risk need to attain pre reading skills. Children who are not so easily distracted, on the other hand, might be less susceptible to a computer program, and a special program does not elicit more attention from these children than other opportunities for development enhancement. Children's environment offers many opportunities that can promote learning and development of skills that are also provided by the computer program.

To test this hypothesis, we selected groups physically differing in dopaminergic efficiency which is associated with decreased attention and more dependence on reward mechanisms (Robbins and Everitt 1999). The third exon of the DRD4 7-repeat allele has been linked to lower dopamine reception efficiency. This dopamine-related genetic polymorphism may therefore play a role in children's susceptibility to instructional experiences related to early literacy development. Having the DRD4 7-repeat allele may increase the risk for inattention and dependency on feedback provided in the instruction. In a sample of 182 four-year-olds from 15 junior kindergarten classrooms, it was studied whether effects of the computer program *Living Letters* are moderated by DRD4 (Kegel et al. 2011). Children with the 7-repeat allele were expected to be most susceptible to an intensive individual-orientated learning environment and show the largest increase in understanding the combination of how a name sounds and looks in the *Living Letters* feedback condition. It was also tested whether carriers of the 7-repeat alleles were more susceptible to negative effects caused by the absence of feedback in the computer program that may lead to erratic interactions with the computer program. They enjoy the animations in the computer program without making serious attempts to solve the computer assignments.

Children with the long variant of the DRD4 allele appeared to be more susceptible to the positive variant of the educational intervention program *Living Letters* (with feedback). Children with the long variant of the allele scored lowest after the negative version of the computer program (without feedback), although they did not differ significantly from the control group. The carriers of two short DRD4 alleles were less influenced by the two kinds of instruction, with or without constructive feedback. Effect sizes of *Living Letters* (with feedback) for the carriers of the long and short alleles strongly differed; they equaled .97 and .35, respectively. To the best of our knowledge, this is not only the first experimental test of genetic differential susceptibility in education but also the first experiment ever including in one design the contrasting effects of a negative and positive variation of an intervention.

Conclusion

Our conclusions are fairly straightforward and include three major points. First, computer-aided instruction can be a useful tool in early literacy education, even in kindergarten age (see also Chap. 5 by Roskos, this volume). Adaptive computer games designed to behaviorally train a particular aspect of literacy hold particular promise, especially for children disadvantaged by socioeconomic status. The current data show that a computer program is one instrument for raising the profile of remedial intervention that can add to a better starting position in first grade for young children from low-SES families. The benefit of the software was substantial, considering that the software was only used for a small number of short sessions. As the program was tested in a real resource room situation, this approach thus proved to be feasible in the school environment. We expect that the treated group who is better prepared to benefit from the reading curriculum will outperform the control group in first grade, but this is an important developmental issue for future studies to address.

Second, not only do computer games have the potential to render repetitive training entertaining, but they can also individualize instruction by constantly assessing children's performance and adapting feedback. Our finding that a group not receiving feedback did not outperform the control group demonstrates that a computer program without immediate individualized oral feedback is not a stronger stimulus for learning code-related skills than the daily experiences with written language, as children in the control condition experienced. To explain this finding, we assume that a computer program that does not provide correction and confirmation in reply to children's responses to the games may actually reward random responses instead of strengthening thoughtful replies. The evidence obtained here indicates that underachievement in children at risk for reading failure is preventable by promoting practice with a computer program that is modeled on typical early educational experiences in literate homes.

Third, not all children are susceptible to instruction and benefit from computer-aided interventions. Differential susceptibility implies that only part of the children are strongly dependent on a high-quality computer intervention as they suffer more from bad instruction and profit more from optimal teaching – teaching target skills in a manner that matches children's skills level and providing instruction through positive, responsive interactions. The less susceptible children seem to adapt to most opportunities that promote learning and development of early literacy skills without performing too well or too badly. We conclude that children differ in susceptibility to the quality of feedback and support provided in an early reading computer program, and that this susceptibility is associated with a genetic predisposition to dopamine-regulated reward- and attention-related mechanisms, independent of cognitive ability.

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Chapter 3
Giving All Children a Good Start: The Effects of an Embedded Multimedia Intervention for Narrowing the Vocabulary Gap Before Kindergarten

Susan B. Neuman

Compelling research studies converge on the importance of language as the foundation for literacy achievement (Dickinson and Neuman 2006; Neuman and Dickinson 2011). Children who come to school with well-developed oral language abilities—a foundation for reading acquisition—are likely to become successful in learning to read. Of particular importance is vocabulary knowledge; a large body of research has demonstrated a critical link between early vocabulary knowledge and successful reading achievement (Beck and McKeown 2007; Cunningham and Stanovich 1997; National Reading Panel 2000). For example, Cunningham and Stanovich (1997) reported that vocabulary size in first grade strongly predicted reading comprehension in 11th grade—a full 10 years later.

However, studies indicate wide disparities in vocabulary knowledge (Chall et al. 1990; Denton et al. 2003; Hart and Risley 1995) and growth trajectory (Hart and Risley 1995) between economically disadvantaged children and their more advantaged peers. Because vocabulary is so closely related to reading achievement, these gaps threaten to further exacerbate already unacceptable achievement gaps between children from different socioeconomic backgrounds. Striking differences between economically advantaged and disadvantaged children suggest that we must work toward *accelerating* economically disadvantaged children's oral language skills if we are to close the gap prior to kindergarten entry.

Quality vocabulary instruction has many dimensions but at its core are the teacher's experience and expertise at delivering instruction and the design of instructional materials. We begin with the assumption that it is the opportunity to learn, not children's natural ability that has often stymied their progress in early literacy. Therefore, to accelerate instruction, we need to provide better instructional tools

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through tested principles of design and to enhance professional development for teachers. This chapter describes these foundational design principles, along with illustrations for how they work within the context of a curriculum we developed, the World of Words (WOW) vocabulary intervention for preschool children (Neuman et al. 2007).

Instructional Design Principles to Accelerate Vocabulary Development and Reduce Disparities

Unlike many fields of study, vocabulary instruction has been a well-researched area. Recent meta-analyses (Marulis and Neuman 2010; Mol et al. 2009), as well as significant new research, highlight the following instructional principles for improving children's early literacy achievement.

Principle 1 The Notion of Acceleration. The statistics that differentiate poor children from their mainstream peers are dramatic and highly disconcerting. Hart and Risley (2003), for example, probably describe it best. They estimate that the accumulated experiences of words prior to kindergarten constitute a 30-million word catastrophe. Put simply, this gap is not going to close easily, particularly when we consider that children have spent 20,000 h with their parents prior to school entry, and the number of hours of instruction in a school year may represent as little as 540 h. To narrow these statistics, it will not be enough to merely improve children's vocabulary. Rather, we will have to find ways to accelerate its development—to create self-teaching strategies early on so that children can learn new words on their own.

Principle 2 The Organization of Word Knowledge. This principle relates to us first and suggests how we may be able to accelerate word learning. Too often, words are taught in isolation with little attention to how these words may fit within larger concepts and ideas. Children learn them and then quickly forget them because they do not understand their relationships.

There is an emerging body of evidence indicating that the organization in which children learn words may support word learning (Booth 2009). Recent research has shown that when children undergo a "vocabulary spurt" (McMurray 2007), a point in development in which the pace of word learning increases rapidly, they also begin to display the ability to categorize. The co-occurrence of these abilities has led researchers to speculate a synergistic relationship between them. Borovsky and Elman (2006), for example, in three computational simulations manipulated the amount of language input, sentential complexity, and the frequency distribution of words within categories. In each of these simulations, the researchers found that improvements in category structure were tightly correlated with subsequent improvements in word learning ability. Their results were consistent with previous research by Gopnik and Meltzoff (1987), who have argued for the "bidirectional interaction" of categorization as a tool for learning language.

Richly organized concepts are structured as taxonomies (groupings of like things, e.g., pets) (Markman and Callanan 1984), a hierarchy in which successive levels refer to increasing generalizations. Taxonomies have similar properties (e.g., pets—dogs, cats are animals that live with people) and fall into an intermediate level of abstraction (Smith 1995). In this respect, they are different than themes or thematic groupings (e.g., things you do in a grocery store—clusters of things that interact), which are based on associations and have a less clear-cut structure (Markman and Hutchinson 1984). Specifically, it is the structure and the coherence of taxonomic categories that have been associated with improved word learning.

A number of studies (Gelman and Markman 1986; Murphy and Lassaline 1997) have shown that categories can have inductive potential, helping children to develop generalizations across categories and inferencing beyond what is specifically taught. Consequently, learning words in categories seems to promote word learning and can lead to potentially accelerating vocabulary growth and concept development. Specifically, here's what we know:

- Children learn new vocabulary in the context of acquiring new knowledge; concepts come in clusters that are systematically interrelated (Anderson and Freebody 1979).
- Children tend to organize information into meaningful categories consisting of multiple features.
- Children learn words using this classification decision process, assessing how well the basic features of the semantic meaning matches existing representations.
- Vocabulary knowledge, then, develops from understanding similarities and differences in categories—efficient method for organizing information (Gelman et al. 1998).

Principle 3 Word Knowledge. Vocabulary is children's entry to knowledge and the world of ideas. In order to have a good conversation or inquiry lesson in science, for example, children need a threshold of content-specific words to talk about their ideas. Therefore, our work is based on the selection of content-rich words that represent labels of common items that will be necessary to build and ultimately activate background knowledge. For example, the words "stems," "leaves," and "bulbs" are foundational words that children will need to discuss things in nature. Examples of background knowledge developed in WOW include concepts and words related to the physical and biological sciences, mathematics, and maintaining one's health and well-being.

In addition, we teach words that help children talk about these concepts. We call them supporting words, since they serve the central function of helping to examine, contrast, and compare different phenomena. Morphology, syntax, and pragmatics provide children with many of the "tricks of the trade" for using language to make meaning. Children who turn out to be successful in reading will use the morphological structure in word forms to understand changes in word meanings (big; bigger), to comprehend sentences of greater syntactic complexity, and to identify and use extended discourse such as narratives, explanations, definitions, and other socially defined genres (Carlisle and Stone 2005; Snow et al. 1998).

To develop proficiency in the forms and functions of language, children will need to use it, play with it, and get feedback from their teachers in order to improve their skills. Therefore, we also included the following functional concepts to help children talk about the vocabulary they are learning to follow instructions, solve logical problems, and answer questions:

- *Pronouns*—I, you, your, my, we, she, her, he, his, they, their, our.
- *Identity statements*—What is this? This is a _____.
- *Opposites*—wet/not wet, full/not full; later teach full/empty, wet/dry.
- *Part/whole*—parts of the body, parts of common objects.
- *Comparatives*—Which is bigger? Which is smaller?
- *Materials*—What is it made of? Cloth, paper, plastic, leather, glass, wood, metal, concrete, rubber, paper, brick (teach that a circle is still a circle, whether it is made out of cloth, paper, or plastic).
- *Spatial and temporal relations*—first, next, last, before/after.
- *Prepositions*—on, over, in front of, in, in back of, under, next to, between.
- *Time*—days of week, months, seasons.
- *Plurals*—hand/hands, ear/ears.
- *Same/different*—I am going to clap my hands. You do the *same* thing. Which of these is *different*? Which are the same?
- *Some, all, none*—Am I holding up *all* of my fingers?
- *Where, who, when, what* statements.

Somewhat different from previous research, we focus on important words that are taxonomically related to topics and that can be applied to higher-order concepts. For instance, children learn to classify vocabulary pictures of concepts with similar properties and learn to differentiate words and concepts through challenge questions, such as "Is a snake an insect? Why or Why not?" (It is not an insect, because an insect has three body segments and six legs.)

Principle 4 The Use of Informational Text. Storybook narratives are a wonderful source for learning new words and developing children's imagination. However, information books provide children with knowledge about their world which can be used to gain greater depth in content knowledge and facilitate comprehension. In our work, lessons are organized into related topics, such as from insects, wild animals, and animals that live in water to prime background knowledge in high-utility content, and concepts are strategically integrated with previously learned material. Children listen to book, followed by comprehension activities to develop knowledge of the text structure and comprehension outcomes. The information book will be read and reread, digging deeper into concepts over an 8-day sequence. Following the topic, children will take home a copy of the book which they can share with their families.

Principle 5 The Case for Embedded Multimedia. Especially for children who have not had extensive experience with content-rich language, sometimes a picture is more than a 1,000 words. In our case, we use embedded multimedia, strategies in which animations and other videos are woven into teachers' lessons. The use of embedded multimedia is based on two related theoretical models. The first is that multimedia can support word learning and concept development through a synergistic relationship (Neuman 2009). Supporting evidence comes from Mayer and his colleagues (Mayer and Moreno 2003; Mayer 2001) who have demonstrated in a series of studies that the addition of moving images, diagrams, and pictures allows for better retention than information held in only one memory system. The second is Paivio's dual coding theory (Paivio 2008), which posits that visual and verbal information are processed differently, creating separate representations for information processed in each channel. Together, these codes for representing information can be used to organize and create mental models of knowledge that can be stored and retrieved for subsequent use. Chambers and her colleagues (Chambers et al. 2006, 2008), for example, have shown that the use of embedded multimedia can enhance learning, reporting a moderate effect size when compared with instruction without media.

We begin each lesson first with a "tuning-in" video clip—a rhyme, song, or word play video "clip" that is shown from a DVD[1] to bring children together to the circle. It builds excitement for the lesson and engages children in rhyming, beginning sounds, segmenting, and blending activities. The "tuning-in" is followed by a "content" video, introducing children to the definition of the category. The first video is designed to act as a prototype of the category, a particularly salient exemplar of the topic, for example, on insects (i.e., a katydid). After the video, the teacher engages the children, focusing on "wh" questions. She might ask, "Where does a katydid live? What is an insect?" Words are then reinforced using the information book (i.e., in this case on insects) specially designed to review the words just learned (e.g., antennae; segments, camouflage; familiar, wings; outside) and to provide redundant information in a different medium.

On subsequent days, the teacher will provide increasing support to develop these words and use additional videos that focus on new words inside and outside the category, helping to build children's knowledge of the properties (e.g., insects have six legs and three body segments) that are related to the category. In addition, videos and teacher questions deepen children's knowledge of the concept by providing information about the topic (e.g., insects live in a habitat that has food, shelter, and the weather they like). Following the video, children are presented with "time for a challenge" items which require them to problem-solve about the category (e.g., Is bat an insect?). These challenge items are designed to encourage children to apply the concepts they have acquired to think critically about what may or may not constitute category membership. Lastly, the children review their learning through journal writing activities that involve developmental (phonic) writing. Together, the scientific and word concepts are integrated with daily experiences, bringing these words to life.

[1] All clips have been specially selected from the archives of Sesame Street and Elmo's World. Clip length varies from 40 s to 1½ min.

Principle 6 Gradual Release of Control. This principle refers to the guidance, assistance, and support that teachers provide to their learners. Teachers use different degrees of support, or scaffolding, to assist their young learners at the initial stage and then systematically and gradually release control so that children can try their new activities on their own. In the beginning, for example, teachers focus on explicit instruction, helping children to "get set"—providing critical background information so that the children establish a purpose for learning. Teachers then "give meaning" to deepen their understanding of the topic. Rather than ask open-ended questions, they provide information to children, giving more meaning to each word and the concept it represents. In these initial sessions, teachers use the "call and response" interactive strategy. They will say something like this: "An insect lives outside. Where does an insect live?" or "Insects have three body parts. How many parts does an insect have?" "Three." The purpose is to engage children in many rapidly paced responses in unison using their words. As the instructional sequence progresses, the teacher begins to "build bridges" to what children have already learned and what they will learn (establishing intertextual linkages across media). Here, the teacher begins to release more control to the children during the teacher-child language interactions. She will dig deeper and talk about other insects that are similar and different from what the children see and watch. Finally, the teacher will "step back" giving children more opportunities for open-ended discussion. Since children now have better background and more words to discuss their ideas, these conversations encourage children to elaborate on what they have learned.

Together, these principles underlie the World of Words intervention and are designed to maximize children's opportunities to learn words and concepts that are targeted to science, math, and health content standards early on in preschool. Throughout the sequence, familiar words are used for helping children talk about a topic and for incorporating the approximately 10–12 content-specific words for each topic into more known contexts. Lessons are 10–12 min daily, most often conducted during circle-time.

Evidence for Effects of the World of Words

Two studies now (Neuman and Dwyer 2011; Neuman et al. 2011) have demonstrated the potential of WOW to improve children's word knowledge and concept development. A quasi-experimental study with 322 children in treatment and control groups provided initial evidence that children could learn content-rich words and could retain word knowledge over time (Table 3.1).

The second study was far more ambitious. We conducted a randomized control trial of 28 Head Start classrooms in a high-poverty urban area with the goal of determining how the program might increase word knowledge and initial concepts tied to prekindergarten content standards. Classrooms in the treatment condition participated in the 12-min, 4-day per week program in addition to their traditional curriculum.

Table 3.1 Demographic characteristics of children across the four samples

	Head Start treatment (N=294)	Head Start control (N=310)	State pre-K control (N=508)	University pre-K control (N=172)
Age in months	47	47	52	47
Woodcock-Johnson (pre-)	98.4	97.5		
Woodcock-Johnson (mid-year)	98.8	96.4	103.9**	111.8***
% Female	55	51	53	42
% Minority	74***	75***	39	45
% White	26	25	62**	56**
% Black	53***	46***	22	3
% Hispanic	1	2	8	0
% Asian	10	7	4	37***
% Middle Eastern	3	6	0	1
% Multiracial	8	14	3	2
% English as primary language	96	96	94	100

*p<.05; **p<.01; ***p<.001

Table 3.2 Comparisons of pre- and posttest scores by treatment group on word knowledge

	H. S. treatment	H. S. control	State pre-K	University pre-k
Unit 1				
Pretest, % correct	.63	.61		
(SD)	(.18)	(.17)		
Posttest	.77	.69***		
(SD)	(.19)	(.17)		
Unit 2				
Pretest, % correct	.78	.78	.90***	.92***
(SD)	(.17)	(.16)	(.12)	(.11)
Posttest	.88	.79***	.92**	.94**
(SD)	(.15)	(.17)	(.09)	(.09)
Unit 3				
Pretest, % correct	.73	.68*	.85***	.88***
(SD)	(.18)	(.20)	(.13)	(.12)
Posttest	.81	.70***	.86**	.89***
(SD)	(.18)	(.20)	(.15)	(.12)
Woodcock-Johnson (post)	100.15	98.35	101.87	109.60***

*p<.05; **p<.01; ***p<.001

Classrooms in the control group used an alternative early literacy curriculum (High/Scope Growing Readers) in addition to their traditional curriculum (Table 3.2).

Two additional samples were added following the first 8-week unit of instruction. The purpose was to examine the extent to which the intervention might close the vocabulary and conceptual knowledge gap for children who were economically disadvantaged compared to children who attended a state pre-K program, or those

Table 3.3 Comparisons by treatment group on conceptual knowledge

	H. S. treatment	H. S. control	State pre-K	University pre-k
Unit 1				
Pretest, % correct	.50	.49		
(SD)	(.11)	(.14)		
Posttest, % correct	.59	.52***		
(SD)	(.13)	(.10)		
Unit 2				
Pretest, % correct	.54	.51*	.58**	.63***
(SD)	(.11)	(.13)	(.13)	(.16)
Posttest, % correct	.62	.54***	.60	.65
(SD)	(.17)	(.13)	(.12)	(.17)
Unit 3				
Pretest, % correct	.55	.53	.58**	.65***
(SD)	(.14)	(.14)	(.13)	(.14)
Posttest, % correct	.61	.54***	.63	.65
(SD)	(.17)	(.17)	(.15)	(.22)

*p < .05; **p < .01; ***p < .001

who were highly advantaged in a university preschool program. Twenty-eight state pre-K classrooms from the same surrounding county as Head Start participants agreed to participate in the study, with an additional 11 classrooms from the university-based preschools. In total, the sample size included 1,284 3- and 4-year-old children.

Pretests to assess children's expressive vocabulary, rhyming, and alliteration skills including the Woodcock Picture Vocabulary Test (Woodcock and Mather 2001), Peabody Picture Vocabulary Test (Dunn and Dunn 1997), and Get It, Got It, Go! (Missall and McConnell 2004) were administered at the beginning of the year (September) and at the end of the year (May). In addition, specially designed labeling and categorizing assessments were developed. Specifically curriculum-based vocabulary was assessed pre- and post units following 8 weeks of instruction, as well as concept-based properties. That is, for each unit of instruction, 40 words were randomly selected and assessed using a receptive task before and after instruction. In addition, a 32-item task to measure growth in children's conceptual understanding of target vocabulary was administered for each unit. Four conceptual properties from each topic were selected. Assessment questions were devised to include the target word in a sentence that was related to the concept (e.g., Do our *legs* help our bodies move around?), or not related to the concept (e.g., Does a *jacket* help our bodies move around?). Each conceptual property was tested using both in-category and out-of-category target words in order to measure children's understanding of when the concept property could be applied to the target vocabulary word and when the concept property could not be applied to the target word. Further, at the end of the intervention, inference and generalization tasks were conducted (Table 3.3).

Given the multilevel nature of the data, we also estimated hierarchical linear models with treatment condition at the classroom level. These analyses are more conservative as they recognize that children are not independent from one another

Table 3.4 Comparisons by treatment group on categories and properties within concepts

	H. S. treatment	H. S. control	State pre-K	University pre-K
Unit 2				
Overall pretest, % correct	.58	.54, ns	.69***	.74***
(SD)	(.22)	(.21)	(.19)	(.22)
Overall posttest	.76	.58***	.74, ns	.78, ns
(SD)	(.22)	(.20)	(.19)	(.21)
Properties pretest, % correct	.56	.51, ns	.66***	.71***
(SD)	(.24)	(.24)	(.23)	(.24)
Properties posttest	.74	.56***	.72, ns	.76, ns
(SD)	(.24)	(.24)	(.22)	(.23)
Category pretest, % correct	.61	.59, ns	.73***	.79***
(SD)	(.30)	(.27)	(.25)	(.26)
Category posttest	.77	.59***	.74, ns	.78, ns
(SD)	(.31)	(.32)	(.28)	(.30)
Unit 3				
Overall pretest, % correct	.54	.51, ns	.64***	.71***
(SD)	(.23)	(.22)	(.23)	(.22)
Overall posttest	.61	.52***	.66, ns	.73***
(SD)	(.26)	(.24)	(.23)	(.23)
Properties pretest, % correct	.46	.43, ns	.56***	.65***
(SD)	(.28)	(.26)	(.26)	(.27)
Properties posttest	.55	.43***	.59, ns	.69***
(SD)	(.30)	(.27)	(.26)	(.26)
Category pretest, % correct	.65	.62, ns	.74***	.79***
(SD)	(.33)	(.32)	(.29)	(.27)
Category posttest	.71	.63, ns	.74, ns	.78, ns
(SD)	(.31)	(.32)	(.30)	(.29)

*$p < .05$; **$p < .01$; ***$p < .001$

but are clustered within classrooms. HLM models allowed us to partition the variance between children and between classrooms to take this into account. For each outcome, we first determined whether there was statistically significant variability in the outcome between teachers and calculated the intraclass correlation (ICC), the amount of variance in the outcome that existed between children and between classrooms. Next, we estimated child-level effects by including covariates to predict variability between children. Covariates that were not significant were eliminated from the subsequent analysis. Finally, we created a fully conditional model to estimate classroom-level and child-level effects simultaneously. At the classroom level, treatment condition was our variable of interest and was included as the predictor of between-classroom variance. Each control condition (Head Start control; state pre-K; university pre-K) was entered into the model as a dummy-coded variable with children in Head Start treatment classrooms as the comparison (Table 3.4).

The results of the experiment, replicated in each unit of instruction, demonstrated significant effects on children's vocabulary and conceptual development. Effect sizes ranged from 0.8 to 1.16. Statistically significant differences were reported consistently between the Head Start treatment and control groups. These differences

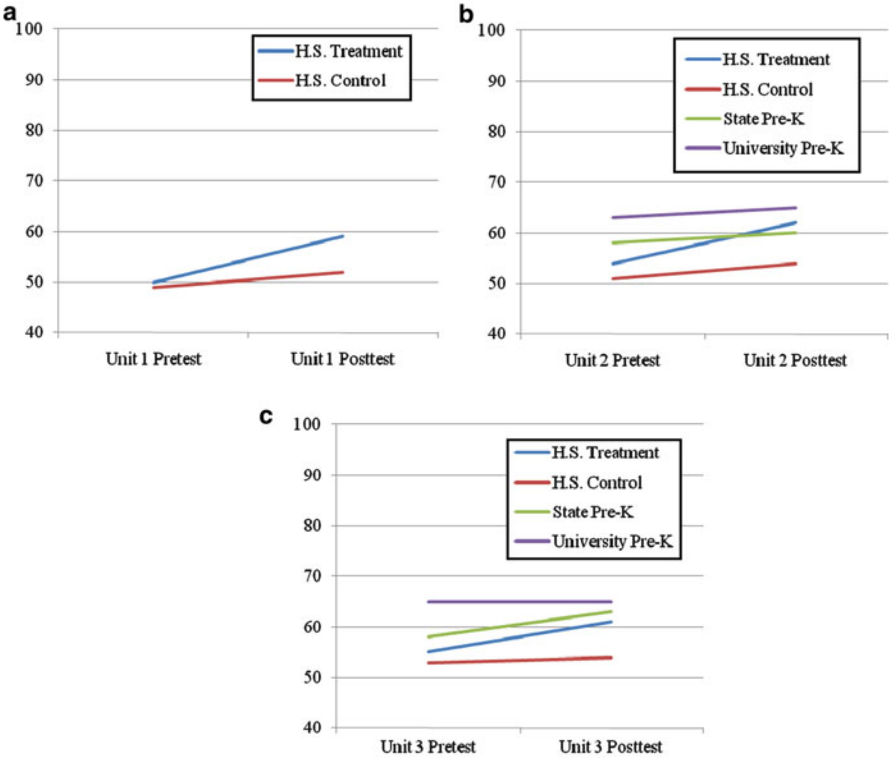

Fig. 3.1 (**a**) Comparisons of Head Start treatment and control groups on concepts—unit 1. (**b**) Comparisons of all groups on concepts—unit 2. (**c**) Comparisons of all groups on concepts—unit 3

were educationally significant (see Fig. 3.1a, b, c), as indicated by the sizes of the effects, which were substantial. Targeted to Head Start early outcome and pre-K standards, they were also educationally relevant and meaningful for content learning in science, math, and health as well. Given that the control group also used a supplemental curriculum, these results suggest that the words and the instructional design features of WOW were more effective in promoting word knowledge in these critical content areas. Figure 3.1 provides an example of the findings in our analyses.

Our use of two additional control groups—one middle class and the other highly advantaged—however, provided evidence of the stark vocabulary gap between low-income and middle-income children. In contrast to the Head Start children, those in the more advantaged groups knew the content-rich words without any additional instruction. At the same time, the results provide powerful evidence for the effects of quality instruction. Within 8 weeks in one case, treatment children essentially closed the gap in word knowledge; in another case, they significantly narrowed the gap, demonstrating their ability to learn and retain these content-specific words.

The lesson that our experience with WOW tells us is that vocabulary development is highly malleable and sensitive to instruction. It is a matter of planned, sequenced, and systematic instruction. Many children who come from high-poverty circumstances have had only limited experiences with language, specifically conceptually based vocabulary. Children who enter school in these situations will need skillfully developed instruction that not only improves their word knowledge but that accelerates it, maximizing the limited time they have in school. This is the potential power of an intervention that embedded multimedia. It provides a synergy of strategies that children can use to support word learning and comprehension.

Vocabulary development is foundational for learning to read. It is the entry to concepts and comprehension. We cannot leave it to chance. Consequently, we must engage in a substantially greater teacher development effort to ensure that children have the opportunity to discuss, describe, and develop word knowledge and concepts they will need in subsequent grades and content areas. Children's future success is dependent upon it.

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Chapter 4
Video Storybooks: A Way to Empower Children at Risk

Maria T. de Jong and Marian J.A.J. Verhallen

Introduction

The Need for Early Interventions

Children will have had many encounters with written language before the start of formal reading and writing instruction in first grade. Most parents read to their children, often on a daily basis. Parents support children's emerging story comprehension by asking questions or explaining unknown words. Scaffolding can trigger young children's interest in books as the increased story comprehension may make sessions more enjoyable (Bergin 2001; Bus 2001; Bus et al. 1995, 1997; Bus and Van IJzendoorn 1997).

Children are also socialized in writing. They see their parents writing letters or shopping lists, thus making children aware that written language conveys meaning and can be understood by others. The value of written language for communication is even more compellingly demonstrated to children through modern written communications such as e-mail and texting as replies are often instantaneous. These experiences, with adults engaging in meaningful written communication, inspire young children to write themselves (Levy et al. 2006).

The support provided by parents in understanding the language in books and with early attempts to write helps children to gain an insight into the relation between spoken and written language. Thus, shared reading and writing activities not only provide *quality time* with the parent but are also *cognitive* stimulating activities (Bus et al. 1995; Mol et al. 2008, 2009). Also, with the support of the adult, children may come to understand the sophisticated language in books. In contrast to the language children encounter in daily life, the type of language used in books is more lexically diverse and higher in thought content (Chafe and Tannen 1987).

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Familiarity with the type of language used in books is essential for learning to read. For instance, reading unknown words is more difficult than reading words that are already stored in the mental lexicon. Compare the words *confirm* and *dinner,* words not uncommon in children's storybooks. If young readers do not know the words, they may find it more difficult to decode these words. The graphemes refer to phonemes, but that the second syllable in *confirm* and the first in *dinner* should be emphasized cannot be inferred from the graphemes. Writing does not include features such as intonation, rhythm, phrasing, and pausing.

Later on when the focus in reading instruction changes from decoding words to text comprehension, language skills and background knowledge become the limiting factors (Cunningham and Stanovich 1998). The foundation for these skills is laid early in a child's life, long before formal schooling starts. Vocabulary gaps that arise in these early years persist or even widen in the years that follow (Biemiller and Slonim 2001). Familiarity with the language in books is essential to participate in education as it is the form of discourse used in schools (Anderson et al. 2003).

Ferreiro and Teberosky's publication (1978) triggered educators' and reading researchers' awareness that lacking these early experiences puts children at a disadvantage. Children may miss the necessary skills and knowledge to profit from initial reading instruction, resulting in increasing delays in the years that follow (Juel 2006; Duursma et al. 2007; National Center for Family Literacy 2008; Raudenbush 2009; Snow et al. 1998; Stanat and Christensen 2006).

In line with this, Heckman (2006) demonstrated that the yield of early interventions is significantly higher than interventions later on. Early interventions can prevent early delays in language or at least diminish them. This in turn may give children a better kickoff when formal schooling begins, thus making reading instruction more effective (Al Otaiba et al. 2010).

Early interventions might reach more children through the use of technology. Internet-connected computers are everywhere nowadays (Anand and Krosnick 2005; Calvert et al. 2005; CBS 2008). Especially devices such as laptop, computers, and tablets allow digital content to be accessed wherever and whenever wanted. Training teachers to deliver effective interventions (Justice et al. 2008) or requiring parents to build in literacy activities that are not part of their every day experiences can be a daunting task (e.g., Brooks-Gunn et al. 2002). The distribution of effective software programs might be easier to accomplish.

Therefore, the aim of this chapter is to explore whether computer programs can effectively intensify early literacy experiences of preliterate children at risk. Story comprehension and vocabulary are not only major determinants of beginning but also of advanced reading comprehension (Cain and Oakhill 2006; Lesaux et al. 2010). In this contribution, we will focus on effects of digital stories or "video storybooks" (also referred to as e-books, CD-ROM storybooks, or living books) as an alternative for shared reading to stimulate story comprehension and vocabulary learning.

Story Understanding

Video Storybooks: A New Generation of Digital Picture Storybooks

From their first appearance, it took more than a decade for digital picture storybooks to attain a well-designed format. The first generation appeared in the 1990s with numerous features that were attractive but did not relate to book reading (De Jong and Bus 2003; Korat and Shamir 2004). Spoken text and pictures were accompanied by hot spots unrelated to the story content, illustrations that could be activated to show a video not related to the events, and a table of contents, icons, and other rather arbitrary extras. These early digital storybooks were hybrid and could be considered as books but also as computer games. Especially for kindergartners, who mainly used computers for playing games, activating these hot spots to evoke funny sounds or animations became a goal in itself. They completely ignored the story line (De Jong and Bus 2002; for older children see also DeJean et al. 1997). An experiment with these first-generation digital books (De Jong and Bus 2002) showed that most kindergarten children scarcely listened to the story text and ignored book-reading conventions such as reading a text from top to bottom or from front to back. They crisscrossed the book in search of games and funny animations.

A new generation of digital picture storybooks emphasizes story meaning. Multimedia contributions in these video storybooks are limited to the spoken text and animated pictures with well-chosen sounds and music to convey the story meaning. The end product is a filmlike presentation of the story that maintains the (literary) story text and the original storybook's pictures. There are several excellent examples, see, for instance, the scholastic video collection of award-winning picture storybooks (Scholastic 2002) that consists of video adaptations of picture storybooks such as *Where the Wild Things Are*, *Harold and the Purple Crayon*, and many others. Unfortunately, there are bad examples as well, which contain many redundant animations that distract attention from the story line, thus obstructing story comprehension (see also De Jong and Bus 2003).

Effects of Video Storybooks on Understanding the Main Story Line

It is evident that video picture storybooks leave less room for guessing the meaning of the story than print storybooks. With the aid of cinematic techniques, scenes that are normally compressed into just one static illustration are cut into a series of shots, thus showing the successive steps that form the action (Gibbons et al. 1986). Compare, for instance, an illustration from the static picture storybook *Winnie the Witch* by Thomas and Paul (1987)) with the video version of the same book. The illustration in the static picture storybook shows Winnie in the doorway holding her cat Wilbur above the grass. From an early age, children try to infer causal relations from what they see (Gergely et al. 1995), but illustrations often are ambiguous

(Greenhoot and Semb 2008; Nikolajeva and Scott 2000; Peek 1993). Does Winnie want to prevent Wilbur from sneaking out of the house? The video storybook shows the opposite to be true: Winnie puts Wilbur outside on the grass.

The additional information provided in video storybooks may offer the extra support needed by children who have difficulty understanding the story text. We tested this in an experiment with 5-year-old Moroccan and Turkish children from low SES immigrant families (Verhallen et al. 2006). Since attending school (the day they reached the age of 4), children had been receiving instruction by means of a second language educational program in immersion classes.

In their retellings, children mentioned about half of the story actions after being read the print version, where they heard the story on the computer with static illustrations. However, after listening to and seeing the video version of the story, they were able to retell significantly more story actions (more than 60%). The video version supported the memory of story events, but this was only true for children who scored among the lowest 25% on a Dutch standardized test for language development (CITO Language Test for Senior Kindergarten Children, Centraal Instituut voor Toets Ontwikkeling 1996). Children scoring within the normal range understood the story's actions irrespective of the version (Verhallen and Bus 2009). It thus seems plausible that the need for visual support will eventually disappear as a result of increasing language proficiency (see also Silverman and Hines 2009).

Effects of Video Storybooks on Understanding Internal Responses

Understanding internal responses of the main story characters is essential for story comprehension (Van den Broek et al. 2005). These emotions, beliefs, or motives form the reasons for story actions. When Wilbur the cat is no longer black but all the colors of the rainbow, he feels embarrassed and hides in a tree. Winnie the witch worries about Wilbur and undoes the spell. Internal responses from Wilbur (embarrassment) and Winnie (worry) determine the course of events here. In order to follow the story line, the reader needs to identify with Winnie's and Wilbur's emotions. When kindergarten children have an underdeveloped *theory of mind* (Wellman 1990), this is too difficult (Thompson and Myers 1985; Van den Broek et al. 1996). They do not pay attention to the internal responses of the main story characters. In their retellings of the stories, children will mention that Winnie turned the cat green (action) or that she put the cat outside (action), but not that Winnie became furious (internal response) when she stumbled over Wilbur for the umpteenth time, which resulted in her taking action. The Winnie the Witch story included six internal responses, but the kindergarten children in our experiments who heard the story accompanied by static pictures only recalled one (Verhallen et al. 2006).

However, in video storybooks, attention is more easily drawn to the internal responses, mental states, or intentions of the main characters such as anger, happiness, and concern. All children – those scoring below as well as within the normal range of second language development – were more aware of internal responses when they "read" the video version of Winnie the Witch (Verhallen and Bus 2009).

On average, they retold 50% more internal responses compared to children who only saw static pictures. As the use of mental state language is related to ToM performance (e.g., Nation and Norbury 2005), it may be that children's theory of mind develops when they focus more on the internal responses of the main story characters and imagine how these emotions have an impact on the story events that follow. This hypothesis awaits further testing in studies that also include false belief tasks as an outcome measure. Apparently, video storybooks not only stimulate story comprehension of children at risk but children who are not at risk also profit.

The Impact of Video Storybooks on Internalizing the Story's Vocabulary

The language in books is rich and complex. Compared to oral language, the number of rare words in books is much higher (Chafe and Tannen 1987; Cunningham and Stanovich 1998). The use of difficult words, such as *orchard* and *clearing*, for example, is common in children's books. Sentences are also more complex in books than in day-to-day communication. Even books for the youngest contain complex sentences to describe relations in the story. Take, for example, the phrase "He played tag with other dogs and became dirtier still," from the still very popular picture storybook *Harry the Dirty Dog* by Gene Zion (1976). Children have to understand that the word "and" refers to a consequence of "playing tag" with other dogs, namely, you become dirty. The last two words infer that he was not clean to begin with. Children's books also contain many proverbs and turns of phrase such as: he has earned his rest not even one note of a birdsong (from: Frog and the Birdsong, by Max Velthuijs 1991).

It is often claimed that animations have a detrimental effect on internalizing the story's wording, thus obstructing vocabulary learning (Hayes and Birnbaum 1980; Hayes et al. 1981). Film scenes that almost speak for themselves are supposed to reduce children's motivation to carefully listen to the story text. Video storybooks are considered an easy medium that induces less effort being put into understanding the story than a story with static pictures that is read to them by an adult (Cennamo 1993). We found no empirical evidence for this assumption. Video storybooks not only stimulate story understanding but vocabulary growth as well (e.g., De Jong and Bus 2002, 2004). Figure 4.1 shows that repeated reading resulted in vocabulary learning (more gains in the video and static storybook groups compared to the control group), but that the video version was an extra strong stimulus for the acquisition of new words (Verhallen and Bus 2009). Apparently, guiding children's attention to the meanings of unfamiliar words by cinematic techniques may take the place of more interactive features added to video storybooks like a dictionary option as was used in Korat's study (2010).

Other research among children who learn Dutch as a second language showed similar results (Verhallen et al. 2006). In the United States, Silverman and Hines (2009) found similar positive effects of video additions to storybooks on English vocabulary of English language learners.

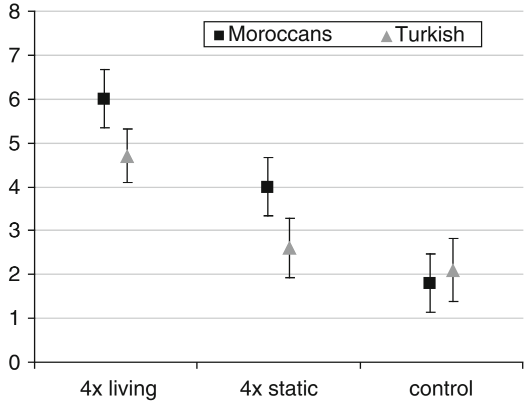

Fig. 4.1 Vocabulary growth in Moroccan and Turkish kindergarten children as a result of repeated "readings" of video or static storybooks or no storybook reading (control group)

Why Are Video Storybooks a Strong Incentive for Understanding and Internalizing the Story Text?

The theory that images linked to language help to give meaning to words and sentences, and in turn help to store the story's wording in the mental lexicon, has been extensively researched (Nino and Bruner 1978; Sipe 1998; Snow and Goldfield 1983; Weizman and Snow 2001). In both static and video storybooks, illustrations with their numerous details are added to the story text, and there is a strong possibility that what children hear coincides with what they see. Children focus on human characters or, as is often the case in stories for the youngest, animals with human characteristics. This is not surprising as their adventures generally form the core of the story. Using eye-tracking equipment to measure where children look in illustrations, Verhallen and Bus (2010) showed that children usually focus on details in the illustrations that match the spoken text, thus matching visual and spoken information. Similar results were found in studies by Evans and Saint-Aubin (2005) and Justice et al. (2005). Video storybooks increase the chance of a good match. Take, for instance, the illustration from Bear and Piglet (by Max Velthuijs 2003). We see Bear sitting in the sun and in the background Piglet carrying a heavy load on his back. The story text tells that Piglet has no time; he needs to work in order to prepare for wintertime. Besides Piglet with her heavy load, the static illustration shows many other details. There is a risk that children will not focus on Piglet but on less relevant details in the illustration. Cinematographic techniques in a video storybook like motion, zooms, and pans attract children's attention to that part of the illustration that is mentioned in the story text. Piglet walking will thus attract the child's attention. It becomes more likely that children will fixate on Piglet when the computer voice says that she "keeps on working." This raises the chance that a strong association between "keep on working" and the image of hardworking Piglet will be forged.

Video storybooks with cinematographic techniques like animation and zoom seem to help children match verbal and visual information. Preliminary results showed that children who saw and heard the video version indeed spend significantly more time looking at the relevant visual information compared to children who saw static pictures (Verhallen and Bus 2010).

Effects of *Interactive* Video Storybooks on Understanding and Internalizing the Story Text

Multiple-Choice Questions

Biemiller and Boote (2006) showed that asking questions during shared reading positively influences the numbers of difficult words kindergarten children will learn. Asking questions and requesting answers seem to provide an opportunity to learn unfamiliar words (Karpicke and Roediger 2008; Mol et al. 2008; Whitehurst et al. 1988). Questions can easily be inserted in digital storybooks, but would these digital questions produce similar learning effects as when questions are asked by an adult during shared reading? To test this, Smeets and Bus (2009) used video storybooks with multiple-choice questions built in. In each reading session, a computer buddy appeared on the screen and asked a question about a difficult word in the story text (e.g., “Where do you see a *shy* bear?”). The children had to choose the correct one from three pictures that show the bear in different moods (shy, broken, furious). In all conditions (with and without questions), the number of readings was kept the same to test whether a simple adaptation can make video storybooks more effective than hearing the story two times while looking at the corresponding video images without inserted questions. Each of the difficult words was presented once as a multiple-choice question.

Words that were the main focus of questions were more often learned. Dutch kindergarten children learned more words expressively when questions were added. Children learned one out of eight difficult words when no questions were asked but two to three words when questions were added. Accordingly, with questions, they learned 15–20% more words than after hearing the story as often but without inserted questions (Smeets and Bus 2009). The questions required an active stance in which children needed to connect the target word to its meaning instead of listening to the target word being repeated. The mechanism described by Karpicke and Roediger (2008), namely, the “repeated retrieval through testing” probably explains the extra effect of the multiple-choice questions. The questions require children to retrieve the meaning of the target word whenever a question pops up on the screen, whereas reading without questions is more similar to what they call “encoding during study.” These results contradict Sénéchal’s hypothesis (Sénéchal and LeFevre 2002) that saying the focus word(s) is necessary for children to expand their expressive vocabulary skills.

Kindergarten children in these experiments were native speakers from Dutch low SES backgrounds with only moderate language skills. Whether results will be the same in groups of at-risk second language learners needs to be tested. However, a recent study by Roberts and colleagues (Roberts et al. 2010), showing that SES may be the more significant factor when explaining growth trajectories in language skills, seems to suggest that similar results may be obtained using this technique with at-risk second language learners from similarly low SES backgrounds.

Digital features, such as the multiple-choice questions, seem to draw children's attention to depictions of unfamiliar words and their meanings quite naturally. Digital storybooks permit the repetition needed to add new words to children's lexicon to occur without the aid of adults. Computers thus become a powerful tool for expanding the child's vocabulary especially in the lives of young at-risk children for whom adult-led shared book reading may not be a common practice (Shamir et al. 2008; Verhallen and Bus 2010; Verhallen et al. 2006).

Level-Up Effects

When at-risk children who score within the lowest 25% on a standardized language test repeatedly hear the same story, they learn 15–20% of the difficult words of the story. After 20 min, the time needed to "read" the story of Winnie the Witch four times, Turkish and Moroccan kindergartners had learned 6 of the 42 difficult words (Verhallen and Bus 2010; Verhallen et al. 2006). The magnitude of this effect becomes clear if we extrapolate this increase to the number of words that children would learn after reading a series of books spread over a whole year. Suppose that children "read" video storybooks for 20 min a week. In that case, their vocabulary would expand by more than 300 words a year (6 per week) (Bus et al. 2009).

Of course, a number of conditions would have to be met: (1) children are attentive, even when no adult is present when books are repeatedly read as was the case in our experiments; (2) each story offers a varied vocabulary of about 40 new words; (3) digital libraries provide enough books to promote reading on a regular basis. Children at risk who learn Dutch as a second language need more reading sessions per week in order to close the gap with their more affluent peers. Reading twice a week for 20 min per session would result in learning about 600 words per year. Unfortunately, there are obstacles. A digital library with at least 60 picture storybooks is necessary, but this number of video storybooks is not yet available. Furthermore, reading routines in classrooms or at home need to be developed. "Reading" video storybooks should be a pleasant event integrated in daily routines (see also Bus et al. 2009).

For native speakers from Dutch low SES backgrounds with only moderate language skills, inserting multiple-choice question into video storybooks appears to be a promising road. With only a few well-chosen questions inserted, children gained on average 15–20% more words.

The Future

Experimental research convincingly shows that video storybooks positively influence story comprehension and vocabulary. The investigation of how effective interventions could find their way to children at risk is essential but too often neglected. Even though all children may profit from reading video storybooks, children at risk have the greatest need of extra learning opportunities. They will profit from the unique features of video storybooks, so the next step is to test how these computer programs can be implemented in the homes and in (pre)schools. Efforts to discuss and model literacy activities in the home with low-educated parents are not very successful (e.g., Raikes et al. 2006). Offering video storybooks via the Internet, however, might provide new opportunities, but it is naive to believe that the availability of educational content on the Internet in itself will change (the lack of) home literacy practices (see, for instance, Neuman and Celano 2006). Similarly, we expect that efforts are needed to help teachers to implement video storybooks in daily classroom practices (see also Selwyn et al. 2009). The use of computers to compensate for the lack of early literacy activities provides teachers with new possibilities. However, finding ways of implementing this in a day-to-day setting in classrooms for at-risk children may be difficult. Teachers need to abandon an egalitarian approach in order to give each child an equal chance to learn. In kindergarten classes, the time allocated to independent seatwork is limited due to other activities like circle time, playing outside, and time for snacks and drinks. Although computers could be used all day, we found teachers to use computers only for limited periods of time, for instance, during work and play (see also La Paro et al. 2009). Further, with few computers available per class, teachers are reluctant to let some children on the computer while excluding others. However, not all children need the same educational content. The evidence provided here suggests a more strategic use of the computer. Although it is currently often used in class management as a way of rewarding more advanced pupils, computers could be more effectively deployed as a learning tool.

The planning problems that may result from attempts to make computers an integral part of the curriculum can, according to Morrison and colleagues (Connor et al. 2007), be solved by applying computer algorithms that facilitate decision making in educational content and educational management. We expect that planning problems can also be reduced when computer programs assist in selecting children at risk, for whom the program is suitable or when the content is adapted to individual differences.

In sum, although there are still some practical obstacles to overcome, video storybooks have the potential to positively affect literacy development, thus empowering young children at risk. The results with video storybooks so far, and meta-analytic evidence with shared book reading by an adult (Bus et al. 1995), justify high expectations for long-term effects of video storybooks, but studies are needed to demonstrate the validity of this assumption.

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Chapter 5
Print to Pixel: Foundations of an E-Book Instructional Model in Early Literacy

Kathleen Roskos and Karen Burstein

Introduction

For students of all ages, the electronic book is a rapidly growing alternative to the traditional book; how this new age tool will impact reading and learning to read at school, however, remains unclear. Equally uncertain is the role of the e-book in beginning reading instruction and early reading experiences as the technology spreads more widely into early childhood settings. Publishers, such as Scholastic and TumbleBooks, for example, offer an increasing array of e-books for young children on a subscription basis—even iTunes now carries an e-book collection downloadable to the iPod/iPad (Mobi). As the technology of the book (as we know it) shifts from largely hard/paperbound to electronic-enabled, our research interest is in not only *what this means* for early literacy development and learning but also *what it might look like* in preschool settings. Formative studies of e-book applications in preschools are particularly appropriate at this early point in this line of research for at least two reasons. One, we have no articulated models of early literacy instruction with e-books. And two, we lack information about e-book pedagogies, that is, approaches and techniques that hold promise for equipping young children for reading in the twenty-first-century literacy. Our chapter describes a four-component e-book instructional model that we are currently implementing in preschool classrooms and observing both in terms of design functionality and usability.

Design has to function at every juncture of the object—Elizabeth Diller

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Foundations of the Model and Preliminary Research

At an early phase in a design process, we conceptualized an e-book instructional model that was purposefully underspecified to allow a wide-angle view of what it takes and what happens when e-book technology is introduced into preschool literacy instruction. The model consists of four components grounded in studies of e-book pedagogy in classrooms (e.g., McKenna and Zucker 2009; Moody et al. 2010) and the knowledge base on early literacy instruction with young children (Dickinson and Neuman 2006; NELP 2008).

- The e-book and its qualities in terms of design and content
- The physical environment of e-book reading in the classroom
- Engagement in e-book reading for small groups and individuals
- Explicit early literacy instruction using e-books

We used a formative research approach, creating a prototype model for implementation in a small sample of Early Reading First classrooms (Midwest, Southwest) and testing it using a convenience sample (4 teachers, 12 children) to observe, define the salient attributes, and rate, in situ, the functioning of each component toward the goal of framing a model for replication and further testing (Collins et al. 2004; Zaritsky et al. 2003). Data were analyzed qualitatively using Carney's ladder of abstraction method (Carney 1990) to formatively assess the functionality of the model in the preschool learning environment and to gauge its potential usability in early literacy practice. Adapting a typological analytic strategy (Lofland 1971), observational data were summarized in the form of ratings based on a rudimentary 0–3 rating scale to represent evidence of presence (0 = no presence, 1 = low presence, 2 = moderate presence, 3 = high presence) of critical attributes in each component. In the following sections, we discuss each component in turn, describing its research foundations and early research results to date.

E-Book Quality

Few studies have directly examined the internal instructional design of the e-book as a literacy learning resource for young children (Roskos and Brueck 2009), although studies focused on literacy development have peripherally observed design problems. Labbo and Kuhn (2000), for example, commented on the need for better designed digital conventions (e.g., pop-ups) to produce more considerate texts that support comprehension. Examining e-books as educational resources in kindergarten, Shamir and Korat (2009) identified several high-level design features beneficial for young learners, such as (a) an oral reading with text highlights that illuminate the nature of print (e.g., word boundaries), (b) a hotspot activation aligned with text, (c) a dictionary option that allows repeated action by the child, and (d) a game mode separate from text mode.

More specifically, de Jong and Bus (2003) developed a three-part framework for examining e-book construction: (a) book processing; (b) multimedia design, that is, the assembly of digital assets such as audio, video, graphics, and print; and (c) interactivity design, that is, the interface that allows choice, control, and engagement. Within these categories, they specified 15 characteristics that describe overall e-book quality. For example, the interactivity of illustrations is described as (1) no interactivity, (2) in games and/or songs and/or hotspots, (3) in games and/or songs, or (4) in hotspots. None of these features, however, were scaled for purposes of critiquing quality. In addition, they examined two other categories—quality of print and of hotspots—creating scales for each. To judge quality of print, they developed a 5-point scale ranging from unclear to clear print size, color, position, and spacing; for quality of hotspots, they used a 3-point scale ranging from incongruent to congruent with the story content. The analytic framework was applied to a corpus of 55 Dutch e-books that were coded for the relative presence of these 15 characteristics. Notably, the corpus showed strengths in book processing, multimedia in pictures (e.g., dynamic visuals) and text (e.g., oral reading), and interactivity with the text (e.g., restarting a page), but moderate to weak evidence of interactivity with illustrations, including games, songs, or hotspots, and weak congruence between hotspots and story. A cross-corpus pattern analysis revealed three subtypes of e-books: (1) talking books with minimal multimedia additions, (2) living books with filmlike story representations, and (3) interactive books that combine multimedia with interactivity. Based on their analysis, de Jong and Bus (2003) tagged interactive e-books as "the most promising prototype" for stimulating and supporting early literacy experience (p. 158).

Through the lenses of two broad reading models (The Simple View, Gough and Tunmer 1986; Interactive-Compensatory, Stanovich 1980), McKenna and Zucker (2009) highlight overarching design features of the electronic reading environment that support code-related skills and comprehension processes in reading. Research is mixed, for example, on the benefits of animations, hotspots, and highlights as code-related supports for young readers. Helpful at times, these features also distract children from paying attention to print. Supportive sometimes, they also can be annoying, thus reducing engagement, especially for able readers. The research is quite clear, on the other hand, as to design features that support story comprehension. Animated illustrations are more robust than static ones, for example, and embedded vocabulary aids look promising, although such cues need to be relevant and child-friendly.

Building on this early design work in a prior study (Roskos et al. 2009), we identified and tested several analytic tools on a corpus of 50 mixed genre e-books from popular online sites. We were interested in the technical adequacy and usability of these tools along three dimensions: multimedia design (how words and pictures are presented), interface design (conventions of use, format, and controls), and learning design (basic features of instruction or *the learn about loop* of purpose, content, and feedback).

Tool 1, derived from de Jong and Bus (2003), examined the design features of the e-book as a unit in four categories: book assistants, multimedia illustrations, multimedia print, and interactivity. Easy to use, the tool analyzed multimedia design to a large extent, interface design to some extent, but learning design only minimally. Based on a set of instructional design principles (Clark and Mayer 2008), tool 2 probed the screen pages of an e-book. Its strengths included tapping features of multimedia and learning design (particularly cognitive demand), but it lacked power for analyzing interface design. Tool 3 focused on digital assets (audio, video, text) to identify screen-page assemblies that create the learning architecture of an e-book (Roskos and Brueck 2009). More difficult to use, the tool nonetheless revealed critical design features across all the major dimensions of design. Different analytic tools, we observed, revealed different design features of an e-book, and we concluded that to judge e-book quality may require a multipurpose tool that examines both the *e* (electronic features) and the *book* (text features) of an e-book.

Based on this line of research, we developed a prototype online e-book Quality Rating Tool consisting of three subscales (ease of use, multimedia, interaction) and a total of 20 items rated on a 5-point Likert scale (Roskos et al. 2011). Our early tests of this tool show strong reliability among external raters (researchers, non-educators) and teacher-users on two dimensions (ease of use, multimedia), but weaker reliability on the interaction dimension. Training for raters, we hypothesize, may not have offered enough examples or allowed sufficient practice for using the tool reliably in judging e-books.

E-Book Physical Environment

Environments have a profound effect on what children think, do, and feel as knowledge seekers and learners (Moore 2001; Weinstein 1979). It was the late Jim Greenman (2005) who argued, "An environment is a living, changing system. More than physical space, it includes the way time is structured and the roles we are expected to play. It conditions how we feel, think and behave…the environment either works for us or against us as we conduct our lives" (p. 5). In an electronic age, the goal is to weave e-book reading into already well-designed physical learning spaces of the classroom and not to isolate this way of reading from traditional book reading areas, such as the book corner or library center.

High-level design of the physical learning environment for young children is guided by several principles, primarily derived from studies in ecological psychology (Gump 1987) and related environmental research (e.g., Moore 2001): the allocation and arrangement of physical space, the complexity and organization of materials, sensory appeal and comfort (e.g., light, temperature, air quality), and the built environment created by children and teachers. At the smaller scale of activity area or center in the classroom, design involves (a) creating boundaries and entries; (b) establishing size, shape, and the illusion of height in an area; (c) combining colors, furnishings, surfaces, and light for mood and tone; (d) setting expectations and rules; and (e) aligning function with program goals (Prescott and Jones 1984). Well-constructed library corners (Morrow and Weinstein 1986), literacy-enriched play areas (Roskos and Neuman 2001), and child-scaled technology niches (Olds 2001) have been found to increase book reading/browsing, literacy play, and engagement in computer-based activities.

Drawing on this knowledge base, we designed an *e-book nook* as a physical place in the classroom for shared and solo e-book browsing/reading that meets several criteria. The *e-book nook* should be a clearly defined place in the classroom with an entry and boundaries that plat the size, shape, and height of the area. It should be built to accommodate small group and solo e-book experiences and merge with traditional library or computer areas. The space should be identifiable with appropriate signage; it should be appealing with attractive color schemes, comfortable seating, mixed lighting (direct, indirect), and a twenty-first-century look and feel (e.g., a café-like setting for browsing and sharing). The general acoustic level in the *e-book nook* should be lower than other areas of the classroom, limiting background noise and eliminating disturbing noises (e.g., HVAC systems) yet supporting the aural potentials of e-book features. E-book devices (touch screen, mobile devices) should be within reach of children; the space should support access to network connectivity and power supplies readily and safely.

To test the feasibility of the physical design of the *e-book nook* in the early childhood classroom, we introduced the *e-book nook* concept over two iterations in Early Reading First classrooms (time 1: 4 classrooms, time 2: 8 classrooms) and observed its arrangement in the classroom environment. Following the initial level of abstraction during year 1, physical design criteria of location, signage, space allocation, acoustics, and access to e-books were used to examine video/photo samples of the *e-book nook* as a physical place in the classroom. In year 2, a survey of the five criteria with operationalized definitions across a 4-point Likert-style rating was developed and used twice, initially to determine baseline and individual classroom needs and 30 days later to measure change in each classroom's physical environment. Four photos of each classroom were taken from "clockface" perspectives of 12:00, 3:00, 6:00, and 9:00 and were individually rated by the five researchers, who then shared their findings, which resulted in a series of recommendations for each classroom. Follow-up observations were conducted 30 days later to determine changes in each classroom. Teachers were informally surveyed on their comfort and satisfaction with changes and provided anecdotal information on their change process. In addition to the information for teachers, year 2 reliability between researchers was analyzed on each of the five criteria of the survey.

Based on post observations, all eight classrooms in the second iteration improved on each of the five criteria and approached a ceiling rating of 3.0 on their presence in the environment. Results indicated that the location of each e-book nook was defined for both teacher and children; all classrooms had adequate signage that included block letters identifying the e-book nook at the child's eye level. Although different in décor, each classroom's e-book nook included space for at least four children and teacher and comfortable seating (e.g., beanbag chairs). Touch screens were at an appropriate height to accommodate interaction; Wi-Fi bandwidth and proper wiring were improved. Generally, acoustics were above average in all the classrooms; all had soft-scapes to dampen the ambient noise of early childhood classrooms.

These changes provided enhanced spaces in which children and teachers could maximize e-book experiences embedded in the ongoing operations of busy classrooms. As they made classroom e-book modifications, teachers indicated willingness to test new strategies and an excitement to share this technology with young children.

E-Book Engagement

In early literacy research, indices of engagement range from physiological (e.g., eye tracking) to behavioral (e.g., self-regulation). Visual eye tracking and skin conductance registers, for example, measure focal visual attention (picture/print) (Evans and Saint-Aubin 2010) and arousal levels as indicators of engagement with printed stories (Verhallen et al. 2006). Inhibitory control measures (e.g., *Head-Toes-Knees-Shoulders*, Ponitz et al. 2009) yield behavioral evidence of attention and distractibility. In a study of electronic versus traditional storybooks, Moody et al. (2010) described reading engagement as "children's attentiveness to a storybook and their ability to sustain attention over time" (p 297) and reported significantly higher levels of child persistence, defined as the ability to complete and maintain participation in shared reading, in e-book over traditional storybook reading conditions. Their results corroborated extant research that shows the benefits of certain digital elements (e.g., animations, graphics) for garnering children's attention in book reading.

Although less precise than physiological evidence, systematic observations of global indicators of engagement, such as persistence (pointing, page turning, question asking), enthusiasm (facial expressions; commenting), and sustained attention (willingness to listen), can provide useful data on child engagement with e-books. At this early point in developing e-book pedagogy in fact, this level of observation is probably more appropriate for assessing the functionality and usability of shared book practices, reserving more precise (and more costly) measures for use when e-book shared reading techniques are more stabilized (Zaritsky et al. 2003). Evidence of engagement in shared e-book reading, for example, may include observations of teacher-child motor behaviors *at the screen*, such as pointing, touching, and gesturing; child attention *to the screen*, such as staring, watching, and nodding; and children's expressions *about the screen content*, such as smiling, frowning, puzzling, and commenting. The frequency of these broad indicators can provide baseline evidence of engagement and inform how it appears to function in the e-book shared reading context, which lays the groundwork for design changes in instructional techniques, as well as experimental research on the benefits of particular techniques over others.

Our observations at the this point are focused on developing analytic tools for observing young children's at-the-screen engagement during shared e-book reading sessions with teachers and with mobile devices. Research objectives include (1) generating an analytic framework for observing at-the-screen engagement in shared book reading, (2) applying qualitative tools and strategies for purposes of grounded description, and (3) developing a systematic procedure for observing at-the-screen engagement in subsequent research.

Preliminary analyses indicate four primary behavioral clusters: (1) teacher-child motor behaviors at the touch screen (e.g., pointing), (2) children's facial expressions during e-book reading (e.g., smiling), (3) teacher-child control of the e-book at the screen, and (4) children's attention to the screen as indicated by eye gaze. Early results show that children repeatedly smiled, gazed, and contemplated the screen during e-book reading sessions, suggesting that they were interested in the e-book stories. Children's motor behaviors also demonstrated strong evidence of engagement on the part of participants. Children's positive motor behaviors (e.g., pointing, acting, touching) were high, while their negative motor behaviors (e.g., wiggling, shifting) were low. Incidences of pointing and sitting predominated over those of wiggling and shifting about "as if" uninterested. Children's focal attention to teacher and screen also provided evidence of moderate-to-high engagement in the e-book reading across sites.

Shared control of the e-book screen, however, emerged as weaker evidence of engagement. This indicator of engagement did not appear well organized or managed at this point. Several teachers reported that asking children to manipulate the controls at the touch screen proved disruptive, diverting children's attention from the story line. However, this represents a negative design feature in this dimension of shared e-book reading at the screen. Children's interactive participation, such as finger-tracking print, pointing to words, and page turning, is a staple of the shared book instructional routine (Mason et al. 1989) because it has been found to develop children's knowledge of print conventions which are foundational in the learn-to-read process (Morris 1992). Shared control of the e-book reading screen, therefore, is a critical design factor that needs to be addressed in the model.

E-Book Instruction

By design, the model limits instruction to science-based techniques that support the development of essential early literacy skills (NELP 2008). The number of scientifically tested instructional techniques is steadily growing, offering practitioners an ever-richer store of effective practices (e.g., U.S. Department of Education Institute of Education Sciences (IES) (n.d.), What Works Clearinghouse, 2011). A critical design feature of the instructional component, therefore, is fidelity to scientifically proven and promising instructional procedures and sequences.

Extant research supports systematic, sequential instruction in early literacy concepts and skills (Pianta and Hamre 2009). Structurally, reading research converges on a before-during-after framework (BDA) of shared book reading where children are primed before reading, guided during reading, and involved in extension activities after reading. Effective instructional techniques, such as dialogic reading (Whitehurst et al. 1994), provide teaching protocols or guidelines that support effective instruction and boost learning opportunities in a BDA framework. Thus, the critical design criteria for the instruction component of the model are twofold: (1) selection of science-based techniques that develop knowledge and skills foundational for reading and writing ability and (2) fidelity of implementation to ensure learning outcomes.

The prototype model employs a direct vocabulary instruction technique referred to as say-tell-do to “test” the viability of the instruction component in the classroom sites (Roskos and Burstein 2009). The technique includes 12 teaching actions before, during, and after shared reading that guide instruction. In addition to evidence of fidelity to the instructional procedure (12 teaching actions), observational data on mean length of session, the percent of teacher explanations of target words during sessions and child use of target words during sessions were calculated and rated on a 0–3 scale of degree of presence to assess how well the instruction component functioned in the e-book shared reading sessions. Ratings on these indices showed considerable variability across sites in teacher implementation of the procedure, verbal explanations of target words, and session length—no surprise given the dynamics of instruction in preschool classrooms. Two patterns emerged in the results. In 3 out of 4 preschool sites, evidence of fidelity to the instructional protocol—the 12 teaching actions—was in the moderate to strong range on a 0–3 scale, which suggests the potential strength of an explicit procedure as a design feature. The generally weak presence of teacher language that supports word learning (explaining word meanings), ranging from 12 to 25% of total utterances, however, suggests that the instructional protocol, per se, is an insufficient design feature. Individual teacher knowledge and skill is a powerful factor and needs to be considered in the effectiveness of the design. More training and self-monitoring may need to be “built into” the design to improve the functionality and usability of this component. Still, it is worth noting the strong showing of child language in the functioning of this model component, ranging from 41 to 55% of total utterances, which provides further evidence of an explicit instructional protocol as a critical design feature of the model. Pre-/postresults on a curriculum-based measure also support this conjecture showing that children made vocabulary gains in either receptive or expressive vocabulary in the implementation sites (See Table 5.1).

Where We Are

Using a formative research approach, we examined the implementation of an e-book instructional model in a small sample of preschool classrooms for its functionality and usability. Salient indicators of each component were identified, observed, and assigned ratings to yield an assessment of design strengths and weaknesses as a basis for further model development. In brief, the design analysis revealed the need for better quality e-books, more precise design specifications for an *e-book nook* in the classroom setting, more explicit teacher guidance for child engagement during e-book reading sessions, and stronger teacher training on “how to” use instructional

Table 5.1 Child performance on a CBM of target vocabulary across classrooms

Classroom	Mean prereceptive assessment	Mean postreceptive assessment	Mean receptive gain/loss	Mean preexpressive assessment	Mean postexpressive assessment	Mean expressive gain/loss
1	13.33	16.33	3.00	7.00	14.67	7.60
2	14.00	16.67	2.67	9.33	8.00	–1.33
3	14.33	19.67	5.33	12.00	18.67	6.70
4	9.00	8.00	–1.00	6.33	9.67	3.30

procedures and skills in shared e-book reading. Several strengths of the model emerged as well. Functionality of the instruction component, for example, appeared to be enhanced by the inclusion of an explicit instructional procedure. Teacher-child motor behaviors at the screen and shared control of the screen, as well as children's generally positive affect in e-book reading sessions, revealed basic features of the engagement component. Usability was marked by a flexibility or "play" in the components that allowed teachers to make adaptations in terms of e-book selection, physical arrangements, and planning for and organizing sessions to facilitate engagement and instruction.

Considerable design research in each of the components is still needed to stabilize the model for more rigorous testing in early childhood classrooms. Not only high-quality sets of e-books for preschoolers but also online professional development materials for teachers need to be developed on the basics of effective e-book shared reading (e.g., pacing, pausing, science-based protocols). This is no small research task—daunting, in fact—but one that warrants our full attention. The e-book represents a technological advance in the book from a two-dimensional to a three-dimensional information tool, replacing the page with the screen and enlivening text with rich imagery, sound, and animation. Research on what this evolution means for early literacy learning is indeed young, but pioneer studies point to the potential of these new dynamic features for supporting children's emerging literacy skills and abilities (Segers et al. 2006; Shamir and Korat 2009; Verhallen et al. 2006). An important research task, however, is not only to understand how these new age tools impact early literacy development and learning processes but also to understand how to use them well in preschool early literacy education. Our e-book model is an instructional framework that moves in this direction—we are at the start-point and open to new possibilities.

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Chapter 6
What Can Better Support Low SES Children's Emergent Reading? Reading e-Books and Printed Books with and Without Adult Mediation

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One of the computer programs introduced for children in recent years is electronic books (e-books). These are most often interactive books which are used as a version of children's books that were originally published in a printed format. Although there has been a sharp increase in the publishing of electronic books, there is to date little research on the quality of these books, the way they are used or their advantages (for details see Chera and Wood 2003; Lankshear and Knobel 2003). There exists primary evidence that electronic books promote young children's literacy in different aspects. Activity with e-books was found to improve children's phonological awareness (Chera and Wood 2003; Korat and Shamir 2008), their ability to recognize written words (Gong and Levy 2009; Lewin 2000; Shamir and Korat 2007), and their ability to read accurately and fluently (Medwell 1998; Oakley 2003). Activity with an e-book also improved children's ability to retell a story (de Jong and Bus 2004; Trushell et al. 2003) as well as their concepts about print (Shamir et al. 2008).

But also, some studies have shown that the electronic book makes little or no contribution to young children's literacy (Burrel and Trushell 1997; Underwood and Underwood 1996). These studies include one that compared the contribution to children's literacy of an independent activity with an e-book with the contribution of reading a printed book. Some studies reported a similar contribution of both contexts (de Jong and Bus 2004; Korat and Shamir 2007), whereas others showed a greater contribution of the adult reading (de Jong and Bus 2002; Segers et al. 2004). To date, only one study has investigated the contribution of reading an e-book with an adult compared to reading a printed book with an adult (Caplovitz 2005). This study found no differences in the emergent reading of children who read an e-book with an adult compared to children who read the same book in a printed format with an adult.

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One of the explanations for the e-book's limited contribution to children's literacy is that adult mediation is needed in addition to the e-book reading in order to more effectively promote children's literacy (Trushell and Maitland 2005; Underwood 2007). Many studies indicated the contribution of adult mediation when reading a printed book to a child (Sénéchal and LeFevre 2002) and during an activity of a child with a computer (Nir-Gal and Klein 2004).

Another explanation is that many commercially available e-books emphasize multimedia, sounds, colors, and graphics, but are not necessarily adapted to promoting children's language and literacy (de Jong and Bus 2003; Korat and Shamir 2004). Two comprehensive reviews on the e-books found in the commercial market have been carried out, one in the Netherlands (de Jong and Bus 2003) and the other in Israel (Korat and Shamir 2004). It was found that many commercial e-books do not have the option of a text that is highlighted congruently with the narrator's reading. This option is important, since it can help children track the text, and may promote their concept about print and reading ability. Furthermore, many commercial e-books do not include the option of seeing or hearing how words from the text can be divided into syllables or sounds, an option that may support children's phonological awareness.

The current study focused on children from a low socioeconomic status (LSES). It has been well established in the literature that LSES children have a lower level of emergent reading than children from a high SES (HSES) (Hecht et al. 2000; Lonigan et al. 1998). In Israel, the gap between the literacy levels of LSES and HSES children is, according to the international literacy test PISA (2002), the largest among the participating countries (Hablin et al. 2004). Studies carried out in Israel showed that this gap has already begun in kindergarten (Korat et al. 2003).

It was also found that Israeli LSES children have a lower home literacy level in terms of materials (e.g., newspapers, books, literacy games) as well as parental mediation during book reading (Korat et al. 2007). Verhallen et al. (2006) claimed that multimedia features, such as those found in e-books, may have a greater potential for promoting emergent reading than printed books with static pictures. They further claimed that this is especially true for children at risk for having difficulties in learning to read. Verhallen et al. (2006) reported that LSES kindergarteners who read e-books with dynamic multimedia features (e.g., active animations and sounds) independently increased their vocabulary and story comprehension to a greater extent than LSES kindergarteners who read e-books with static multimedia features (e.g., static animations and no sounds) independently.

Mixed results were obtained in studies that focused on the effect of e-book reading by LSES kindergarteners on their emergent reading skills. Some studies reported that among LSES kindergarteners, an independent activity with an e-book promoted word reading, phonological awareness, and CAP (Korat and Shamir 2008; Shamir et al. 2008). Others found that this activity only promoted children who had an initial high emergent reading level (Korat and Shamir 2007; Verhallen et al. 2006). It is therefore interesting to examine whether reading an e-book with adult mediation could have a different effect on the emergent reading of LSES children than an independent activity with the e-book as well as compared with reading the same version of the printed book with adult mediation.

The present study is unique because it is the first to compare the interventions of an independent activity with an e-book without adult mediation, reading the e-book with adult mediation and reading a printed book with adult mediation, and the effects of these mediations on promoting children's emergent literacy. A central issue in the present study is whether the reading and mediation of an electronic book by an adult makes a unique contribution to kindergarten children's emergent reading compared to reading a printed book with adult mediation and compared to the children's independent activity with the e-book.

Method

Participants

The sample consisted of 128 children from 12 kindergarten classes. The mean age of the children was 69.65 months ($SD = 4.14$). A nearly equal number of boys and girls were included in each group. All children attended kindergartens located in LSES neighborhoods. Neighborhood SES levels were determined according to the Israeli municipalities' statistical report (Central Bureau of Statistics 2005), which includes data such as the parents' education level, income level, housing density, PC ownership, etc. All kindergartens that participated in the research had the same educational program.

Procedure

Children in each of the kindergarten classes were randomly assigned to four different groups. Each group participated in four book-reading sessions. One intervention group (EB) read the e-book independently without adult mediation. Another group (EBM) read the e-book with adult mediation during and after the sessions. The third group (PBM) read the printed book with adult mediation during and after the sessions. The fourth group, which served as the control group, received the regular kindergarten program.

The children's activity with the computer or the printed book took place in their kindergarten classes. The children worked in pairs in a separate room. Working in pairs was found to promote young children's emergent literacy when engaging with e-books (Shamir 2009; Shamir and Korat 2007; Shamir et al. 2008). Sessions in all three experimental groups lasted 20–30 min. The sessions with the adult after the readings in the EBM and PBM groups lasted 20–30 min. In the EB and EBM groups, the children were given technical support as needed, and some were encouraged to finish their session. The mediation in the EBM and PBM groups occurred during and after the sessions and emphasized the promotion of emergent reading based on studies that indicate that discussion of print concepts and emergent literacy aspects in shared book readings promotes children's literacy skills (Justice et al. 2008; Korat et al. 2007). The activities with the adult after reading the books were conducted with reference to the books that were read before and the mediation given by the adult during the reading. For example, during the sessions with the e-book, the adult focused the children's attention on the option of hearing and seeing how words from the text can be divided into syllables and sub-syllables. In the PBM group, the adult stopped at those words which were divided in the e-book and divided them into syllables and sub-syllables. In both the EBM and PBM groups, this activity took place repeatedly with the adult and the child after the sessions by clapping hands.

The Printed and Educational Electronic Books

Two books, each in a printed and an electronic version, were used. Half of the children in the intervention groups read one book and half read the second book. The e-books were electronic versions of *Yuval Hamebulbal* (*Confused Yuval*) by Miriam Rot (2000) and *Hatractor Beargaz Hachol* (*The Tractor in the Sandbox*) by Meir Shalev (1995). These e-books were designed by the authors to capture general educational principles and those found especially beneficial for developing literacy, while avoiding drawbacks identified in standard e-books (de Jong and Bus 2003; Korat and Shamir 2004). The story's protagonist in *Confused Yuval* is Yuval, a young boy who tends to be confused and forgetful until his grandmother makes a special hat for him to help him remember. The *Tractor in the Sandbox* tells the story of an old farmer (Uncle Aaron) and his special relationship with an old tractor. A large colored drawing covering more than half of the page appears on each of the two books' pages, as do three to five written sentences totaling approximately 40 words. We scanned the pages from the printed books for the e-books in order to maintain similarity between the versions. An animated figure explained the different options for activating the story in the electronic version.

The children were offered two modes or options: (1) read story only and (2) read story and play (in the first session, they were told to read the "read story only" mode, and in the other three sessions, they were told to read the "read story and play" mode). Each activation mode included an oral reading of the printed text by an actor. The e-books also contained automatic dynamic visuals that dramatized story details, events, and the complete story plot, as well as music and film effects that were intended to "bring the story content to life." The e-books had a forward button (a colored arrow that points to the right) and a backward button (an arrow that points to the left) on each screen in order to stimulate the children's reading orientation and involvement, thus enabling the children to return to previous screens or continue to the next one. A function that allowed the children to reread/re-listen to the text was also available. The highlighting of written phrases as the text was rendered aloud was intended to focus the children's attention on the relationship between the text and the oral reading, thus perhaps supporting their exposure to the written text and word recognition (de Jong and Bus 2002).

The "read story only" mode included an oral reading of the printed text as well as automatic dynamic visuals that dramatized story scenes, extra music, and film effects. The "read story and play" mode was designed to enhance the children's story understanding and phonological awareness. Its interactive functions allowed the children to activate the story by clicking on hidden hotspots as they appear on (a) characters or objects and (b) words appearing in the text. However, since we did not want the hotspots to distract the children from listening to or reading the story, they were programmed so that the children could activate them only after reading/listening to the text on each page. Activation of characters or objects was designed to enrich story comprehension by means such as a discourse between the main characters as well as voice and sound effects. The inclusion of hotspots of words also aimed at promoting the children's phonological awareness of syllabic and sub-syllabic levels. For example, when the word "Yuval" in *Confused Yuval* is shown, it is divided into its syllables and sub-syllables, which the narrator reads out loud.

Preliminary studies that tested the effectiveness of these two e-books showed that activity with them improved kindergarten children's phonological awareness and their ability to recognize written words (Korat 2009; Korat and Shamir 2008; Shamir and Korat 2007), vocabulary (Korat and Shamir 2007, 2008), story comprehension (Korat 2009; Korat and Shamir 2007), and writing ability (Korat and Shamir 2007).

Children's Emergent Reading Level (EL)

The children's EL was assessed before and after the activity with the e-book/printed book. The measures used for assessing EL were recognition of letter names, letter-sound connection, phonological awareness (opening and closing phoneme and division into syllables and sub-syllables), word reading, and concept about print (CAP). A general emergent reading level grade was built from all the measures. The alpha score for this grade was .82.

We also investigated whether the children's progress in EL was influenced by their initial EL. For this purpose, the participants were divided into two groups: high and low initial EL. The children's level was determined according to the general EL test score prior to the intervention. The 40% of children in each group with the lowest scores were defined as having a low EL. The 40% of children in each group with the highest scores were defined as having a high EL. The division of 40% was carried out in order to insure a sufficient number of children in each level for performing the statistical analyses.

Results

Preliminary analyses of the overall pre-intervention early reading scores were performed using univariate analysis of variance by groups (EB, EBM, PBM, control). Significant differences were found between the groups before the intervention in

Table 6.1 Children's emergent literacy degree of improvement scores (means and standard deviations) by treatment group

	Control	EB	EBM	PBM
Letter names recognition	−1.25 (20.44)	3.75 (15.81)	11.25 (16.21)	2.81 (14.64)
Letter-sound connection	10.31 (14.97)	8.91 (16.15)	6.25 (16.01)	1.56 (25.35)
Phonological awareness – opening sound	8.51 (20.16)	11.46 (17.18)	3.13 (15.84)	5.21 (20.11)
Phonological awareness – closing sound	18.13 (30.69)	23.54 (30.51)	31.04 (33.43)	8.33 (32.06)
Phonological awareness – division into syllables	3.39 (17.56)	−.78 (14.26)	2.34 (7.40)	.26 (12.79)
Phonological awareness – division into sub-syllables	2.02 (13.70)	8.07 (16.14)	7.29 (8.81)	14.39 (22.93)
Emergent word reading	.52 (11.52)	1.91 (14.24)	60.76 (17.72)	4.95 (15.82)
CAP	.20 (12.14)	8.20 (14.84)	24.61 (11.70)	11.91 (15.66)
General reading level	5.18 (8.19)	8.13 (7.64)	18.31 (6.70)	6.18 (7.53)

two measures: phonological awareness ($F[3,120]=5.05$, $p<.01$, $\eta_p^2=.11$) and CAP ($F[3,120]=13.08$, $p<.001$, $\eta_p^2=.25$). Differences in phonological awareness were found between the EBM and the PBM group in favor of the former. Differences in CAP were found between the PBM and the other three groups. CAP achievements for the PBM group were lower than the achievement level in the other three groups.

A univariate one-way analysis of variance with Bonferoni corrections was then performed in order to determine improvements in the children's early literacy measures as a function of the intervention group (EB, EBM, PBM, control) and EL (low and high). The analyses were carried out for each EL measure separately as well as for the overall general EL score. The analyses were controlled for differences found between the groups in the pretests. Means and standard deviations of improvement in the children's EL scores in each treatment group and by initial EL are presented in Tables 6.1 and 6.2.

The achievement in the EBM group was significantly higher than the other three groups (PBM, EB, and the control) in recognition of letter names [$F(3,119)=3.98$, $p<.05$, $\eta_p^2=.09$], word reading [$F(3,119)=142.47$, $p<.001$, $\eta_p^2=.78$], concept about print (CAP) [$F(3,129)=29.71$, $p<.001$, $\eta_p^2=.43$], and general reading level [$F(3,119)=23.54$, $p<.001$, $\eta_p^2=.37$]. Furthermore, achievement in the EBM group was significantly higher than that of the PBM group in phonological awareness – closing phoneme [$F(3,119)=5.51$, $p<.01$, $\eta_p^2=.12$]. The EBM group scored significantly higher than the EB group and the control group in phonological awareness – sub-syllables [$F(3,119)=4.83$, $p<.01$, $\eta_p^2=.11$]. The EB group was significantly higher than the PBM group in phonological awareness – opening phoneme [$F(3,119)=2.70$, $p<.05$, $\eta_p^2=.06$].

Table 6.2 Children's emergent literacy degree of improvement scores (means and standard deviations) by treatment group and by beginning of EL

	Control		EB		EBM		PBM	
	Low	High	Low	High	Low	High	Low	High
Letter names recognition	6.15	−5.38	10.00	−1.54	15.38	3.85	4.62	1.54
	(25.99)	(12.66)	(19.51)	(12.81)	(20.25)	(10.44)	(20.25)	(9.87)
Letter-sound connection	8.85	12.69	13.08	6.15	10.00	−5.38	.38	3.85
	(13.56)	(18.44)	(20.77)	(14.02)	(10.08)	(14.06)	(16.26)	(37.03)
Phonological awareness – opening sound	10.26	4.62	8.72	12.82	9.49	−3.59	6.41	.51
	(16.24)	(21.54)	(15.55)	(19.00)	(20.13)	(11.58)	(21.54)	(16.71)
Phonological awareness – closing sound	28.96	13.08	20.51	24.36	16.67	43.85	.51	20.77
	(36.03)	(34.71)	(27.21)	(35.18)	(30.00)	(35.32)	(3.29)	(47.98)
Phonological awareness – division into syllables	10.90	−.64	−3.85	1.92	.00	2.56	.00	−.64
	(25.55)	(5.34)	(21.95)	(3.65)	(.00)	(7.12)	(18.94)	(6.33)
Phonological awareness – division into sub-syllables	4.33	−1.28	12.82	4.17	5.61	9.46	18.75	10.10
	(19.37)	(7.09)	(22.08)	(10.24)	(9.86)	(7.64)	(25.73)	(23.74)
Emergent word reading	2.99	−3.42	5.13	−2.14	58.76	61.32	−2.14	12.18
	(10.30)	(12.01)	(9.13)	(18.60)	(17.45)	(16.84)	(8.72)	(18.48)
CAP	0.48	−1.92	6.25	7.21	22.60	24.04	11.54	8.65
	(12.62)	(13.83)	(12.76)	(18.55)	(10.38)	(12.46)	(17.65)	(13.63)
General reading level	7.13	3.15	9.56	5.66	20.71	12.88	5.01	7.12
	(9.01)	(5.68)	(8.37)	(5.55)	(8.78)	(4.18)	(8.24)	(9.75)

Table 6.3 Promoters of hierarchical regression analysis for variables predicting children's EL according to difference scores

Variable		*B*	*SE*	*β*	*t*	R^2	ΔR^2
Step 1						.11	.01
	Gender	−.03	.07	−.04	−.42		
	Age	−.01	.01	−.06	−.64		
	Mother's education	−.01	.03	−.03	−.25		
	Father's education	.02	.02	.09	.78		
Step 2						.33**	.10**
	Gender	−.03	.07	−.04	−.41		
	Age	−.01	.01	−.05	−56		
	Mother's education	.00	.02	.016	.13		
	Father's education	.03	.02	.15	1.42		
	Initial EL	−.20	.06	−.33**	−3.34**		
Step 3						.65***	.31***
	Gender	−01	.06	−.01	−.14		
	Age	−.00	.01	−.03	−.34		
	Mother's education	−.01	.02	−.03	−.29		
	Father's education	.01	.02	.04	.45		
	Initial EL	−.25	.05	−.42***	−5.00***		
	EB compared to control group compared	.09	.09	.11	1.09		
	EBM compared to control group	.47	.08	.61***	5.79***		
	PBM compared to control group	.00	.08	.00	.03		

*p<.05; **p<.01; ***p<.001

Reading the e-book with adult mediation was found to be the only reading that significantly raised scores for the children from both the low initial EL and the high initial EL in phonological awareness [$F(3,95)=4.62$, $p<.05$, $\eta_p^2=.13$] and word reading [$F(3,95)=3.73$, $p<.05$, $\eta_p^2=.11$]. Children who began with a low EL were advanced promoted in phonological awareness and word reading, and those who began with a high EL were advanced promoted in word reading. Reading the printed book with an adult was associated with enhanced word reading of children with an initial high EL.

A hierarchical regression analysis was carried out in order to explore the possible contribution of the study's variables to the children's general EL score. Demographic variables (child's age, gender, mother's education and father's education) were entered as the first predictor, the initial EL (low or high) as the second, and intervention groups (EB, EBM, or PBM) as the third. The intervention groups were entered as dummy variables with the control group as a reference group. Results of these analyses are presented in Table 6.3, which also presents the additional contribution of each predictor as well as the cumulative variance explained by the combination of several predictors to children's EL.

The initial EL accounted significantly for 10% of the variance in the children's reading, and the activity of reading the e-book with adult mediation accounted significantly for 31% of the variance in the children's reading. Demographic variables did not explain variance in the children's EL.

Discussion

The findings of the current study might indicate that educational computer programs which their features are pedagogically adapted to kindergarten children's abilities (e.g., animations, sounds, colors, and graphics) are not sufficient for greatly promoting their emergent literacy. The findings show that an independent activity with a computer program, such as an e-book, even though one adapted for young children, may not be sufficient for achieving good progress in emergent reading. The present study indicates that the interactive features of the e-book (e.g., the option of a text that is highlighted congruently with the narrator's reading or the option of seeing or hearing how words from the text can be divided into syllables or sounds) that researchers claim may be used as mediators for promoting literacy (Bus et al. 2006; Caplovitz 2005) are not enough for a high level of emergent reading. The findings show that young children might need augmentation by adult mediation in order to gain better results in emergent reading skills (see also Trushell and Maitland 2005; Underwood 2007).

The present study revealed that adult mediation makes a unique contribution to kindergarten children's emergent reading, compared to an adult's mediation when reading a printed book and compared to children's independent activity with the e-book. The combination of the support of the educational e-book with adult mediation focused on promoting emergent reading led to the most improvement in children's emergent reading. The findings indicate that use of new computer programs, such as e-books, together with supportive and suitable adult mediation, can promote young children's emergent reading and their achievements in the written language. This promotion might be effective among kindergarten children, in general, and among children from a low SES and children with a low emergent reading level in particular.

These results are important for children from low SES communities, where there are large differences in children's homes with reference to literacy tools (books, computers, literacy software) and to joint literacy activities with others (DeBaryshe 1993; Korat et al. 2007). Our study demonstrates that an educational e-book with adult mediation may facilitate emergent literacy skills for such children.

One of the innovations of the present study is that reading an e-book with adult mediation advanced the emergent word reading of children with a low initial EL and children with a high initial EL compared to those who read the e-book independently. These results are important since the research literature focused on the effect of adult book reading to preschoolers usually showed only little effect on children's emergent literacy skills, including phonological awareness and emergent word reading. The present study indicates that adult mediation tuned not only to reading the story content but also to print may afford the children new knowledge related to later reading skill. Children with a high literacy level were able to read words better after reading printed books, whereas all children, with both low and high initial emergent literacy levels, were able to read the words after they were read by the e-book software together with adult mediation. The synergism between multimedia features such as highlighting of the words as they are read by the narrator combined with an adult supporting the child during and after reading the e-book made a big difference for children of all levels.

In conclusion, it is recommended to develop e-books that emphasize the books' pedagogical quality and suitability for supporting young children's literacy. The contribution of e-book programs to children's literacy is in the existence of a significant and authentic context, the books and story world, compared to many computer programs that promote literacy only by training and practicing discrete (and often fairly low level) early reading language skills. We stress also the importance of developing guiding programs for kindergarten teachers, school teachers, and parents for promoting children's literacy combined with new technologies such as e-books. These programs should emphasize the suitable adult support and mediation.

It is recommended to compare the adult contribution in reading an e-book to other literacy skills such as the oral language in future studies. Some studies have shown that an independent activity with an e-book promotes the oral language of young children (Korat 2009; Korat and Shamir 2008; Lewin 2000; Segers et al. 2004; Segers and Verhoeven 2002, 2003; Shamir 2009; Shamir and Korat 2007; Shamir et al. 2008). However, it is possible that reading an e-book with adult mediation would contribute more to this domain, especially to children from a low SES and a low oral language level.

Appendix: Examples of the Unique Features of the E-Book

An Example of Promoting Phonological Awareness in The Tractor in the Sandbox

An Example of Promoting Phonological Awareness in Confused Yuval

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Chapter 7
The Effects of Multimedia on Early Literacy Development of Children at Risk: A Meta-analysis

Victor van Daal and Jenny Miglis Sandvik

Introduction

As we have concluded in the first decade of the twenty-first century, the advent of new technologies has necessitated a redefinition of literacy. The term literacy has undergone a transformation from the ability to simply read and write to the ability to communicate through various means, including technology.

Today, exposure to multimedia is ubiquitous. Multimedia in the context of this review refers to the integration of text, images, and sound presented electronically. Children, even very young children, are increasingly exposed to electronic media in the form of television, DVDs, computer software programs, electronic books, talking books, Internet, video games, mobile phone applications, and interactive toys, to name a few. Whereas the term "media" includes traditional forms such as books and magazines, "multimedia" implies multiple forms of digital or electronic media.

As long as 20 years ago, researchers called into question the efficacy of the prevailing teaching paradigm of one-dimensional, primarily verbal delivery of instruction (Clark and Paivio 1991) and recognized the potential for multimedia technologies to facilitate interactive learning opportunities. Fifteen years ago, the National Association for the Education of Young Children (NAEYC) issued a position statement acknowledging that "used appropriately, technology can enhance children's cognitive and social abilities" and recommended that "computers should be integrated into early childhood practice physically, functionally, and philosophically" (NAEYC 1996, p. 2).

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However, while some recognize the potential for multimedia to enhance learning, particularly with regard to literacy, others debate the desirability of technology in early childhood education settings (for reviews, see Lankshear and Knobel 2003; Buckingham 2000; Stephen and Plowman 2003). Some argue that the use of technology in early childhood may not be developmentally appropriate, particularly in terms of cognitive load or, more aptly, overload (Kirschner 2002). Conversely, proponents of dual-coding theory maintain that the combination of visual with auditory stimuli results in enhanced comprehension (Sadoski and Paivio 2007). Some reference teachers are resistant to incorporating technology into lessons (Turbill 2001), while others argue that integrating technologies into classrooms, particularly those of young children, costs much and produces little in measurable educational gains (Yelland 2005). Still others go so far as to contend that the use of technology undermines the very nature of childhood (Buckingham 2000).

Whether or not young children *should* engage with electronic media has been long debated. Nonetheless, it is clear that children *are,* in fact, doing so on a daily basis (Rideout and Hamel 2006). In their survey of more than 1,000 American households with children ages six and under, it was found that in a typical day, 83% of these children use some type of screen media. Twenty-seven percent of parents reported their children used a computer several times a week or more, and sixty-nine percent of parents surveyed indicated that they felt computers helped their children's learning. Depending on which side of the debate one hails from, those who view technology as a powerful resource for early literacy enhancement, supporting "children of the digital age" (Marsh 2005), or, alternatively, those who criticize technology as "the death of childhood" (Buckingham 2000), in-depth research on the topic is long overdue.

Review of Research

It is inarguable that children's exposure to and interaction with multimedia influence the ways in which they play and learn. *How* exactly has yet to be determined. Several research reviews and meta-analyses have attempted to provide an overview of the existing research on the topic (Hisrich and Blanchard 2009; Lankshear and Knobel 2003; Plowman and Stephen 2003; Yelland 2005; Zucker et al. 2009).

Kamil, Intractor, and Kim undertook a comprehensive review of 350 articles including empirical studies and research reviews on the effects of multimedia on literacy; however, only a few related to the early literacy development of young children, under age eight. It was suggested that the use of multimedia did, in fact, facilitate children's comprehension through "mental model building," hypothesized to be a result of information presented as animation. The research literature also provided some support for the assertion that multimedia can benefit children at risk of reading failure such as children who come from language and cultural minority backgrounds.

Similarly, Lankshear and Knobel (2003) provided a synthesis of the research on the use of technology in promoting early literacy, focusing specifically on young children. They found only 22 published articles that were relevant for review. In their quantitative assessment of the literature, it was found that the research literature was unevenly distributed, with most focusing on the conventional aspects of reading such as encoding and decoding, rather than meaning making, comprehension, or generating texts. Most significantly, they concluded that the effects of technology on early literacy development were "radically under researched."

Likewise, Burnett's (2009) literature review on literacy and technology in primary classrooms also noted a lack of research on the topic. In their review 38 studies published between 2000 and 2006, 22 quantitative and 16 qualitative were it was concluded that the studies reviewed were limited in scope, as technology was used to support literacy in the same way as print literacy, "assimilating technology by grafting it onto existing practices," and therefore rendering the differential impact of multimedia on literacy, per se, difficult to ascertain.

Recognizing the need for research evidence on the topic, Zucker et al. (2009) provided a synthesis of studies published between 1997 and 2007 on the effects of electronic books (e-books) on the literacy outcomes of children from preschool through fifth grade. Seven randomized-trial studies and twenty quasi-experimental narrative studies met the selection criteria for their review. The aim of the study was to examine effects of e-books on children's comprehension and decoding-related skills, specifically in relation to emergent and beginning readers and children with reading disabilities or at risk of reading failure. Of the seven randomized-trial studies included, results of their meta-analysis showed small to medium effect sizes for comprehension. The effect on decoding was inconclusive, as only two studies that met the inclusion criteria examined it. The 20 studies included in the narrative review indicated mixed results. While it was found that overall e-books supported comprehension, they could, under some circumstances, actually undermine it. For example, De Jong and Bus (2002) found that if games were integrated into the e-book text, children spent nearly half of their time playing them rather than interacting with the more educational content. With regard to at-risk populations, no experimental studies included in the synthesis addressed the effects of e-books on at-risk populations; thus, no conclusions could be formulated. As with all of the aforementioned research, the findings were presented with the caveat that they were "preliminary due to the limited scope of available research" (Zucker et al. 2009, p. 77).

As evidenced, scarce empirical research exists on the impact of multimedia on literacy development in general and even less on young children in the beginning phases of learning to read. More research is required to contribute to the ongoing debate about whether or not technology is effective in facilitating early literacy development. Specifically, quantitative research is needed to establish how multimedia can be used to enhance literacy-related outcomes across different populations and settings, particularly in relation to children at risk of literacy underachievement.

The present study addressed the following research questions:

1. Can multimedia facilitate the early literacy development of young children (0–8 years old) at risk of literacy underachievement (e.g., dyslexic children, low-SES children, linguistic and cultural minority children)?
2. If so, how? Which literacy-related learning outcomes are most influenced by the use of multimedia?

Method

A meta-analysis was performed in order to synthesize the findings of multiple quantitative studies and provide evidence-based conclusions about the effect of multimedia on children's early literacy learning. Meta-analysis is a widely used statistical procedure that allows for the analysis and comparison of the effect sizes of multiple studies, thus to provide a more accurate estimate of the overall, cumulative results. Meta-analysis accommodates for differences in the precision of the assessments of the dependent variables across studies, due to different numbers of participants, by weighting the studies when computing a mean effect size.

Prior to performing a meta-analysis, it is necessary to outline the selection criteria for the inclusion of studies, determine the key words to be used in the search, and establish the search strategy.

Studies were included in the meta-analysis by meeting the following criteria based on the content of the article abstract, if it provided the necessary information, and full text if the abstract was not sufficient.

1. Quantitative research published in peer-reviewed journals between the years 2000 and 2010
2. Studies in which participants were classified as "early childhood" (subjects 0–8 years old)
3. Studies that included children at risk for literacy failure (e.g., dyslexia, low SES, and/or language/cultural minority children)
4. Studies that included mainstream children
5. Studies that measured for *at least one* of the following literacy outcome variables: Alphabetic Knowledge (AK), Phonological Awareness (PA), Rapid Automatic Naming (RAN), Writing (W), Phonological Memory (PM), Reading Readiness (RR), Oral Language (OL), Visual Processing (VP), Concepts of Print (COP). For definitions of each category, see Appendix A.
6. Studies that were published in English

The literacy outcome variables were determined by consulting the large-scale, comprehensive meta-analysis of more than 500 highly vetted studies (from 8,000), which identified early literacy skills positively correlated with later literacy achievement (National Institute for Literacy 2008).

Next, a list of keywords and phrases was defined in order to execute a broad, systematic electronic search for relevant studies. Specific terms and phrases related to multimedia and early literacy were identified by reviewing the research literature on the topic and cross-checking reference lists of relevant articles found. Several reference books were consulted in order to devise relevant search terms including *Handbook of Early Literacy Research* (Neuman and Dickinson 2001), *Handbook of Research on New Literacies* (Coiro et al. 2008), and *International Handbook of Literacy and Technology, Volume II* (McKenna et al. 2006). Keyword search strings were devised by the two authors independently, then cross-referenced, and combined (see Appendix B for list of search words).

The educational databases Educational Resources Information Center (ERIC) and PsycINFO were searched simultaneously using the keyword search strings. The broadest terms were "input first" and "find all search terms"; "apply related words" and "also search full text" were options selected in order to attain the highest number of hits. In PsycINFO, a selection was made to narrow the subject age range by selecting the age group "childhood (birth–12 years)." The databases were then searched for peer-reviewed articles published in English between 2000 and 2010. References for several hundred potential studies were located. After reviewing the abstracts of each, 92 studies were acquired or downloaded for further evaluation. In addition, several key journals were searched (see Appendix C for a detailed list). The search and the review process were carried out by each of the authors independently and then cross-checked.

Search Results

After reviewing the abstracts or full text of each article collected, 51 studies met the selection criteria. Sixteen of these were later excluded for missing relevant statistics (number of participants, means, or standard deviations). Of the remaining 35 studies, 24 studies included children at risk of reading failure. Of the studies of children at risk, seven studies were reported on interventions with second language learners, most stemming from cultural or language minority groups; seven studies included children of low socioeconomic status (SES); and ten studies dealt with underachieving readers. Additionally, 11 studies on the effects of multimedia interventions on mainstream children were found.

The literacy outcome variables as defined by the National Early Literacy Panel (NELP) served as a guideline for the search process; however, not in all categories were found, and some studies found did not fit into one of these categories. In addition to the NELP categories, Vocabulary (V), Comprehension (C), Non-Word Reading (NWR), Reading (R), Spelling (S), and Syntax (SYN) were included. In sum, there were 325 literacy outcomes that were ultimately classified into the following 10 categories: Alphabetic Knowledge, Phonological Awareness, Rapid Automatic Naming, Concepts of Print, Vocabulary, Comprehension, Non-Word Reading, Reading, Spelling, and Syntax (see Appendix A).

The majority of studies were conducted in English-speaking countries: the USA (14), the UK (4), and Canada (2). Ten studies were conducted in the Netherlands (Dutch) and five in Israel (Hebrew). Two studies dealt with embedded multimedia in teachers' reading lessons, one with subtitled video, 13 with e-books, and 18 with computer-assisted instruction. A summary of the studies is presented in Table 7.1.

In addition to children at risk who received literacy-related multimedia interventions, the following comparison groups were defined: (1) children at risk of reading failure who did not receive a multimedia-literacy intervention or performed a control task (e.g., arithmetic with multimedia), (2) mainstream children receiving the same intervention as the children at risk (from same studies as at-risk children), and (3) mainstream children who received literacy-related interventions in studies which did not include children at risk (Identified as "unrelated studies," because the interventions could confound the comparisons between children at risk and those who are not). Any effect sizes obtained for children at risk who received an intervention were balanced with effect sizes of children at risk who did not receive an intervention in order to rule out effects of "spontaneous recovery," "maturation," and the like. Comparisons with mainstream children, whether in the same or in unrelated studies, shed light on how children at risk may specifically benefit from multimedia-literacy interventions.

For all studies included in the meta-analysis, effect sizes, which determine the direction and strength of the intervention, were computed. Effect sizes based on means were calculated, using Cohen's d, which indicates the difference between the mean of the control and experimental subgroup (or in the case of a pretest-posttest design: pretest-posttest) divided by the pooled within-group variance (Borenstein et al. 2009). Hence, negative signs mean a positive effect of the treatment or a higher score at posttest. In order to avoid biased d's in small samples, Hedges' g was computed. For each category which included four or more outcomes, a mean effect size based on Hedges' g was computed, together with a 95% confidence interval, using the random effects model, because seldom the same instruments were used across studies. See Tables 7.2, 7.3, 7.4 and 7.5. In Table 7.2, the results for the children at risk are summarized. The results for children at risk without intervention are presented in Table 7.3. Effect sizes for studies for mainstream children with intervention can be found in Table 7.4. Results for mainstream children with intervention in studies that did not select children at risk are presented in Table 7.5.

Results: Effect Sizes

Alphabetic Knowledge

A medium, fairly consistent effect (0.64, confidence interval: 0.49–0.79, 15 outcomes) of multimedia interventions on Alphabetic Knowledge was found. However, similar results were found for the untreated children at risk (ES = 0.89, ranging from 0.66 to 1.13, 6 outcomes), which implies that literacy-related multimedia interventions are no more successful than leaving children at risk untreated.

Table 7.1 Studies included

Author	Year	Risk factor	Language	Country	Treatment	Design
Brabham, E.G., Murray, B.A., & Bowden, S.H.	2006	No risk	English	USA	e-Book, Dr. Seuss	Pretest-posttest control group
Cassady, J.C., & Smith, L.L.	2003	No risk	English	USA	CAI, early reading	Pretest-posttest control group
Chambers, B., Chueng, A.C.K., Madden, N.A., Slavin, R.E., & Gifford, R.	2006	SES	English	USA	Embedded multimedia in teacher's reading lessons	Posttest only/adjusted posttest scores/gain scores
Chambers, B., Slavin, R.E., Madden, N.A., Abrami, P.C., Tucker, B.J., Cheung, A., & Gifford, R.	2008	ESL	English	USA	Embedded multimedia in teacher's reading lessons	Posttest only/adjusted posttest scores/gain scores
Chera, P, & Wood, C.	2003	No risk	English	UK	CAI, bangers and mash	Pretest-posttest control group
Comaskey, E.M., Savage, R.S., & Abrami, P.	2009	ESL	English	Canada, Montreal	CAI, analytic phonics	Pretest-posttest control group
De Jong, M.T., & Bus, A.G.	2004	No risk	Dutch	Netherlands	e-Book	Posttest only/adjusted posttest scores/gain scores
Doty, D.E., Popplewell, S.R., & Byers, G.O.	2001	No risk	English	USA	e-Book, Thomas' Snowsuit	Pretest-posttest control group
Hecht, S.A., & Close, L.	2002	Poverty	English	USA	CAI, Waterford Early Reading Program	Posttest only/adjusted posttest scores/gain scores
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	Reading failure	English	USA	CAI, IntelliTools reading	Pretest-posttest control group
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	Reading failure	English	UK	CAI, ORT for clicker	Pretest-posttest control group
Kegel, C.A.T., Van der Kooy-Hofland, V.A.C., & Bus, A.G.	2009	Reading failure	Dutch	Netherlands	CAI, Living Books	Pretest-posttest control group

(continued)

Table 7.1 (continued)

Author	Year	Risk factor	Language	Country	Treatment	Design
Korat, O.	2010	No risk	Hebrew	Israel	e-Book: Yuval Hamebulbal	Pretest-posttest control group
Korat, O., & Shamir, A.	2007	SES	Hebrew	Israel	e-Book: Hatractor Beargaz Hachol	Pretest-posttest control group
Korat, O., & Shamir, A.	2008	SES	Hebrew	Israel	e-Book: Hatractor Beargaz Hachol	Posttest only/adjusted posttest scores/gain scores
Lewin, C.	2000	No risk	English	UK	e-Book: All aboard	Pretest-posttest control group
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	Poverty	English	USA	Video with closed captions	Pretest-posttest control group
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	Reading failure	English	USA	CAI, PA program	Pretest-posttest control group
Macaruso, P., & Walker, A.	2008	Reading failure	English	USA	CAI, early reading	Posttest only/adjusted posttest scores/gain scores
Macaruso, P., Hook, P.E., & McCabe, R.	2006	Reading failure	English	USA	CAI, early reading	Pretest-posttest control group
Mathes, P.G., Torgesen, J.K., & Allor, J.H.	2001	Reading failure	English	USA	CAI, Daisy	Posttest only/adjusted posttest scores/gain scores
McKenney, S., & Voogt, J.	2009	No risk	Dutch	Netherlands	CAI: PictoPal	Pretest-posttest control group
Mioduser, D., Tur-Kaspa, H., & Leitner, I.	2000	Reading failure	Hebrew	Israel	CAI, not specified	Posttest only/adjusted posttest scores/gain scores

Mitchell, M.J., & Fox, B.J.	2001	Reading failure	English	USA	CAI, Daisy	Posttest only/adjusted posttest scores/gain scores
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	Reading failure	Dutch	Netherlands	CAI, word building	Pretest-posttest control group
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	ESL	English	Canada, Montreal	CAI:ABRACADABRA,	Pretest-posttest control group
Segers, E., & Verhoeven, L.	2002	Dutch as L2	Dutch	Netherlands	e-Book, Schatkist met de muis	Pretest-posttest control group
Segers, E., & Verhoeven, L.	2003	No risk	Dutch	Netherlands	e-Book, not specified	Pretest-posttest control group
Segers, E., Takke, L., & Verhoeven, L.	2004	Dutch as L2	Dutch	Netherlands	E-book, Schatkist met muis	Pretest-posttest control group
Shamir, A., Korat, O., & Barbi, N.	2008	SES	Hebrew	Israel	e-Book, Just Grandma	Pretest-posttest control group
Silverman, R., & Hines, S.	2009	ESL	English	USA	Embedded multimedia in teacher's reading lessons	Pretest-posttest control group
Van Daal, V.H.P., & Reitsma, P.	2000	No risk	Dutch	Netherlands	CAI: Leescircus	Pretest-posttest control group
Verhallen, M.J.A.J., & Bus, A.G.	2010	SES	Dutch	Netherlands	e-Book: Heksenspul	Posttest only/adjusted posttest scores/gain scores
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T.	2006	Dutch as L2	Dutch	Netherlands	e-Book: Heksenspul	Pretest-posttest control group
Wild, M.	2009	No risk	English	UK	CAI: rhyme and analogy	Posttest only/adjusted posttest scores/gain scores

Table 7.2 Effect sizes for interventions in at-risk children

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Chambers, B., Chueng, A.C.K., Madden, N.A., Slavin, R.E., & Gifford, R.	2006	C/Woodcock RMT-R	−0.08	8.48	−0.52	0.16	0.40	−1.31	0.27
Chambers, B., Slavin, R.E., Madden, N.A., Abrami, P.C., Tucker, B.J., Cheung, A., & Gifford, R./ Computer-assisted tutoring	2008	C/GORT	−0.55	5.70					
Chambers, B., Slavin, R.E., Madden, N.A., Abrami, P.C., Tucker, B.J., Cheung, A., & Gifford, R./ Embedded multimedia	2008	C/GORT	−0.04	6.75					
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	C/experimental: literal comprehension	−1.32	2.35					
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	C/experimental: inferential comprehension	−2.22	1.85					
Macaruso, P., & Walker, A.	2008	C/Gates-McGinitie	−0.48	3.73					
Mathes, P.G., Torgesen, J.K., & Allor, J.H.	2001	C/Woodcock RMT-R	−0.50	6.18					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./ Analytic phonics	2009	C/GRADE	−0.86	6.38					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./ Synthetic phonics	2009	C/GRADE	−0.61	6.43					

Segers, E., Takke, L., & Verhoeven, L.	2004	C/experimental: what and why questions	−0.26	5.77					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./Multimedia	2006	C/experimental: retelling stories	−0.99	3.17					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./Static	2006	C/experimental: retelling stories	−0.35	3.40					
Comaskey, E.M., Savage, R.S., & Abrami, P./Analytic phonics	2009	AK/experimental: letters and sounds	−1.90	1.01	−0.64	0.01	0.08	−0.79	−0.49
Comaskey, E.M., Savage, R.S., & Abrami, P./Synthetic phonics	2009	AK/experimental: letters and sounds	−1.91	9.11					
Hecht, S.A., & Close, L.	2002	AK/experimental: letter name knowledge	0.40	18.80					
Hecht, S.A., & Close, L.	2002	AK/experimental: letters and sounds	0.34	18.91					
Hecht, S.A., & Close, L.	2002	AK/WRAT	0.16	19.11					
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	AK/PAT	−0.52	8.61					
Kegel, C.A.T., Van der Kooy-Hofland, V.A.C., & Bus, A.G.	2009	AK/experimental: phoneme recognition	−0.86	20.93					
Macaruso, P., & Walker, A./All students	2008	AK/DIBELS: letter naming fluency	−1.53	10.30					
Macaruso, P., & Walker, A./At-risk students	2008	AK/DIBELS: letter naming fluency	−2.18	3.93					
Macaruso, P., & Walker, A./At-risk students	2008	AK/Gates-McGinitie	−0.75	5.98					
Macaruso, P., Hook, P.E., & McCabe, R.	2006	AK/Gates-McGinitie	−4.04	2.51					

(continued)

Table 7.2 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Mioduser, D., Tur-Kaspa, H., & Leitner, I.	2000	AK/experimental: letter name knowledge	−2.52	4.44					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	AK/combination of standardized tests	−1.90	10.88					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./Analytic phonics	2009	AK/experimental: letters and sounds	−0.58	21.48					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./Synthetic phonics	2009	AK/experimental: letters and sounds	−0.26	21.70					
Chambers, B., Chueng, A.C.K., Madden, N.A., Slavin, R.E., & Gifford, R.	2006	NWR/Woodcock RMT-R	−0.31	22.36	−0.53	0.00	0.07	−0.67	−0.39
Chambers, B., Slavin, R.E., Madden, N.A., Abrami, P.C., Tucker, B.J., Cheung, A., & Gifford, R./Computer-assisted tutoring	2008	NWR/Woodcock RMT-R	−0.46	14.93					
Chambers, B., Slavin, R.E., Madden, N.A., Abrami, P.C., Tucker, B.J., Cheung, A., & Gifford, R./Embedded multimedia	2008	NWR/Woodcock RMT-R	−0.25	24.52					
Comaskey, E.M., Savage, R.S., & Abrami, P./Analytic phonics	2009	NWR/experimental: high-neighbor hood words	−0.72	13.03					

Comaskey, E.M., Savage, R.S., & Abrami, P./Analytic phonics	2009	NWR/experimental: low-neighborhood words	−0.77	12.91					
Comaskey, E.M., Savage, R.S., & Abrami, P./Synthetic phonics	2009	NWR/experimental: high-neighborhood words	−1.03	11.80					
Comaskey, E.M., Savage, R.S., & Abrami, P./Synthetic phonics	2009	NWR/experimental: low-neighborhood words	−0.77	12.44					
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	NWR/DIBELS: nonword fluency	−0.95	3.47					
Mathes, P.G., Torgesen, J.K., & Allor, J.H.	2001	NWR/TOWRE	−0.89	17.32					
Mathes, P.G., Torgesen, J.K., & Allor, J.H.	2001	NWR/Woodcock RMT-R	−0.68	18.03					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	NWR/KLEPEL	−0.84	10.08					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./Analytic phonics	2009	NWR/Woodcock-Johnson III	−0.20	22.27					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	NWR/Woodcock-Johnson III	−0.17	21.81					
Comaskey, E.M., Savage, R.S., & Abrami, P./Analytic phonics	2009	PA/experimental: blending CV	−0.73	3.83	−0.75	0.00	0.04	−0.83	−0.68
Comaskey, E.M., Savage, R.S., & Abrami, P./Analytic phonics	2009	PA/experimental: blending VC	−0.58	13.31					
Comaskey, E.M., Savage, R.S., & Abrami, P./Analytic phonics	2009	PA/experimental: segmenting CV	−0.94	12.49					

(continued)

Table 7.2 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Comaskey, E.M., Savage, R.S., & Abrami, P./Analytic phonics	2009	PA/experimental: blending VC	−0.60	13.29					
Comaskey, E.M., Savage, R.S., & Abrami, P ./Analytic phonics	2009	PA/experimental: rhyme articulation	−0.80	12.85					
Comaskey, E.M., Savage, R.S., & Abrami, P./Analytic phonics	2009	PA/experimental: coda articulation	−0.65	13.18					
Comaskey, E.M., Savage, R.S., & Abrami, P./ Synthetic phonics	2009	PA/experimental: blending CV	−1.99	8.86					
Comaskey, E.M., Savage, R.S., & Abrami, P./ Synthetic phonics	2009	PA/experimental: blending VC	−1.50	10.38					
Comaskey, E.M., Savage, R.S., & Abrami, P./ Synthetic phonics	2009	PA/experimental: segmenting CV	−1.36	10.83					
Comaskey, E.M., Savage, R.S., & Abrami, P./ Synthetic phonics	2009	PA/experimental: blending VC	−1.71	9.74					
Comaskey, E.M., Savage, R.S., & Abrami, P./ Synthetic phonics	2009	PA/experimental: rhyme articulation	−0.46	13.05					
Comaskey, E.M., Savage, R.S., & Abrami, P./ Synthetic phonics	2009	PA/experimental: coda articulation	−1.76	9.58					
Hecht, S.A., & Close, L.	2002	PA/CTOPP: segmenting	−1.29	15.85					

Hecht, S.A., & Close, L.	2002	PA/CTOPP: blending	−0.93	17.27
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	PA/Cunningham: rhyme	−1.78	12.75
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	PA/Cunningham: onset	−2.16	11.22
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	PA/Snider: phonetic awareness	−1.32	14.62
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	PA/PAT: rhyme	−0.44	8.70
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	PA/PAT: segmentation	−0.47	8.67
Korat, O., & Shamir, A.	2007	PA/experimental: syllabic segmentation	−0.36	9.21
Korat, O., & Shamir, A./e-Book: Read only	2008	PA/experimental: syllabic segmentation	−0.73	9.49
Korat, O., & Shamir, A./e-Book: Interactive	2008	PA/experimental: syllabic segmentation	−0.29	10.05
Korat, O., & Shamir, A./e-Book + Dictionary	2008	PA/experimental: syllabic segmentation	−0.64	9.63
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: rhyme oddity	−0.49	10.09

(continued)

Table 7.2 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: rhyme matching	–0.81	9.60					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: word blending	–0.66	9.86					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: syllable blending	–0.22	10.34					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: multiple choice blending	–0.08	10.40					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: word elision	–1.09	9.02					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: syllable elision	–1.04	9.12					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: multiple choice elision	–0.34	10.25					

Macaruso, P., & Walker, A.	2008	PA/Gates-McGinitie	−1.17	5.45
Mathes, P.G., Torgesen, J.K., & Allor, J.H.	2001	PA/CTOPP: elision	−0.16	19.00
Mathes, P.G., Torgesen, J.K., & Allor, J.H.	2001	PA/CTOPP: segmentation	−0.33	18.80
Mioduser, D., Tur-Kaspa, H., & Leitner, I.	2000	PA/Lapidot	−3.26	3.40
Mitchell, M.J., & Fox, B.J.	2001	PA/PAT	−1.37	9.98
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	PA/combination of standardized tests	−0.94	14.28
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./Analytic phonics	2009	PA/CTOPP: elision	−0.30	22.14
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./Analytic phonics	2009	PA/CTOPP: blending	−0.68	21.15
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./Synthetic phonics	2009	PA/CTOPP: elision	−0.32	21.62
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./Synthetic phonics	2009	PA/CTOPP: blending	−0.65	20.76
Shamir, A., Korat, O., & Barbi, N./Tutor	2008	PA/Aram & Levin: initial phonemes	−0.58	13.32
Shamir, A., Korat, O., & Barbi, N./Tutor	2008	PA/Aram & Levin: final phonemes	−0.71	13.06
Shamir, A., Korat, O., & Barbi, N./Tutor	2008	PA/Aram & Levin: syllabic awareness	−0.22	13.82

(continued)

Table 7.2 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Shamir, A., Korat, O., & Barbi, N./Tutor	2008	PA/Aram & Levin: sub-syllabic awareness	−1.31	11.40					
Shamir, A., Korat, O., & Barbi, N./Tutee	2008	PA/Aram & Levin: initial phonemes	−0.39	13.63					
Shamir, A., Korat, O., & Barbi, N./Tutee	2008	PA/Aram & Levin: final phonemes	−0.32	13.72					
Shamir, A., Korat, O., & Barbi, N./Tutee	2008	PA/Aram & Levin: syllabic awareness	−0.68	13.11					
Shamir, A., Korat, O., & Barbi, N./Tutee	2008	PA/Aram & Levin: sub-syllabic awareness	−0.41	13.60					
Shamir, A., Korat, O., & Barbi, N./Individual	2008	PA/Aram & Levin: initial phonemes	−0.59	13.30					
Shamir, A., Korat, O., & Barbi, N./Individual	2008	PA/Aram & Levin: final phonemes	−0.55	13.38					
Shamir, A., Korat, O., & Barbi, N./Individual	2008	PA/Aram & Levin: syllabic awareness	−0.43	13.58					
Shamir, A., Korat, O., & Barbi, N./Individual	2008	PA/Aram & Levin: sub-syllabic awareness	−0.34	13.69					
Hecht, S.A., & Close, L.	2002	COP/Clay	0.12	2.83	−0.86	0.02	0.13	−1.11	−0.61
Macaruso, P., & Walker, A.	2008	COP/Gates-McGinitie	−0.64	6.10					
Mathes, P.G., Torgesen, J.K., & Allor, J.H.	2001	COP/TERA-2	−0.53	18.41					
Shamir, A., Korat, O., & Barbi, N.	2008	COP/CAP	−1.63	10.34					
Shamir, A., Korat, O., & Barbi, N.	2008	COP/CAP	−1.09	12.04					

Shamir, A., Korat, O., & Barbi, N.	2008	COP/CAP	−0.81	12.81					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	RAN/digits, letters and objects combined	−0.22	10.77	−0.21	0.01	0.08	0.05	0.38
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	RAN/digits	0.20	14.46					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	RAN/letters	−0.10	14.52					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	RAN/objects	−0.14	14.50					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./ Analytic phonics	2009	RAN/CTOPP: letters	−0.62	21.35					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./ Analytic phonics	2009	RAN/CTOPP: objects	0.02	22.39					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./ Synthetic phonics	2009	RAN/CTOPP: letters	−0.58	20.98					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./ Synthetic phonics	2009	RAN/CTOPP: objects	−0.09	21.87					
Hecht, S.A., & Close, L.	2002	S/WRAT: invented spelling	−1.26	26.25	−1.11	0.01	0.11	−1.32	−0.90
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	S/Clay: write total	−0.79	16.56					
Howell, R.D., Erickson, K., Stanger, C./Wheaton, J.E.	2000	S/Clay: developmental spelling	−1.04	15.71					

(continued)

Table 7.2 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Kegel, C.A.T., Van der Kooy-Hofland, V.A.C., & Bus, A.G.	2009	S/Levin & Bus: word dictation	−1.26	19.03					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	S/PI-dictee	−1.07	9.64					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./ Multimedia 4X	2006	SYN/experimental: sentence repetition	−1.19	6.48	−0.66	0.04	0.21	−1.08	−0.25
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./ Static 4X	2006	SYN/experimental: sentence repetition	−0.37	5.35					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./ Multimedia 1X	2006	SYN/experimental: sentence repetition	−0.48	5.29					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./ Static 1X	2006	SYN/experimental: sentence repetition	−0.50	5.27					
Hecht, S.A., & Close, L.	2002	V/Stanford-Binet: vocabulary	−0.11	2.30	−0.68	0.00	0.06	−0.80	−0.57
Korat, O., & Shamir, A.	2007	V/curriculum dependent: word meanings	−0.92	8.50					
Korat, O., & Shamir, A./e-Book: Read only	2008	V/curriculum dependent: word meanings	−1.18	8.60					

Korat, O., & Shamir, A./e-Book: Interactive	2008	V/curriculum dependent: word meanings	−0.45	9.89
Korat, O., & Shamir, A./e-Book + Dictionary	2008	V/curriculum dependent: word meanings	−0.50	9.84
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	V/curriculum dependent	−1.86	2.64
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./ Analytic phonics	2009	V/GRADE	−0.65	21.25
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./ Synthetic phonics	2009	V/GRADE	−0.74	20.48
Segers, E., & Verhoeven, L./K1	2003	V/CD-ROM words	−0.72	5.55
Segers, E., & Verhoeven, L./K2	2003	V/CD-ROM words	−1.06	11.69
Segers, E., & Verhoeven, L./K1	2003	V/TAK	−0.57	5.69
Segers, E., & Verhoeven, L./K2	2003	V/TAK	−0.97	11.94
Segers, E., & Verhoeven, L./K1	2002	V/curriculum dependent	−1.08	11.22
Segers, E., & Verhoeven, L./K2	2002	V/curriculum dependent	−0.63	14.66
Segers, E., Takke, L., & Verhoeven, L.	2004	V/experimental: word meanings	−0.26	15.27
Silverman, R., & Hines, S.	2009	V/curriculum dependent	−1.71	15.59
Silverman, R., & Hines, S.	2009	V/PPVT	−0.75	19.95
Silverman, R., & Hines, S.	2009	V/experimental: science concepts	−1.45	16.87

(continued)

Table 7.2 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Verhallen, M.J.A.J., & Bus, A.G.	2010	V/experimental: receptive	0.90	14.54					
Verhallen, M.J.A.J., & Bus, A.G.	2010	V/experimental: expressive	1.22	13.49					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./ Multimedia 4X	2006	V/experimental: low-frequency words	−1.87	3.69					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./ Static 4X	2006	V/experimental: low-frequency words	−0.93	4.87					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./ Multimedia 1X	2006	V/experimental: low-frequency words	−0.85	4.96					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./ Static 1X	2006	V/experimental: low-frequency words	−0.78	5.04					
Chambers, B., Chueng, A.C.K., Madden, N.A., Slavin, R.E., & Gifford, R.	2006	R/DIBELS: fluency	−0.11	1.54	−0.60	0.00	0.04	−0.68	−0.52
Chambers, B., Chueng, A.C.K., Madden, N.A., Slavin, R.E., & Gifford, R.	2006	R/Woodcock RMT-R: word identification	−0.18	98.34					
Chambers, B., Slavin, R.E., Madden, N.A., Abrami, P.C., Tucker, B.J., Cheung, A., & Gifford, R./ Computer-assisted tutoring	2008	R/Woodcock-Johnson: letter-word identification	−0.46	14.92					

Chambers, B., Slavin, R.E., Madden, N.A., Abrami, P.C., Tucker, B.J., Cheung, A., & Gifford, R./Computer-assisted tutoring	2008	R/GORT: fluency	−0.48	14.89
Chambers, B., Slavin, R.E., Madden, N.A., Abrami, P.C., Tucker, B.J., Cheung, A., & Gifford, R./Embedded multimedia	2008	R/Woodcock-Johnson: letter-word identification	−0.35	24.33
Chambers, B., Slavin, R.E., Madden, N.A., Abrami, P.C., Tucker, B.J., Cheung, A., & Gifford, R./Embedded multimedia	2008	R/GORT: fluency	−0.27	24.48
Comaskey, E.M., Savage, R.S., & Abrami, P./Analytic phonics	2009	R/WRAT: word reading	−0.72	13.02
Comaskey, E.M., Savage, R.S., & Abrami, P./Analytic phonics	2009	R/experimental: unique word reading	−0.54	13.40
Comaskey, E.M., Savage, R.S., & Abrami, P./Synthetic phonics	2009	R/WRAT: word reading	−0.82	12.34
Comaskey, E.M., Savage, R.S., & Abrami, P./Synthetic phonics	2009	R/experimental: unique word reading	−0.76	12.48
Hecht, S.A., & Close, L.	2002	R/Woodcock-Johnson: letter-word identification	−1.05	16.85
Howell, R.D., Erickson, K., Stanger, C., Wheaton, J.E.	2000	R/curriculum dependent word reading	−2.04	11.69

(continued)

Table 7.2 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	R/experimental; lexical decision, words	−0.67	8.43					
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	R/experimental; lexical decision, nonwords	0.26	8.84					
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	R/SWORT: word reading	−0.60	8.52					
Korat, O., & Shamir, A.	2007	R/experimental: word recognition	−0.28	9.26					
Korat, O., & Shamir, A./e-Book: Read only	2008	R/experimental: word recognition	−0.77	9.43					
Korat, O., & Shamir, A./e-Book: Interactive	2008	R/experimental: word recognition	−0.33	10.01					
Korat, O., & Shamir, A./e-Book + Dictionary	2008	R/experimental: word recognition	0.22	10.09					
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	R/DIBELS: fluency	−0.02	3.91					
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	R/curriculum dependent word reading	−1.33	3.14					
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	R/DOLCH	−1.49	2.99					
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	R/DIBELS: decontextualized word recognition	−1.89	2.61					
Macaruso, P., Hook, P.E., & McCabe, R.	2006	R/Gates-McGinitie: NCE	−1.76	5.63					
Macaruso, P., Hook, P.E., & McCabe, R.	2006	R/Gates-McGinitie: basic story words	−3.21	3.36					

Mathes, P.G., Torgesen, J.K., & Allor, J.H.	2001	R/basic skills progress: oral reading fluency	–0.65	18.10
Mathes, P.G., Torgesen, J.K., & Allor, J.H.	2001	R/TOWRE: accuracy and fluency words	–0.22	18.95
Mathes, P.G., Torgesen, J.K., & Allor, J.H.	2001	R/Woodcock RMT-R: word identification	–0.44	18.61
Mioduser, D., Tur-Kaspa, H., & Leitner, I.	2000	R/experimental: word recognition	–0.15	8.14
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	R/EMT	–0.87	10.04
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./Analytic phonics	2009	R/Woodcock RMT-R: word identification	–11.53	1.25
Savage, R.S., Abrami, P., Hipps, G., & Deault, L./Synthetic phonics	2009	R/Woodcock RMT-R: word identification	–11.37	1.25
Shamir, A., Korat, O., & Barbi, N./Tutor	2008	R/Levin, Share & Shatil: word recognition judgment	–0.61	13.27
Shamir, A., Korat, O., & Barbi, N./Tutor	2008	R/Levin, Share & Shatil: word recognition justification	–0.68	13.12
Shamir, A., Korat, O., & Barbi, N./Tutee	2008	R/Levin, Share & Shatil: word recognition judgment	–0.66	13.17

(continued)

Table 7.2 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Shamir, A., Korat, O., & Barbi, N./Tutee	2008	R/Levin, Share & Shatil: word recognition justification	−0.50	13.47					
Shamir, A., Korat, O., & Barbi, N./Individual	2008	R/Levin, Share & Shatil: word recognition judgment	−0.23	13.80					
Shamir, A., Korat, O., & Barbi, N./Individual	2008	R/Levin, Share & Shatil: word recognition justification	−0.35	13.68					
Shamir, A., Korat, O., & Barbi, N./Tutor	2008	R/experimental: e-book word reading, no picture	−0.76	12.93					
Shamir, A., Korat, O., & Barbi, N./Tutor	2008	R/experimental: e-book word reading with picture	−1.47	10.89					
Shamir, A., Korat, O., & Barbi, N./Tutee	2008	R/experimental: e-book word reading, no picture	−0.23	13.81					

Shamir, A., Korat, O., & Barbi, 2008 N./Tutee	R/experimental: e-book word reading with picture	−0.99	12.36
Shamir, A., Korat, O., & Barbi, 2008 N./Individual	R/experimental: e-book word reading, no picture	−0.53	13.42
Shamir, A., Korat, O., & Barbi, 2008 N./Individual	R/experimental: e-book word reading with picture	−1.31	11.39

C comprehension, *AK* alphabetic knowledge, *NWR* nonword reading, *PA* phonological awareness, *COV* concepts of print, *RAN* rapid naming, *S* spelling, *SYN* syntax, *V* vocabulary, *R* reading

Table 7.3 Effect sizes for untreated at-risk children, or at-risk children performing a control task

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	Arithmetic	–0.15						
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	Arithmetic	–0.09						
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	Arithmetic	–0.17						
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	C/GRADE	–0.35						
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./Multimedia	2006	C/experimental: retelling stories	–1.78						
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./Static	2006	C/experimental: retelling stories	–0.87						
Kegel, C.A.T., Van der Kooy-Hofland, V.A.C., & Bus, A.G.	2009	AK/experimental: phoneme recognition	–0.85	20.96	–0.89	0.01	0.12	–1.13	–0.66
Macaruso, P., & Walker, A.	2008	AK/DIBELS: letter naming fluency	–1.71	16.68					
Macaruso, P., & Walker, A.	2008	AK/Gates-McGinitie	–2.30	3.77					
Macaruso, P., Hook, P.E., & McCabe, R.	2006	AK/Gates-McGinitie	–2.01	5.17					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	AK/combination of standardized tests	–0.55	12.90					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	AK/experimental: letters and sounds	–0.19	28.76					

Regtvoort, A.G.F.M., & Van der Leij, A.	2007	NWR/KLEPEL	–0.87						
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	NWR/Woodcock-Johnson III	–0.06						
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: rhyme oddity	0.28	10.80	–0.15	0.00	0.07	–0.29	–0.02
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: rhyme matching	0.02	10.91					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: word blending	–0.30	10.78					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: syllable blending	–0.25	10.82					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: multiple choice blending	0.16	10.87					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: word elision	–0.14	10.88					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: syllable elision	0.06	10.90					
Lonigan, C.J., Driscoll, K., Phillips, B.M., Cantor, B.G., Anthony, J.L., & Goldstein, H.	2003	PA/experimental: multiple choice elision	–0.64	10.36					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	PA/combination of standardized tests	–0.43	13.09					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	PA/CTOPP: elision	–0.06	28.87					

(continued)

Table 7.3 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	PA/CTOPP: blending	−0.25	28.67					
Shamir, A., Korat, O., & Barbi, N.	2008	PA/Aram & Levin: initial phonemes	−0.25	13.79					
Shamir, A., Korat, O., & Barbi, N.	2008	PA/Aram & Levin: final phonemes	−0.24	13.80					
Shamir, A., Korat, O., & Barbi, N.	2008	PA/Aram & Levin: syllabic awareness	−0.42	13.60					
Shamir, A., Korat, O., & Barbi, N.	2008	PA/Aram & Levin: sub-syllabic awareness	0.12	13.88					
Shamir, A., Korat, O., & Barbi, N.	2008	COP/CAP	−0.50						
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	RAN/digits, letters and objects combined	−0.53	12.93	−0.41	0.01	0.10	0.22	0.61
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	RAN/digits	−1.11	11.57					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	RAN/letters	−0.79	12.41					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	RAN/objects	−0.19	13.34					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	RAN/CTOPP: letters	−0.44	28.20					
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	RAN/CTOPP: objects	−0.03	28.88					
Kegel, C.A.T., Van der Kooy-Hofland, V.A.C., & Bus, A.G.	2009	S/Levin & Bus: word dictation	−0.92						

Regtvoort, A.G.F.M., & Van der Leij, A.	2007	S/PI-dictee	–0.83						
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./control 'nothing'	2006	SYN/experimental: sentence repetition	–0.56						
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./control computer game	2006	SYN/experimental: sentence repetition	–0.22						
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	V/GRADE	–0.62	27.53	–0.56	0.01	0.08	–0.73	–0.40
Segers, E., & Verhoeven, L./K1	2003	V/CD-ROM words	–0.52	10.06					
Segers, E., & Verhoeven, L./K2	2003	V/CD-ROM words	–0.24	11.32					
Segers, E., & Verhoeven, L./K1	2003	V/TAK	–1.14	8.48					
Segers, E., & Verhoeven, L./K2	2003	V/TAK	–0.37	18.08					
Segers, E., & Verhoeven, L./K1	2003	V/curriculum dependent	–1.02	9.16					
Segers, E., & Verhoeven, L./K2	2003	V/curriculum dependent	–0.28	11.29					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./control 'nothing'	2006	V/experimental: receptive	–1.03	4.76					
Verhallen, M.J.A.J., Bus, A.G., & de Jong, M.T./control computer game	2006	V/experimental: expressive	–0.40	5.34					
Macaruso, P., Hook, P.E., & McCabe, R.	2006	R/Gates-McGinitie: NCE	–0.83	7.26	–0.77	0.01	0.12	–1.00	–0.54
Macaruso, P., Hook, P.E., & McCabe, R.	2006	R/Gates-McGinitie: basic story words	–2.20	4.83					
Regtvoort, A.G.F.M., & Van der Leij, A.	2007	R/EMT	–0.47	10.02					

(continued)

Table 7.3 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Savage, R.S., Abrami, P., Hipps, G., & Deault, L.	2009	R/Woodcock RMT-R: word identification	–10.99	1.77					
Shamir, A., Korat, O., & Barbi, N.	2008	R/Levin, Share & Shatil: word recognition judgment	–0.62	13.25					
Shamir, A., Korat, O., & Barbi, N.	2008	R/Levin, Share & Shatil: word recognition justification	–0.31	13.73					
Shamir, A., Korat, O., & Barbi, N.	2008	R/experimental: e-book word reading, no picture	–0.20	13.83					
Shamir, A., Korat, O., & Barbi, N.	2008	R/experimental: e-book word reading with picture	–0.33	13.70					

C comprehension, *AK* alphabetic knowledge, *NWR* nonword reading, *PA* phonological awareness, *COV* concepts of print, *RAN* rapid naming, *S* spelling, *SYN* syntax, *V* vocabulary, *R* reading

Table 7.4 Effect sizes for not-at-risk children

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	C/experimental: literal comprehension	–0.82						
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	C/experimental: inferential comprehension	–1.71						
Macaruso, P., & Walker, A.	2008	C/Gates-McGinitie	–0.27						
Macaruso, P., & Walker, A.	2008	AK/DIBELS: letter naming fluency	–0.19						
Regtvoort, A.G.F.M., & Van der Leij, A.*	2007	AK/combination of standardized tests	–0.57						
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	NWR/DIBELS: nonword fluency	–1.25						
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	PA/Cunningham: rhyme	–0.70	12.14	–0.75	0.02	0.15	–1.04	–0.47
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	PA/Cunningham: onset	–1.01	11.40					
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	PA/Snider: phonetic awareness	–0.81	11.89					
Macaruso, P., & Walker, A.	2008	PA/Gates-McGinitie	–0.54	16.29					
Regtvoort, A.G.F.M., & Van der Leij, A.*	2007	PA/combination of standardized tests	–0.73	7.86					
Macaruso, P., & Walker, A.	2008	COP/Gates-McGinitie	–0.37						
Regtvoort, A.G.F.M., & Van der Leij, A.*	2007	RAN/digits, letters and objects combined	0.34						

(continued)

Table 7.4 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	S/Clay: write total	–0.49						
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	S/Clay: developmental spelling	–0.61						
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	V/curriculum dependent	–1.02						
Howell, R.D., Erickson, K., Stanger, C., & Wheaton, J.E.	2000	R/curriculum dependent word reading	–1.07	11.24	–0.13	0.01	0.12	–0.37	0.11
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	R/DIBELS: fluency	2.24	4.76					
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	R/curriculum dependent word reading	0.35	7.76					
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	R/DOLCH	0.38	7.74					
Linebarger, D., Piotrowski, J.T, & Greenwood, C.R.	2010	R/DIBELS: decontextualized word recognition	0.27	7.81					
Macaruso, P., Hook, P.E., & McCabe, R.*	2006	R/Gates-McGinitie: NCE	–0.68	40.07					

C comprehension, *AK* alphabetic knowledge, *NWR* nonword reading, *PA* phonological awareness, *COV* concepts of print, *RAN* rapid naming, *S* spelling, *SYN* syntax, *V* vocabulary, *R* reading

*Not trained

Table 7.5 Effect sizes for treated not-at-risk children in unrelated studies

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
De Jong, M.T., & Bus, A.G.	2004	C/experimental: story understanding	−2.20						
Doty, D.E., Popplewell, S.R., & Byers, G.O.	2004	C/experimental: reading comprehension	1.12						
Doty, D.E., Popplewell, S.R., & Byers, G.O.	2004	C/experimental: oral story retelling	−0.09						
Brabham, E.G., Murray, B.A., & Bowden, S.H./Meaning	2006	AK/experimental: phoneme identity	−0.06	40.37	−0.57	0.01	0.09	−0.75	−0.40
Brabham, E.G., Murray, B.A., & Bowden, S.H./Phoneme	2006	AK/experimental: phoneme identity	−0.07	36.36					
Brabham, E.G., Murray, B.A., & Bowden, S.H./Meaning	2006	AK/experimental: letter name knowledge	−0.57	38.79					
Brabham, E.G., Murray, B.A., & Bowden, S.H./Phoneme	2006	AK/experimental: letter name knowledge	−0.66	34.49					
Chera, P, & Wood, C.	2003	AK/experimental: auditory letter sound	−1.90	5.37					
Chera, P, & Wood, C.	2003	AK/experimental: visual letter sound	−1.93	5.31					
Van Daal, V.H.P., & Reitsma, P.	2000	AK/Struiksma, Van der Leij & Vieijra	−0.85	4.51					
Cassady, J.C., & Smith, L.L.	2003	PA/PAT: PA	−0.01	18.64	−0.55	0.01	0.08	−0.71	−0.39
Chera, P, & Wood, C.	2003	PA/PAT: auditory onset	−1.54	6.04					
Chera, P, & Wood, C.	2003	PA/PAT: verbal onset	−1.52	6.07					
Chera, P, & Wood, C.	2003	PA/PAT: visual onset	−1.65	5.82					
Chera, P, & Wood, C.	2003	PA/PAT: rhyme	−2.09	5.03					
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	PA/PAT: rhyme	−0.50	29.96					

(continued)

Table 7.5 (continued)

Author/treatments – subgroups	Year	Outcome/test	Effect of study	Raw weight of study	Mean effect size	Variance of mean effect size	Standard error of mean effect size	Lower limit 95% confidence interval M	Upper limit 95% confidence interval M
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	PA/PAT: segmentation	−0.27	30.61					
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	PA/PAT: graphemes	−0.45	30.13					
Lewin, C.	2000	PA/experimental: phonics knowledge	−0.19	8.38					
Lewin, C.	2000	PA/experimental: phonics knowledge	−0.30	8.32					
Wild, M.	2009	PA/PhAB total	−0.30	21.11					
Cassady, J.C., & Smith, L.L.	2003	COP/CAP	−0.71	17.71	−0.46	0.02	0.12	−0.70	−0.22
McKenney, S., & Voogt, J./control, not specified	2009	COP/Verhoeven & Aernoutse	−0.32	10.76					
McKenney, S., & Voogt, J./control, not specified	2009	COP/Verhoeven & Aernoutse	−1.28	3.24					
McKenney, S., & Voogt, J./Look and Choose	2009	COP/Verhoeven & Aernoutse	−0.41	19.96					
McKenney, S., & Voogt, J./Look and Choose	2009	COP/Verhoeven & Aernoutse	−0.08	9.90					
Van Daal, V.H.P., & Reitsma, P.	2000	COP/Struiksma, Van der Leij & Vieijra	−0.29	4.90					
Brabham, E.G., Murray, B.A., & Bowden, S.H./Meaning	2006	R/experimental: phonetic cue reading	−0.67	38.23	−0.45	0.01	0.09	−0.62	−0.29
Brabham, E.G., Murray, B.A., & Bowden, S.H./Phoneme	2006	R/experimental: phonetic cue reading	−0.46	35.44					
Chera, P, & Wood, C.	2003	R/BAS: word reading	−0.75	7.37					
Van Daal, V.H.P., & Reitsma, P.	2000	R/EMT: word reading fluency	−0.49	5.57					

Van Daal, V.H.P., & Reitsma, P.	2000	R/KLEPEL: nonword reading fluency	−0.39	5.64					
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	R/SWORT: written word reading	−0.45	30.11					
Karemaker, A.M., Pitchford, N.J., & O'Malley, C.	2010	R/experimental: lexical decision	−0.55	29.76					
Korat, O./youngest participants	2010	R/curriculum dependent	−0.68	9.81					
Korat, O./oldest participants	2010	R/curriculum dependent	−0.59	9.96					
Lewin, C./All Aboard Enhanced	2000	R/BURT: word reading	−0.47	8.19					
Lewin, C./All Aboard Basic	2000	R/BURT: word reading	−0.30	8.32					
Lewin, C./All Aboard Enhanced	2000	R/SALFORD: sentence reading	−0.44	8.21					
Lewin, C./All Aboard Basic	2000	R/SALFORD: sentence reading	−0.41	8.24					
Wild, M.	2009	S/Clay: dictation	0.02						
Brabham, E.G., Murray, B.A., & Bowden, S.H./Meaning	2006	V/curriculum dependent	−0.73	37.82	−1.12	0.02	0.14	−1.39	−0.84
Brabham, E.G., Murray, B.A., & Bowden, S.H./Phoneme	2006	V/curriculum dependent	−0.87	33.18					
Korat, O./youngest participants	2010	V/curriculum dependent	−2.45	5.85					
Korat, O./oldest participants	2010	V/curriculum dependent	−1.32	8.48					

C comprehension, *AK* alphabetic knowledge, *NWR* nonword reading, *PA* phonological awareness, *COV* concepts of print, *RAN* rapid naming, *S* spelling, *SYN* syntax, *V* vocabulary, *R* reading

Phonological Awareness

The effect of multimedia interventions on Phonological Awareness is substantial and consistent (ES = 0.75, ranging from 0.68 to 0.83, 51 outcomes). In the control group of children at risk, the effect is very weak (0.15, 15 outcomes). Therefore, it can be concluded that multimedia interventions have a large effect on the development of phonological skills. Furthermore, the effect is even greater for children at risk than the effect for mainstream children (ES = 0.73 and 0.55, for same and unrelated studies, respectively).

Rapid Automatic Naming

The effect on Rapid Automatic Naming is small (ES = 0.21, ranging from 0.05 to 0.38) and even smaller than in the control group (ES = 0.41, ranging from 0.22 to 0.61). It is reasonable to conclude, as did De Jong and Oude Vrielink (2004), that rapid automatic naming cannot be trained.

Concepts of Print

The effect of multimedia interventions in children at risk is strong and consistent and far larger than in unrelated studies with mainstream children, even in those with multimedia interventions (ES = 0.86, ranging from 0.61 to 1.11, 6 outcomes; unrelated studies: ES = 0.46, ranging from 0.22 to 0.70 across 6 outcomes) with respect to Concepts of Print outcomes. It can be inferred that multimedia applications are beneficial for the development of concepts of print in children at risk.

Vocabulary

Twenty-eight outcomes were found for the effect of multimedia on vocabulary; however, the effect in the children at risk who received multimedia interventions (ES = 0.68, ranging from 0.57 to 0.80) is not much larger than in the children at risk who did not receive intervention (ES = 0.56, ranging from 0.40 to 0.73).

Comprehension

Twelve outcomes concern comprehension. The mean effect size found was medium (0.52), however with a wide range (Confidence Interval: −0.27–1.31). Although outcomes in control children at risk and in mainstream children indicate effect sizes within the same confidence interval, the number of outcomes is small (nine in three control groups). Therefore, it is assumed that multimedia applications can have an impact on comprehension skills of children at risk.

Non-word Reading

The effect of multimedia interventions on non-word reading is moderate in size, however consistent (ES = 0.53, ranging from 0.39 to 0.67, 13 outcomes).

Reading

The effect of multimedia on reading for children at risk (ES = 0.60, ranging from 0.52 to 0.68, 44 outcomes) more or less equals the effect in the non-treated group of children at risk (ES = 0.77, ranging from 0.54 to 1.00, 8 outcomes). This means that learning to read is not specifically trained in multimedia applications for children at risk.

Spelling

Seemingly, spelling is enhanced by multimedia interventions in children at risk (ES = 1.11, ranging from 0.90 to 1.32, 5 outcomes); however, effect sizes are slightly smaller in untreated children at risk (2 outcomes). Therefore, it is not possible to presume that multimedia interventions have a substantial effect on learning to spell.

Syntax

A similar conclusion must be drawn for the learning of syntax (ES = 0.66, ranging from 0.25 to 1.08, 4 outcomes), as the confidence interval is relatively wide, and effect sizes in untreated children at risk are approximately 0.80 (2 outcomes).

Discussion

As noted by Plowman and Stephen (2003, p. 150): “There has been a proliferation of reports, articles, and web sites that make claims for the benefits to be derived from children using computers, but the evidence… for much of this writing is weak… the claims rely on assertion rather than empirical study". This is the first study to indicate, by quantitative analysis, that literacy-related multimedia applications have a substantial effect on the learning outcomes of children at risk. Multimedia applications were particularly effective in facilitating Phonological awareness and concepts of print in children at risk for literacy failure. In addition, multimedia was somewhat effective in promoting comprehension and nonword reading. Although medium effects were also found for spelling and syntax, too few studies were available to confirm these results. In addition, while large effect sizes were found for vocabulary and reading in treated children at risk, these effect sizes were also large in untreated groups, which means that these outcomes are not specifically affected by multimedia applications. This study extends on findings by Blok et al. (2002) who reported an overall effect size of 0.19 (95% confidence interval: ±0.06) for beginning readers, of whom some were underachieving. It could well be that both CAI and e-books, the majority of studies we included are concerned with, have improved over the last decade in specifically and efficiently targeting literacy outcomes. The present study also fills the gap in research noted by Lankshear and Knobel (2003) by showing that multimedia are indeed beneficial for young children at risk of underachieving in their literacy development. Moreover, this research shows that effects can be replicated in non-English-speaking countries.

It has been concluded by the author's of this study that multimedia applications did not specifically affect growth in alphabetic knowledge, vocabulary, and reading skills. In all studies with alphabetic knowledge outcomes, the untreated children at risk received regular instruction (Kegel et al. 2009; Macaruso and Walker 2008; Savage et al. 2009) for at least 12 weeks, in one study, on early intervention, even for 2 years (Regtvoort and Van der Leij 2007). While there are few studies conducted with untreated children at risk for vocabulary (3, with altogether 11 outcomes), the children in these studies followed the regular curriculum, again for at least 12 weeks. In the four studies with reading outcomes, the untreated children also received regular reading instruction. Thus, it was concluded that regular instruction is not improved when examining outcomes like alphabetic knowledge, vocabulary, and reading.

All types of interventions included in this meta-study, that is, embedded multimedia, video, CAI, and e-books, were compared with a control group that did "nothing," which may produce inflated effect sizes. A more telling comparison would be to look at the "added value" of multimedia applications. Several of the studies included in this meta-study offer such a possibility in addition to the aforementioned studies that compared multimedia interventions with regular classroom instruction. For example, in the study by Chambers et al. (2008), computer-assisted tutoring was compared with embedded multimedia. Effect sizes were larger for embedded multimedia than for computer-assisted tutoring with respect to comprehension and non word reading, 0.55 and 0.04 and 0.46 and 0.25, respectively. Another example is the study by Mathes et al. (2001), in which an extensive phonics program was compared with the same program plus CAI. On phonological awareness, reading, and comprehension, the phonics plus CAI program produced added results on the phonics only program (0.32 and 0.22 added to two different phonological outcomes, 0.18 and 0.14 to two reading outcomes, and 0.30 to the comprehension outcome, respectively). However, there was no advantage of the phonics plus CAI program on concepts of print. Comaskey et al. (2009) compared two PA programs with each other. On almost all phonological awareness outcomes, the analytic phonics version produced smaller effect sizes than the synthetic phonics version (0.73–1.99, 0.58–1.50, 0.94–1.36, 0.60–1.71, 0.80–0.46, and 0.65–1.76, respectively). Another example of an appropriate comparison can be found in De Jong and Bus (2004), in which an e-book treatment was compared with the printed version, ES = 2.20, a large effect, however, in children who were not at risk. In sum, although studies were not systematically classify studies on the type of control group that was used, it seems that multimedia still maintains at least medium effects on various literacy outcomes in children at risk.

Another way to learn more about the effects of multimedia on learning to read, is to include different kinds of control groups, as Verhallen et al. (2006) did. Remarkably, the control group in this study that did nothing progressed more on a vocabulary measure than the group that played a computer game, 1.01 and 0.40, respectively. The participants in this study were children who learned Dutch as a second language. These participants were distracted from learning Dutch vocabulary when playing computer games. Without the computer games, the children spontaneously learned some vocabulary. This is in line with cautions against the overuse of animations and hyperlinks (e.g., Zucker et al. 2009).

While the current meta-analysis provides substantive corroboration of the research evidence that supports the efficacy of using new technologies to foster early literacy development, it cannot be viewed as unequivocally conclusive. The primary limitation of all meta-analyses is the methodological soundness of the original studies that are included. Assessment of both quality of methodology of studies included as well as quality of the specific educational software or technology used was beyond the scope of the meta-analysis. In addition, it was not possible to determine the administrators' (researchers, teachers, parents) fidelity to the program in terms of the effectiveness with which they implemented it. Nor was it possible to differentiate the effects of the method of instruction (e.g., phonics versus whole word) from the mode of delivery (e.g., computer versus talking book).

As only articles published in peer-reviewed journals were included, the methodological integrity of the studies was assumed. The decision to include only articles published in refereed journals assured a standard of methodological soundness, as each of the studies had undergone a review by experts in the field. However, the sole use of published studies risks undermining the validity of the results by publication bias; the assumption being that studies will only be published if positive results are achieved, thereby inflating effect sizes. Furthermore, it is uncertain whether the results of this meta-study would have been any different (larger or smaller effect sizes), if it had been possible to retrieve the required statistical details from the 16 studies that had to be excluded in the last round. At least, the precision of the results would have been increased with another 16 studies added to the current 35 studies. Publication bias could have been mitigated by including unpublished studies in the analysis, such as reports and dissertations, but the amount of time required to assure methodological validity was prohibitive. It is with publication bias in mind that the effect sizes achieved in the meta-analysis must be considered. In addition, while this is the first study of this kind, replication studies as well as complementary studies are required in order to draw confident conclusions. Especially with respect to comprehension, more studies would be informative, as a wide range of effect sizes were found.

The specific method used, computing effect sizes as differences between pretest and posttest scores, may seem unusual, though it is mentioned as an option in Borenstein et al. (2009). With the method used, floor effects at pretest, for example, when children do not know any word meaning at all in a certain domain, will cause inflated effect sizes. On the other hand, if measurements with ceiling effects are used, effect sizes may be underestimated. However, floor and ceiling effects were accounted for by contacting the authors of the studies in which we suspected that such effects may have occurred and excluded them in case there was no control group. If there was a control group involved, and very many other studies were present in that specific outcome sample, the overall effect of such a study was marginal, and the study was retained. In any case, having only one such study in two outcome samples, the ABACADABRA evaluations, this did not jeopardize our conclusions.

Nonetheless, as large, consistent effect sizes were found for phonological awareness and concepts of Print, and medium effects were found for comprehension and non word reading in children at risk for literacy failure. It is asserted that the use of multimedia in beginning reading instruction provides opportunities for children at risk to catch up with their peers or, at least, to close the gap between them.

Appendix A

Definitions of Literacy-Learning Outcome Variables

Alphabet Knowledge

Knowledge of the names and sounds associated with printed letters, including letter naming fluency, sound discrimination, and letter-sound relations.

Phonological Awareness

The ability to detect, manipulate, or analyze the auditory aspects of spoken language (including the ability to distinguish or segment words, syllables, or phonemes), independent of meaning.

Rapid Automatic Naming

The ability to rapidly name a sequence of random letters, digits, colors, or objects.

Writing

The ability to write letters in isolation on request or to write one's own name.

Phonological memory

The ability to remember spoken information for a short period of time.

Concepts of Print
Knowledge of print conventions (e.g., left-right, front-back) and concepts (book cover, author, text).

Print Knowledge
A combination of alphabetic knowledge, concepts of print, and early decoding.

Reading Readiness
A combination of alphabetic knowledge, concepts of print, vocabulary, memory, and phonological awareness.

Oral Language
The ability to produce or comprehend spoken language, including vocabulary and grammar.

Visual Processing
The ability to match or discriminate visually presented symbols.

Comprehension
The ability to comprehend and recall a story and make inferences.

Non-word Reading
Word attack (nonword reading), and the reading of low-frequency words.

Spelling
The ability to complete both conventional and invented spelling tasks.

Syntax
Knowledge of the grammatical structure of language.

Vocabulary
Active and passive.

Reading
The ability to read real words, read of sentences, and lexical decision-making (decide whether a string of letters is a word or not).

Appendix B

Keyword search terms
Primary search words:
Children (young children, children at risk, minority children, language minority children, cultural minority children, low-SES children, disadvantaged children, children with reading disabilities, dyslexic children)

+ Secondary search words:
Literacy (including emergent literacy, early literacy)
Reading (including early reading, beginning reading)
Writing (including early writing, beginning writing)

+ Tertiary search terms:

Media
Multimedia
Electronic media
Digital media
Technology
ICT
Information technology
Educational technology
Interactive technology
Digital books
Online books
Talking books
Electronic books (including e-books)
CD-ROM
Computers
Computer-assisted learning
Computer-based learning
Internet
World Wide Web
Television (included related terms educational television, children's television)
Sesame Street
Between the Lions
DVD
Mobile phones

Appendix C

Journals searched:

Computers & Education
Early Childhood Research Quarterly
Journal of Computer Assisted Learning
Journal of Early Childhood Literacy
Journal of Literacy Research
Journal of Research in Reading
Reading and Writing
Reading Research Quarterly

Special issues on technology and young children searched:

"Technology in early childhood education," in *Early Education and Development*, Volume 17, number 1, 2006

"Using Technology as a Teaching and Learning Tool" in *Young Children*, November 2003 "Literacy and Technology: Questions of Relationship" in *Journal of Research in Reading*, Volume 32, number 1, 2009

"Technology Special Issue" in *Contemporary Issues in Early Childhood*, Volume 3, number 2, 2002

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Part II
School Children

Chapter 8
Teachers' Use of Assessment to Instruction (A2i) Software and Third Graders' Reading Comprehension Gains

Carol McDonald Connor, Barry Fishman, Elizabeth Crowe, Phyllis Underwood, Christopher Schatschneider, and Fredrick J. Morrison

Increasingly, computer technology is finding its way into the classroom with good results with regard to student literacy outcomes (Barker and Torgesen 1995; Chera and Wood 2003; Penuel et al. 2009; Shamir and Korat 2008). One particularly promising technology is online administration of and access to assessment information (Connor et al. in press; Landry et al. 2010). There are a variety of software packages available in the USA, including ThinkLink (http://thinklinkassessment.com/about.php), Wireless Generation (http://www.wirelessgeneration.com), and the Florida FAIR assessments (http://www.fcrr.org/FAIR/index.shtm), as well as software that provides access to instructional materials with professional development for their use, such as Knowledge Networks on the Web (KNOW, Fishman 2003; Fishman et al. 2003). In this chapter, we describe research that investigates online teacher assessment and instruction support for third grade teachers provided through

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Assessment to Instruction (A2i) online software, which is the centerpiece of a program of research investigating the impact of differentiated literacy instruction that is based on documented child characteristic by instruction interactions (Connor 2011). A2i uses dynamic systems forecasting intervention models (i.e., algorithms), based on empirical evidence, to recommend specific amounts and types of reading activities. This line of work demonstrates that the impact of specific reading instruction strategies depends on children's initial and current vocabulary and reading skills from kindergarten (Al Otaiba et al. 2011) through third grade (Connor et al. 2007; 2011a, b, in press).

In the USA and around the world, proficient literacy skills, including the ability to read and learn from text, are critical but one that too many students fail to attain (PIRLS 2006 studies, http://nces.ed.gov/surveys/pirls/idepirls/). One of the reasons many students fail to attain proficient literacy skills is that they do not receive the amounts and types of instruction needed to meet their potential (Connor et al. 2009a, b; Taylor et al. 2010). There is good evidence that effective teachers are masterful classroom organizers and plan instruction carefully, and that their students spend most of the school day in meaningful learning activities (Taylor and Pearson 2002; Wharton-McDonald et al. 1998). Moreover, there is increasing evidence that effective teachers plan to differentiate reading instruction (Fuchs et al. 1994) and are able to use assessment information appropriately to guide the differentiated instruction they provide (Roehrig et al. 2008).

Third grade in the USA, when students are between 8 and 9 years of age, represents a critical juncture in their literacy learning. Formal reading instruction begins in kindergarten and first grade. Skills begin to consolidate in second grade, and by third grade, students are expected to read well enough that they can begin to learn from text (Adams 1990).

Results of a recent study (Connor et al. 2011a) showed that when third grade literacy instruction was differentiated, taking into account child characteristics by instruction interactions using the Individualizing Student Instruction (ISI) intervention, students showed greater gains on a standardized measure of reading comprehension, the Gates-MacGinitie Reading Test (MacGinitie and MacGinitie 2006). The ISI intervention, fully implemented, provides students with specific amounts of targeted literacy instruction at their skill level, provided in small groups with the teacher, while the other students work with peers or independently in meaningful and appropriately challenging literacy activities. The study results also showed that students in the ISI intervention classrooms were more likely to receive the A2i recommended amounts of literacy instruction during a 90-min block of time devoted to literacy instruction than were students in control classrooms. Moreover, the more precisely the students received the recommended amounts, the greater were their reading comprehension skill gains. Findings thus demonstrate that it is important for teacher to receive and to be able to use or implement accurate guidance for Individualizing Student Instruction. A2i software is a key element of the ISI intervention, featuring both guidance for teachers with regard to recommended amounts and types of instructions for each student and professional development and training for teachers on how to enact that instruction.

Assessment to Instruction (A2i) Software

A2i software has four components: (1) assessment and recommended instruction, (2) planning, (3) professional development, and (4) teacher communications. In this study, we examine whether third grade teachers' use of A2i predicts students' reading comprehension skill gains and whether specific components of the software appear to be independently predictive of students' gains. The aim is to begin to explicate the role A2i use might play in improving teachers' literacy instruction and, hence, students' reading comprehension outcomes.

Assessment and Recommended Instruction

A2i recommends four types of literacy instruction that capture the multiple dimensions of reading: (1) *Teacher-/child-managed meaning-focused activities (TCM MF)* are activities where teachers work directly with small groups of students, who have similar learning needs, on activities, henceforth called flexible learning groups. These activities are designed to increase children's ability to actively extract and construct meaning from texts (Snow 2001). Activities might include robust vocabulary instruction (Beck et al. 2002), teaching comprehension strategies (Cain et al. 2004; NICHD 2000), discussing the content of books, and reading aloud. (2) During *teacher-/child-managed code-focused activities* (TCM CF), teachers provide instruction in flexible learning groups that support students' decoding skills. Only small amounts of TCM CF instruction were recommended in third grade and only for students reading well below grade level. Activities might include teaching students how to decode multisyllabic words, morphological awareness (Carlisle 2000), and more advanced grapheme-phoneme correspondences and phonics. (3) *Child-managed meaning-focused activities* (CM MF) are activities also designed to support students' comprehension, but during these activities children are expected to work independently or with peers. Such activities might include buddy reading, writers' workshop, and independent sustained silent reading. (4) *Child-managed code-focused activities* (CM CF), which are recommended only in very small amounts for third grade students unless they are reading below a first grade level, are designed to provide independent practice for students on phonics, morphological awareness, word encoding, and other code-focused activities that support children's ability to decode unfamiliar words.

The recommended amounts of instruction are provided to teachers in the *Classroom View* of the A2i software (see Fig. 8.1). Clicking the mouse on the students' names brings the teacher to the *Child Information* screen that displays children's assessment scores and graphs of their progress in vocabulary, word reading, and reading comprehension. Teachers may also make notes on this page. Additional assessment information is provided on the *Assessment Page*. On this page, teachers can access and update assessment information for all of the students in their class, view the

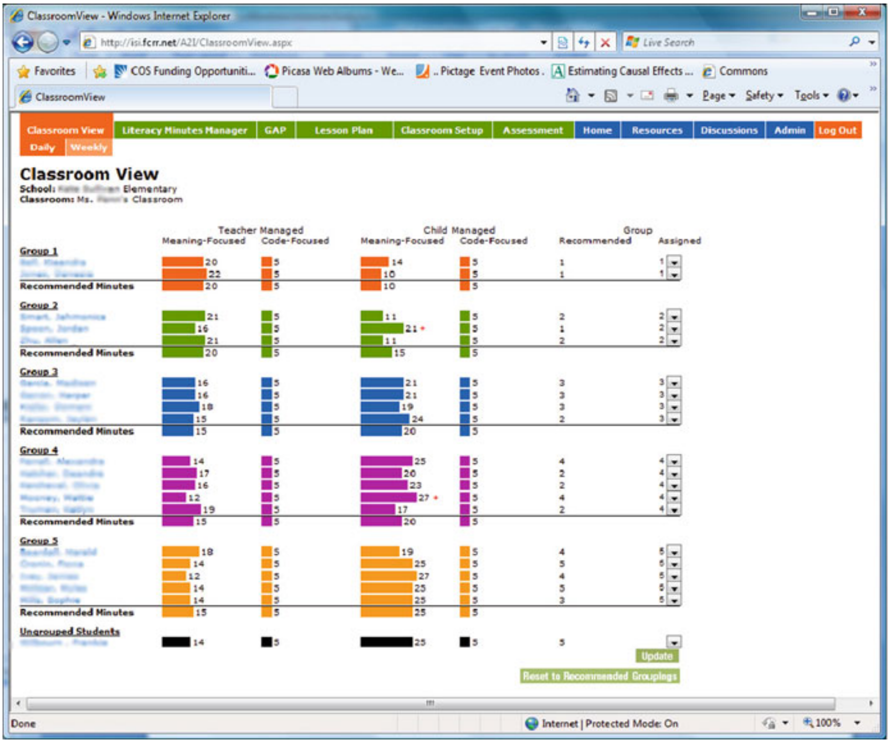

Fig. 8.1 The A2i classroom view. Children's names are blurred to protect confidentiality. The *colored bars* represent the recommended amount of instruction in minutes for each student. Also provided are the recommended groups, which teachers may change (Permission provided by first author)

classroom progress chart, which provides a snapshot of class-wide gains (see Fig. 8.2), and the *Word Match Game*. The *Word Match Game* is an online semantic matching task that can be used in the instruction recommendation algorithms and to monitor students' vocabulary growth. Children click on the two of the three or four words that are semantically related (e.g., bride and groom, cat and kitten). The assessment is adaptive and provides grade and age equivalents as well as developmental scale scores. The latter are used for research purposes. All assessment results are displayed to the teacher as grade equivalents.

The A2i algorithms recommend amounts of instruction that, based on previous research and children's vocabulary and comprehension skills, should allow them to reach grade level (grade equivalent, GE, of 3.9) or, if they are already at or above grade level, achieve a school year's worth of growth by the end of the school year on the Passage Comprehension test of the Woodcock Johnson III (Woodcock et al. 2001). When students' skills are reevaluated in January, the recommended amounts are recomputed using the new scores. The A2i algorithms are based on empirical evidence from longitudinal descriptive studies (Connor et al. 2004, 2009a) that used hierarchical linear modeling to predict students' spring reading comprehension

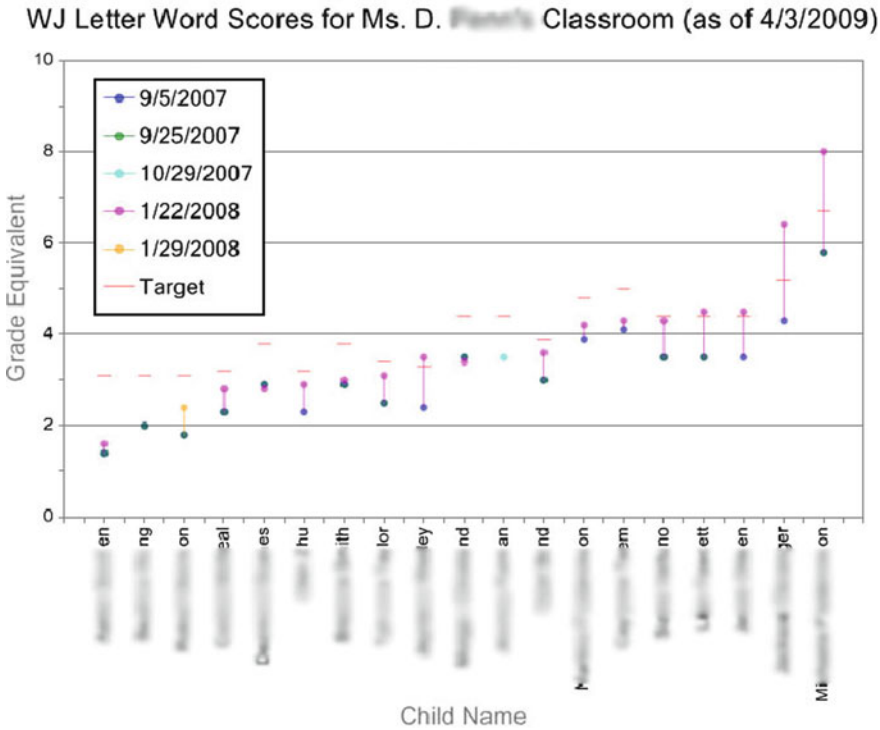

Fig. 8.2 This is a chart showing the status for all the children in the classroom. The *dots* represent scores on particular dates; the *horizontal bar* represents the target outcome

scores as a function of their fall vocabulary and reading scores and the reading instruction they received. The dynamic system forecasting intervention models, analogous to those used by meteorologists to predict the path of hurricanes, essentially reverse engineer and adapt these equations with the target outcome set as end of third grade reading comprehension skills, or a school year gain in reading comprehension, whichever is greater. The students' fall comprehension and vocabulary scores are then used to solve for the number of minutes per day required to meet the target outcome. For example, the algorithm for TCM MF recommended amounts of instruction are computed using the following equation:

TCM MF = ((8.3*Fall RC GE – (Target Outcome – (.75*(Fall Voc AE + 8.0))) – 30)/
(–.41 *Fall RC GE – 1.74)) + 15

RC GE = Passage Comprehension grade equivalent; Fall Voc AE = Picture Vocabulary age equivalent. Target Outcome = 3.9 or fall passage comprehension GE + .9, whichever is greater.

The result is a nonlinear function where children with lower fall comprehension grade equivalents (GE) need exponentially more time in TCM MF small group instruction to achieve the target outcome (Connor et al. 2011a). Recommended amounts for students with lower fall vocabulary scores are greater than they are for peers with the same reading comprehension scores but higher vocabulary scores. In cases where there is no evidence for child X instruction interactions, the recommended amounts were set at the mean amount of instruction observed.

Grouping algorithms use cluster analysis to recommend homogenous skill-based small groups (i.e., flexible learning groups) based on students' WJ Passage Comprehension GE scores. Teachers may change these groups although they are encouraged to use the A2i recommended groups.

Planning

The Planning pages of A2i include the *Literacy Minutes Manager* (LMM) and the *Lesson Plan*. Teachers use the LLM to schedule their daily 90-min block of time so that each student receives the recommended amount of each type of instructional activity. The lesson plan then provides recommended activities that align with the type of instruction (e.g., TCM MF, CM MF) and the mean GE of the flexible learning small group. There is a database of activities that have been reviewed by master teachers and assigned GEs. We make use of the Florida Center for Reading Research (FCRR) center activities (http://www.fcrr.org/curriculum/SCAindex.shtm), which are an excellent resource. Core literacy curriculum materials are also indexed and rely on the sequence of activities to assign GEs. Teachers may change the recommended activities through a pop-up menu.

Professional Development

Teachers receive professional development on how to use assessment to guide instruction and how to plan differentiated reading instruction, classroom management, differentiating literacy instruction in the classroom, and using research to guide instruction. They participate in a half-day workshop in the early fall before the school year begins and attend monthly meetings that are facilitated by a research assistant who is a certified teacher funded by the research project. The research assistant also provides biweekly classroom-based support during the 90-min literacy block. Such professional development is well described in the extant literature, and there is good evidence that such a regime can improve teachers' practice (Bos et al. 1999; Chard 2004). To facilitate the face-to-face professional development, A2i provides online content about how to set up the classroom, getting ready to differentiate instruction, using assessment to guide instruction, effective reading instruction, and access to research articles (see Fig. 8.3). This includes online video of master teachers demonstrating and explaining how they differentiate instruction. There are also research articles that are annotated and discussed monthly through the discussion board, discussed below.

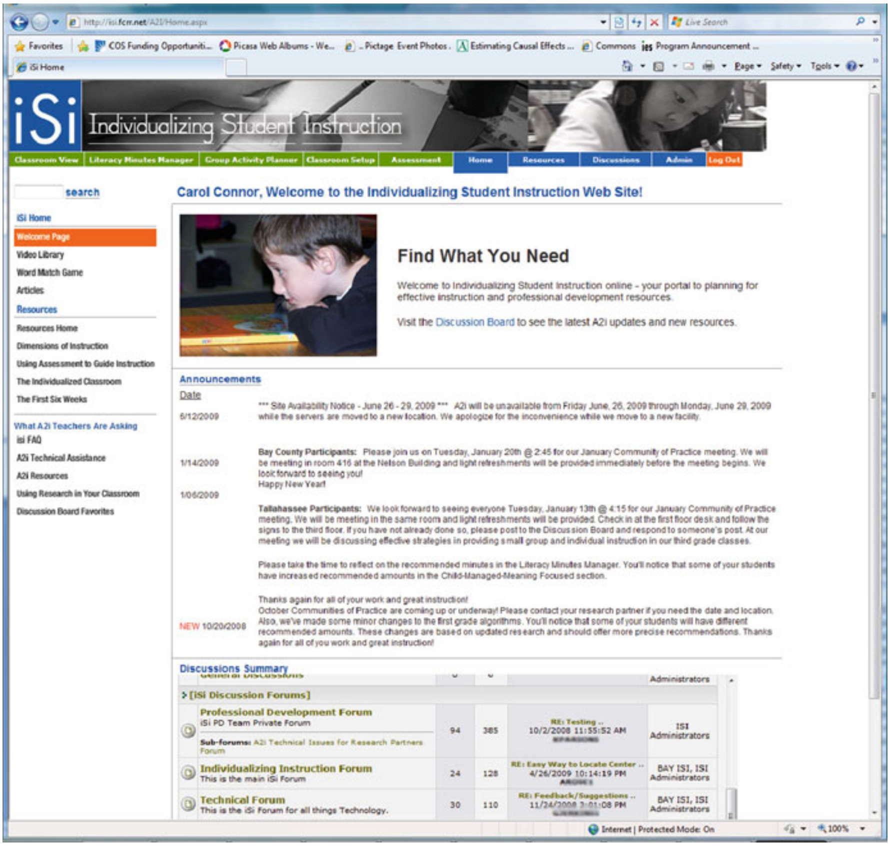

Fig. 8.3 The home page for the ISI professional development Pages. Note also the discussion board (Permission to use provided by first author)

Teacher Communication

Additional teacher support is provided during the month through the use of monitored discussion boards. There are two study-wide topics: technology and instruction. The technology discussion board is where teachers can ask for help using components of the A2i software and can report any bugs they find. The instruction discussion board is where teachers can share instruction ideas, ask for help from their peers and from the researchers, and where they post their thoughts about the monthly readings. Research articles focus on a variety of topics from the results of the A2i research (Connor et al. 2007) to topics on specific aspects of teaching reading (Connor et al. 2010) and the neurological basis of dyslexia (Hudson et al. 2007).

The Vocabulary Intervention

At the beginning of the study and after teachers had volunteered to be in the study, they were randomly assigned to implement either the ISI intervention or a vocabulary intervention. The vocabulary intervention was based on the work of Gersten and colleagues (Gersten 2007) and used the book *Bringing Words to Life: Robust Vocabulary Instruction* (Beck et al. 2002). In this intervention, teachers participated in a monthly teacher study group where they read an assigned chapter of the book and then met in small groups to discuss the implications of the chapter, design a lesson plan using the research, and to discuss previous lesson plans developed. They then implemented the lesson plan in their classroom. At the next meeting, they then discussed how well the lesson worked and ways to improve it before they began discussing the next chapter. It was hypothesized that this intervention would contribute to greater gains for students in these classrooms. However, analyses revealed that there were no significant differences in either oral or reading vocabulary when the ISI and vocabulary groups were compared (Connor et al. 2011a).

Does Third Grade Teachers' Use of A2i Predict Student Reading Comprehension Gains?

Participants

Teachers were randomly assigned within schools ($n=7$) to implement the ISI intervention and use A2i or to implement the vocabulary intervention. Only the 16 third grade teachers who were randomly assigned to the ISI intervention and their students ($n=226$) participated in this study. The 17 remaining teachers implemented the vocabulary intervention just described (Connor et al. 2011a) and did not use A2i. Approximately 50% of the students qualified for the US free or reduced lunch program, which is a commonly used indicator of family poverty. Approximately 52% were African American, 33% were White, and 3% were Latino/a. The remaining children belonged to other ethnic groups or were multiracial.

Assessments

Time Using A2i

A2i automatically tracks teachers' use of the software by recording the time and destination of each click. These data can be downloaded through the A2i reporting features. Using data from the entire year, we computed the total time, to the hundredth of a second, teachers spent using A2i, as well as time spent in each of the four component areas. If teachers failed to log off, the software automatically logged them out after 30 min. However, we assumed that they stayed on the last page for 1 min to avoid inflating the estimated usage. This happened fairly infrequently because teachers were encouraged to formally log off the software so that students' confidential assessment information could not be accessed by unauthorized persons. Variables were created by summing the time teachers spent on the pages in each of the four areas of A2i: assessment and instruction recommendations, planning, professional development, and communication. This yielded four variables in minutes, one for each area.

Students' Reading Comprehension

Students' reading comprehension skills were assessed using two measures: the Woodcock Johnson III (WJ) Passage Comprehension test and the Gates-MacGinitie (GM) Reading Test (MacGinitie et al. 2000; Woodcock et al. 2001). The WJ task, which was administered in the fall, winter, and spring, uses a cloze procedure where students are asked to supply the word missing from a sentence or short passage read silently. The GEs of the passage comprehension test were used by the A2i algorithms to compute recommended amounts of instruction and to formulate flexible learning groups.

The GM task, which was administered only in the fall and spring, provides longer passages that students read silently. They then are asked to respond to multiple choice questions that vary in levels of inferencing required. Teachers did not view these scores through A2i although they were provided to teachers on paper, nor were these scores used for progress monitoring. It is also quite likely that the two tests measure different aspects of comprehension (Keenan et al. 2008). Tests were administered by trained research assistants in a quiet area of the school close to students' classrooms.

Classroom Observations

Classrooms were observed and videotaped in the fall, winter, and spring for the entire literacy block. Using these videos, the amount of time students spent in each type of instruction was coded in seconds using Noldus Observer Pro software. The difference (DIF) between the A2i recommended amount and the observed amount was computed. These data were then aggregated to the mean for each classroom to create a teacher DIF score, which represents the precision with which teacher provided the A2i recommended amounts of instruction to the students in his or her classroom. Previous results showed that the more precisely teachers provided the A2i recommended amounts of TCM MF instruction (TCM MF DIF), the greater were students' comprehension gains (Connor et al. 2011a).

In addition, research assistants who were blind to condition rated each teacher from 1 (low) to 6 (high) on the quality of instruction across four dimensions: individualizing

Table 8.1 Descriptive statistics for teachers' use of A2i from September through May (in minutes) and their practice, based on classroom observations

	Mean	Std. deviation	Min	Max
A2i online software use (min)				
Total amount	612.7330	321.65662	220.15	1408.29
Assessment and instruction recommendations	65.7908	37.70578	11.24	142.99
Planning	96.2687	99.06260	13.78	343.75
Communication	171.1307	184.47919	8.47	713.50
Professional development	279.5051	163.27278	96.45	609.51
Classroom observations				
TCM MF DIF (min)	−6.12	9.37	−16.49	7.96
Quality individualizing	2.94	1.91	1	6
Quality organization	4.9	1.06	3	6
Quality vocabulary	3.56	1.14	1	5
Quality warmth/discipline	4.38	1.06	2	6

Note: TCM MF DIF is the difference between the observed and A2i recommended amount of teacher-/child-managed meaning-focused instruction. Quality ratings are from 1 (low) to 6 (high)

instruction, planning and organization, vocabulary instruction, and warmth/responsiveness/discipline. For both observation variables, inter-rater reliability was acceptable with kappas greater than .70.

Results

Overall, students made significant gains on both measures of reading comprehension from fall to spring. They gained more than 7 W points on the WJ Passage Comprehension test [$t(433) = 16.98$, $p < .001$]. They gained almost 14 ESS points on the GM [$t(447) = 10.53$, $p < .001$]. These represent effect sizes (d) of .66 and .33, respectively.

Teachers' Use of A2i

On average, from September 2008 to May 2009, teachers used A2i for an average of 612 min (about 10 h). This ranged, however, from 220 min (about 3.6 h) to 1,408 min (about 23 h). Time spent in each of the four areas also varied greatly (see Table 8.1). In general, teachers spent the greatest amount of time on professional development pages and on the discussion board. Nevertheless, they still spent substantial amounts of time on assessment and instruction recommendation pages (about 1 h) and on planning pages (about 90 min). Again, this varied among teachers.

The four A2i variables appeared to operate fairly independently. That is, when correlations among variables were examined, no associations were significant with one exception. Teachers who spent more time on the assessment and instruction recommendation pages were also more likely to spend more time on the discussion boards ($r = .68$, $p = .004$).

Table 8.2 Descriptive statistics for student comprehension scores in the fall and spring including W and scale scores (ESS), score used in analyses, standard score (ST, mean = 100), and percentile rank (PR, mean = 50)

	Mean	Std. deviation	Min	Max
Fall WJ passage comprehension ST	93.33	11.373	36	124
Fall WJ passage comprehension W	482.78	13.173	407	518
Fall GM comprehension PR	48.25	28.712	1	99
Fall GM comprehension SS	459.03	41.728	333	596
Spring WJ passage comprehension ST	95.41	10.237	65	121
Spring WJ passage comprehension W	490.83	10.957	458	518
Spring GM comprehension PR	49.82	29.805	1	99
Spring GM comprehension SS	475.24	42.465	375	592

Table 8.3 HLM results indicating effects of A2i total use (min) on spring WJ passage comprehension W scores (WJ PC) and GM comprehension scale scores

Fixed effects	Coefficient WJ PC	Standard error (SE) WJPC	Coefficient GM comprehension	SE GM comprehension
Intercept	490.25***	.423	495.07***	1.306
Student level variable				
Fall score	.60***	.036	.77***	.037
Classroom level variable				
A2i total use	.004**	.001	.029***	.003
Random effects	**Variance**	**Chi-square**	**Variance**	**Chi-square**
Classroom	.016	9.33	.217	10.93
Student	58.65		574.41	

Note: All continuous variables were grand mean centered. Child level df = 221 for WJ PC and 216 for GM comprehension. Classroom level df = 14
***$p < .001$; **$p < .01$;

Teachers' Use of A2i Predicts Reading Comprehension

In general, children made good progress from fall to spring on both measures of comprehension (see Table 8.2). Previous research indicated that students whose teachers used A2i made significantly greater gains compared to children in the control group (Connor et al. 2011a).

Because our data have a nested structure, students nested in classrooms, we used hierarchical linear modeling (HLM, Raudenbush and Bryk 2002), which partials student and classroom level variance. We started with an unconditional model for each spring reading comprehension assessment. This revealed intraclass correlations (ICC), which are the proportion of between-classroom variance explained, of .28 for the GM and .10 for the WJ comprehension assessments. We then added the fall assessment and total duration to each model (see Table 8.3). The models revealed that the more time teachers spent using A2i overall, the greater were their students' reading comprehension skill gains (i.e., residualized change) on both measures.

Table 8.4 HLM results indicating effects of A2i components (min) on spring WJ passage comprehension W scores (WJ PC) and GM comprehension scale scores

Fixed effects	Coefficient WJ PC	Standard error (SE) WJPC	Coefficient GM comprehension	SE GM comprehension
Intercept	490.17***	.388	474.73***	1.25
Student level variable				
Fall score	.602***	.039	.760***	.041
Classroom level variable				
Assessment and instruction recommendations	.035***	.007	.131	.075
Planning	.002	.002	.020**	.005
Communication	.002	.001	.020*	.009
Professional development	.002	.002	.017	.013
Random effects	**Variance**	**Chi-square**	**Variance**	**Chi-square**
Classroom	.018	7.07	.329	8.20
Student	7.672		575.35	

Note: All continuous variables were grand mean centered. Child level df = 218 for WJ PC and 213 for GM comprehension. Classroom level df = 11
***$p < .001$; **$p < .01$; *$p < .05$

We then repeated the procedure but added each of the four A2i components instead of the total amount (see Table 8.4). Results differed for the two assessments. For the WJ passage comprehension test, the greater amount of time teachers spent on the assessment and instruction recommendation pages of A2i, the greater were their students' gains. In contrast, the more time teachers spent on the planning and discussion pages of A2i, the greater were their students' gains on the GM reading comprehension task.

A2i Use and Classroom Instruction

In general, there was substantial variability among teachers in their TCM MF DIF scores where negative values indicate that the teacher generally provided less than the recommended amount (see Table 8.1). The quality ratings differed as well with teachers generally receiving lower ratings (3 out of 6) for the quality of individualizing instruction than for organization, vocabulary, and warmth/discipline (see Table 8.1). We computed zero-order correlations for the 16 teachers who were in the ISI intervention condition. Results revealed that teachers who spent more time using the planning features of A2i tended to have smaller TCM MF DIF scores and received higher ratings on individualizing than did teachers who used these features of A2i less (A2i planning and TCM MF DIF $r = .527$, $p = .036$; A2i planning and quality individualizing $r = .502$, $p = .048$).

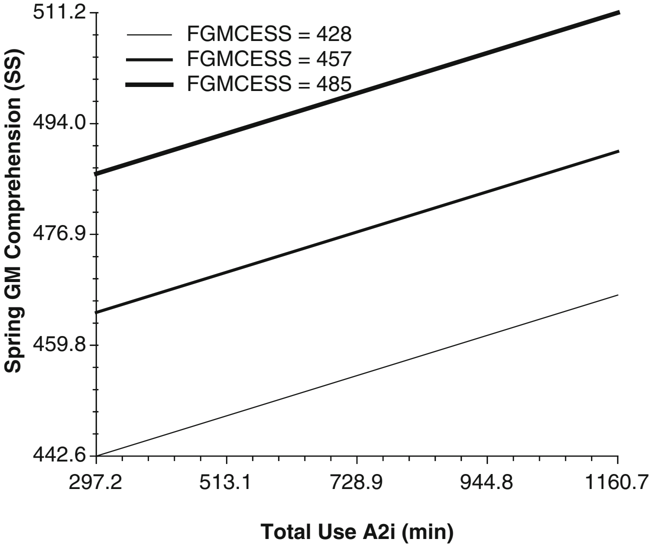

Fig. 8.4 Predicted spring GM comprehension score as a function of the number of minutes teachers used A2i from September to May (Total Use A2i) and students' fall GM comprehension score (FGMCESS) where children with fall scores falling at the 25th percentile for the sample are indicated by the lightest line, 50th percentile by the middle line, and 75th percentile by the darkest line. Note that the sample mean spring scale score (SS) was 475. Total Use A2i modeled ranges from the 10th to the 90th percentile of the sample

Discussion

The results of this study indicate that the use of A2i appears to facilitate more effective literacy instruction. The more third grade teachers used A2i over the entire school year, the greater were their students' reading comprehension skill gains (see Fig. 8.4). For every 10 min over the mean that teachers used A2i, our models predicted that their students would achieve almost 8 points more on the GM reading comprehension test. This is an effect size of .72, which is large. Moreover, on average, the more time teachers spent using the planning features of A2i, the more precisely they provided the TCM MF recommended amounts. Plus the quality with which they implemented individualized instruction was judged to be higher. The scale for judging the quality of individualizing rated teachers on how well they used flexible groupings and whether the content of instruction was aligned with students' skills and learning needs. To receive the highest rating (6), the teachers' instruction is described in the rubric as follows: *Teachers who fully implement ISI use multiple and flexible student grouping configurations and regrouping of students based on formal or informal assessment data. The content of literacy instruction is differentiated.* These findings suggest that using A2i may help teachers improve their ability to use assessment information to inform instruction, to differentiate instruction in the classroom more effectively, and to provide the recommended amounts more precisely; this, in turn, may help to improve students' reading comprehension gains. Coupled with other evidence (Al Otaiba et al. 2011; Connor et al. 2011a), A2i does appear to be one of the several active ingredients in the ISI intervention; the others include professional development and, most important, actually implementing the recommended instruction in the classroom.

We argue that A2i use alone is unlikely to improve students' reading comprehension achievement. For example, in addition to using A2i, teachers in the ISI intervention, compared to the control teachers, were more likely to provide the amounts of small group teacher-/child-managed code- and meaning-focused instruction amounts recommended by A2i (Connor et al. 2011a). As our research has shown, the important thing is that teachers provide the recommended number of minutes and have support with grouping (Connor et al. 2009b, 2011b). There are many ways to do this and A2i appears to be a particularly easy-to-use one. Richard Clark made this argument well, in observing that the delivery truck does not affect the nutritional value of the food at the grocery story although it may make it possible for us to have access to foods we otherwise would not have (Clark 1983).

Using student assessment results to guide instruction is difficult (Roehrig et al. 2008), but accumulating evidence indicates that by making the links between assessment and instruction more salient, we can support more effective instruction (Connor et al. 2007; Landry et al. 2010). Such systems (called "clinical-decision support systems") have been used and studied extensively in the medical field. These online systems link results of patient assessments with computer-generated diagnosis and recommendation for treatment and are associated with better patient outcomes than are traditional doctor- or clinician-generated treatment (Garg et al. 2005; Kawamoto et al. 2005, p. 765). Kawamoto and colleagues (2005) conducted a meta-analysis of over 70 randomized trials examining the features of clinical decision support systems that were associated with stronger practitioner and patient outcomes. Features included (a) provision of a recommendation rather than just assessment results, (b) computer-based generation of decision support (i.e., diagnosis and treatment recommendation), and (c) decision support provided at the time that decision making typically occurred. A2i incorporates each of these features through the four components.

When we investigated how the four components – assessment and instruction recommendations, planning, professional development, and communication – affected student outcomes, we found that they predicted the two reading comprehension tests differently. Time spent on the assessment and instruction recommendation pages predicted WJ passage comprehension gains, whereas time spent on the planning and communication pages predicted GM reading comprehension gains. We conjecture that because the WJ passage comprehension scores were actually available to teachers through A2i, were provided in the fall and winter during the school year, and in particular were salient on the assessment and instruction recommendation pages, teachers were directly monitoring students' progress on this test and hence were more likely to adjust instruction accordingly when they were more familiar with students' status. In contrast, the GM reading comprehension scores were not available through A2i, and teachers were provided only fall scores at the beginning of the school year. Moreover, the GM reading comprehension task is arguably more similar to the task of comprehension inasmuch as children are expected to read longer passages and answer questions that require varying levels of inference. The WJ test is a cloze task. Thus, teachers' use of the planning pages and participation in discussions on the communication pages may have improved their proficiency with providing instruction that supported students' text comprehension more generally. Again, this is conjecture.

There are limitations to this study. Most importantly, although conducted in the context of a randomized trial, only the teachers randomly assigned to the ISI intervention condition used A2i, so these results are essentially correlational. Our sample size of 16 teachers is small, and so there might be some type II error. Finally, these results have been replicated with first graders (Connor et al. 2007, in press), but additional replication study analyses are still ongoing.

In sum, the results of this and other studies indicate that online software can, potentially, improve teachers' instructional decision making and the efficacy of their literacy instruction. Therefore, in addition to software that directly supports student learning, software for teachers presents a promising avenue for advancing students' achievement.

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Chapter 9
An Online Learning Community as Support for At-Risk Students' Literacy Growth: Findings, Implications, and Challenges

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This chapter reviews the decade-long process of developing an online learning environment focused on bringing together 9–12-year-old students in American elementary schools with adult mentors in order to read, respond to, and write about children's books of different genres that address a variety of topics. Over the years, the project has developed curricular units of study as well as professional development materials for the teachers and the adult pen pals. During this time, we have gathered data about the project's processes and its impact on student achievement, as well as a variety of factors involved in constructing an online environment that is designed to be both user-friendly and educationally impactful.

In what follows we address five crucial issues that have arisen in this process that we feel are instructive for future developments related to online learning environments that intend to promote skill in reading comprehension, writing, and higher-level thinking for elementary school-age children. We address these five issues after first presenting a brief description of the project—In2Books—and a summary of the three research studies conducted to date.

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In2Books: History and How It Works

ePals' In2Books is a research-based program, with the central mission of building a digital learning community among grade 3–5 students (aged 9–12 years old), their teachers, and adult pen pal volunteers. From its inception in 1998, I2B has focused especially on under-resourced neighborhoods where many students come from low-income, culturally diverse backgrounds and typically have school achievement levels significantly lower than children from economically higher circumstances. The program was developed to motivate elementary school-age children to engage in authentic literacy activities across curriculum subject areas and, in so doing, foster higher-level thinking, composing, and comprehension skills. The principal feature of I2B is a pen pal exchange that has adult volunteers and students writing to each other about a common set of children's books they have each read. The focus is on creating a context in which students are motivated to read books and to comprehend them deeply because they will write about them to an adult who engages in dialogue about what has been read. In their classrooms, teachers employ a range of instructional activities (e.g., discussion, questioning, vocabulary and fluency activities, process writing) to develop children's literacy skills and subject area knowledge, helping students not only to write good letters to their pen pals but also to effectively apply their reading and writing strategies in a variety of contexts.

From its inception, the program has been digitally supported (online resources for teachers, students, and pen pals; the adults wrote and sent their letters online), but in 2008, ePals completed the creation of an all-digital version of In2Books (except for the books) facilitated by three resource-rich websites—Teacher Place, Student Place, and Pen Pal Place, each customized to serve its audience and support the I2B experience. Teacher Place contains content resources related to the various books and genres, sample lesson plans, and social networking tools to connect with other In2Books teachers, as well as the needed range of resources for managing the daily logistics of the program (student roster, a writing assessment tool, schedule, tools for approving and ordering books and reviewing letters, etc.). The Student Place site provides students with tools for sending letters to and receiving them from pen pals, as well as with a range of resources related to the topics and books in each unit. Pen Pal Place serves as an online vehicle for helping pen pals write effective letters—it provides sample letters, an interactive tutorial for letter writing, additional information of program topics, all the tools necessary for communicating electronically with students, and means for ongoing messaging with the teacher and In2Books staff. From 2008 to 2010, the program was offered at no cost to high-poverty (Title I) classrooms and served approximately 7,000 students. In 2010–2011, groups of 3–10 teachers participated in 21 schools across the United States to involve 3,300 children.

Research Efforts

Throughout the entire time of this development, we have attempted to conduct research that would enable us to understand better (1) the effects of In2Books on students' literacy achievement and motivation, (2) the impact of I2B on teachers' instructional practices, and (3) the program elements associated with any of these effects. Following are synopses of three of the studies.

Study 1: Large-Scale Achievement Patterns

First is an examination of student achievement patterns in District of Columbia Public Schools (DCPS), an urban school district with historically low levels of student literacy achievement (see the United States National Assessment of Educational Progress Long-Term Trend Study results at http://nces.ed.gov/nationsreportcard/ltt/). We worked with the DCPS teachers over a period of 8 years, providing professional development and supporting the implementation of I2B in the classroom. Over 80% of the DCPS children taking part in the project attended schools that received supplementary government funding (the schools qualified for this supplementary funding because at least 40% of the children attending came from families living in poverty). Most of these children were struggling readers and writers, with literacy achievement 1 year or more below grade level.

During the 2003–2004 school year, we worked with over 2,000 DCPS students in grades 2–4 who were in In2Books classrooms. The school district supported conducting an evaluation to help answer the following research question:

- How does participation in In2Books relate to student literacy achievement patterns?

The district supplied the end-of-year test scores for all students in the district on the SAT-9 reading test, a standardized reading achievement test that measured reading comprehension, vocabulary, and word identification via a multiple-choice format (http://www.pearsonassessments.com/haiweb/cultures/en-us/productdetail.htm?pid=e139a). The scores of students in In2Books classrooms were compared with the scores of approximately 8,500 students in comparison classrooms that had not participated in I2B. We summarize here results from grades 3 to 4 because currently the program operates only from grade 3 onward. (See Teale and Gambrell 2007, for more details on this analysis.)

The following categories and numbers of students/classrooms were examined in the analysis:

- *Veteran In2Books*: teachers who had been implementing I2B for two or more years (Gr 3: 26 classrooms, 462 students; Gr 4: 21 classrooms, 390 students).

Table 9.1 Mean SAT-9 reading test scale scores

Grade level	Veteran I2B	First-year I2B	Total I2B	Non-I2B
3	626.9*** (47.7)	612.9* (48.2)	619.2*** (48.4)	607.7 (40.9)
4	637.3*** (46.1)	637.5* (44.3)	637.4** (45.1)	626.8 (39.2)

***$p < .001$; **$p < .01$; *$p < .05$

- *First-year In2Books*: classrooms where teachers implemented the program for the first time during the 2003–2004 school year (Gr 3: 33 classrooms, 570 students; Gr 4: 24 classrooms, 428 students).
- *Total In2Books:* veteran + first-year I2B classrooms and students (Gr 3: 59 classrooms, 1,032 students; Gr 4: 45 classrooms, 818 students).
- *Non-In2Books classrooms*: classrooms in DCPS whose teachers were not participating in I2B in any way and did not implement the program in their classrooms that year (Gr 3: 3,121 students; Gr 4: 3,648 students). (The number of non-In2Books classrooms could not be determined from the DCPS database used in the analyses because data from numerous schools were labeled "No Name Given." Therefore, only numbers of students are provided.)

Table 9.1 provides the mean scale scores and standard deviations for each group at each grade level. Results were analyzed using a one-way analysis of variance within each grade, with a four-level grouping variable. In every case, there was a statistically significant main effect of group, with students in I2B teachers' classrooms performing at higher levels compared with students not in the program. Tukey's post hoc tests showed that the significant differences between means occurred in the cells marked with asterisks in Table 9.1, summarized as follows:

- At both grade levels, both veteran I2B and first-year I2B teachers' students scored significantly higher in reading achievement than non-I2B students.
- At both grade levels, students of veteran I2B teachers scored significantly higher than those of first-year I2B teachers.

The calculated effect size for the significant difference ranged from small to moderate (.26–.46).

The vast majority of students in the In2Books group (80–83%, depending on grade level) were from Title I schools. Additional analyses comparing achievement patterns in only Title I I2B schools with non-I2B students showed the same overall pattern of results. Thus, the scores indicated that "at-risk students" who experienced In2Books as part of their instructional program were significantly more likely to have higher achievement levels in reading than students not in the program. It is important to note, of course, that causal connections cannot be made between the higher scores and the I2B program because it was not possible to conduct pre- and post-testing or compare the I2B student learning with students in another reading/literacy intervention, but this initial study did provide suggestive results about the positive effects of the In2Books program.

Study 2: Literacy Engagement and Book Discussion Patterns Across Three Grade Levels[1]

This study focused on reading, writing, book discussion, and literacy motivation in grade 3–5 students (ages 9–11) (Gambrell et al. 2011). Three research questions were formed to examine the central feature of In2Books, the pen pal intervention focused on authentic literacy activities:

- Does engagement in a pen pal intervention focused on authentic reading, writing, and discussion tasks influence the literacy motivation (self-concept and value of reading) of grade 3, 4, and 5 students?
- Does engagement in the intervention provide a context for small group interactions that reflect dimensions of accountable talk (community, content, and critical thinking)?
- What do students report regarding their participation in the intervention?

Participants were 7 US elementary school teachers and their 219 elementary school students in grades 3–5. Across the four schools involved, the percentage of students qualifying for free/reduced price lunch (and therefore described as at risk because they come from low-income homes) ranged from 47 to 75%. The study used a mixed method design and a triangulation convergence model (Creswell and Plano Clark 2006; Ross et al. 2004). Data collection involved gathering quantitative information (e.g., Literacy Motivation Survey, Gambrell et al. 2011) as well as qualitative information (e.g., audio recordings and transcriptions of small group discussions and key informant interviews) so that the data could be integrated to reveal a rich description of what occurred during the intervention.

Especially emphasized in this intervention were discussion groups in which 6–8 students talked about the books they read and the letters they received from the adult pen pals. All students in each classroom participated in the small group peer-led discussions using strategies introduced by the teacher during reading instruction. They talked about the ideas in the book they had read as well as questions that they could ask their adult pen pals. Students participated in at least two small group discussions about each book before writing to their adult pen pal.

Key findings from the study were as follows:

- Both boys' and girls' reading motivation increased significantly from fall to spring, as measured by the Literacy Motivation Survey (Gambrell et al. 2011). This result is particularly interesting in light of the robust findings from prior research showing that US elementary students' reading motivation typically

[1] This research was supported in part by a Creative Inquiry grant from Clemson University and a CARL grant from the In2Books Foundation to Dr. Linda Gambrell. At the time of the study, the In2Books Foundation was a not-for-profit organization. CARL was created by the In2Books Foundation to support research on broader issues of literacy development and did not sponsor research specifically on the In2Books program. Dr. Gambrell currently serves on the Academic Advisory Board of ePals/In2Books.

declines across the school year and as students progress through the grades (e.g., McKenna et al. 1995). Since this study was descriptive in nature, causal factors in this increase cannot be directly determined; however, interviews with 28 key informants across grade levels revealed that factors related to the authenticity of the In2Books literacy activities (e.g., exchanging ideas with an adult who is personally interested) had created situational interest in the school-related tasks of reading, writing, and discussing a commonly read book.

- Transcripts of 15 small group discussions were analyzed using an adaptation of an instrument developed by Resnick and colleagues based on the concept of accountable talk (Michaels et al. 2007; Resnick 1999; Wolf et al. 2005). Accountable talk provides a framework for evaluating academically productive group discussions (Michaels et al. 2007). Of particular interest in this study was whether authentically situated small group interactions about a shared text would provide a context for accountability to *community (learning community), content* of the text (knowledge), and *critical thinking (rigorous thinking).* Across the 15 discussions, students demonstrated consistent reference to the text and discussion topic. There were only two brief instances of off-topic discussion, and both occurred in fourth grade classrooms. More specifically, the analysis of the transcripts provided evidence of purposeful student cognition and suggested that the authentic literacy tasks of reading books, exchanging letters, and engaging in small group discussions are viable tools for creating a learning context that reflects student accountability to community, content, and critical thinking.
- When asked what they liked best about the program, key informants most often mentioned that they valued having an adult pen with whom they could exchange letters (57%). Writing to an adult who does not assess you, but to whom you are responsible for communicating effectively in order to continue the valued connection, seems to represent a task that relates to students engaging more fully in the important academic elements of reading, writing, and discussing books.
- Students also frequently mentioned that the classroom activity that helped them most to understand the books was the small group discussions (48%). Such responses provided support for view that students appropriate the tools for understanding through the socially embedded connections provided by discussions (and letter exchanges) (Malloy and Gambrell 2010; Vygotsky 1978). In this study, students reported that their personal workspace, or individual understanding of the text, was enhanced through interactions with peers in discussion groups.

Study 3: One Teacher's Study of Her Own Fifth-Grade Classroom[2]

This study yielded yet another perspective on the In2Books program. It was "action research" (Mills 2003) and thus provided a look at the issues a teacher wrestles with in using the learning community afforded by technology for working in school

[2] This research was supported by a Teachers Network Leadership Institute MetLife Fellowship from the Chicago Foundation for Education.

settings where many students struggle with reading and writing. This research was conducted by a fifth-grade teacher who was implementing In2Books in her Chicago Public Schools (CPS) classroom over the course of one school year (Lyons 2010). She conducted the work as a member of a group of CPS teachers supported by a fellowship experience designed to enable them to "share their research and recommendations for improving student achievement with colleagues while working with educational leaders to inform and influence policy decisions impacting classrooms" (http://www.chicagofoundationforeducation.org/pages/all_about_cfe/18.php).

This was Lyons' third full year of implementing I2B (she had one prior year of experience with the program in CPS and one in DCPS). The vast majority of students in the classroom were considered "at risk"—97% received free or reduced price lunch and most resided in public housing facilities (government-supported housing for low-income families). Eighteen of the 28 students in the classroom started the school year at an academic warning (also termed below grade level) status based on scores from the Illinois Standards Achievement Test (ISAT) (http://www.isbe.state.il.us/assessment/isat.htm). Eight had been previously identified with learning disabilities and received special education instruction.

Two questions were examined in the study:

- How does the use of authentic writing experiences through In2Books impact the students' reading and writing skills and their engagement in literacy?
- What kinds of questions, responses, and interpersonal connections developed between the students and their pen pals, as evidenced in the letters about books that they wrote to each other?

The following data were collected:

- Engagement in literacy: beginning- and end-of-year scores on the motivation to read profile (MRP) (Gambrell et al. 1996)
- Reading achievement: three data sources served as indicators of student literacy achievement across the course of the year:
  - Beginning- and end-of-year scores on the Northwest Evaluation Association *Measures of Academic Progress* (MAP) standardized reading tests (http://www.nwea.org/products-services/computer-based-adaptive-assessments/map)
  - End-of-year scores on the ISAT reading test
  - In2Books Rubric (Glasswell and Teale 2007) scores, completed for all student letters written for the Realistic Fiction, Social Studies, and Biography cycles
- Content analysis of student letters from three I2B cycles/units—Realistic Fiction (topic: Bullying), Social Studies Informational Text (topic: Westward Expansion); Biography (topic: Inventors)

At the beginning of the school year, Lyons used the MRP scores for reading self-concept as reader and value of reading, together with student achievement levels, to help plan her instructional approach in literacy. The overall patterns of scores led her to conclude that it would be especially important during the school year for this group of students to be engaged in literacy activities they would consider as meaningful and valuable to both their academic and social lives. Follow-up informal conversations with each of the students about personal literacy and leisure activities indicated that they valued social networking and preferred literacy tasks that were online, so she incorporated In2Books into the curriculum. In addition, she planned that while teaching the I2B content, she would frame activities in such a way as to make explicit for the students how the academic literacy tasks in the program were also an investment in their social and personal lives. For example, in shared readings, she mainly used nonfiction texts that highlighted historical events or (auto) biographical accounts typically neglected in traditional history textbooks (e.g., *Black Soldiers in the Revolutionary War*, *The Trail of Tears*, *Crispus Attucks*); Lyons was able to facilitate discussions in which students could realize how these events and people helped to shape today's world. Such activities also helped many students realize the connection between their personal feelings of marginalization (owing to low proficiency in reading and writing) and the similar experiences with these events and historical figures. Additionally, Lyons incorporated numerous activities that required her students to conduct research about these events/individuals online and then share their findings, thus creating another connection between academic and social literacy tasks.

Lyons also noted from these beginning-of-year scores something she found surprising: the warning/below students scored as highly on self-concept as reader on the MRP as the more accomplished readers in the class. This led her to conclude that "I needed to teach this group strategies for self-monitoring while reading so that they could become more appropriately aware of their comprehension levels" and that "I needed to be explicit and honest with them about their reading levels."

Such examples illustrate a teacher's use of systematically collected data for planning, having opportunities for collaborative discussions about it, and, as a result, differentiating instruction, a process associated with enhanced teacher effectiveness and student achievement (Lai and McNaughton 2009; Timperley et al. 2009).

In addition to these insights into literacy/technology/struggling students, this study led to the following findings:

- Scoring of student letters using the In2Books Rubric yields a score on each of two dimensions of students' writing: (1) communication of ideas about the book and (2) use of language and organizational features. ANOVAs for each of these scores across the three genres/topics followed up by paired t-tests found identical patterns: the quality of ideas and the language/organization in the social studies (SS) and biography (bio) letters did not differ significantly, but both were significantly higher than scores for the realistic fiction (RF) letters. Interestingly, students indicated that they enjoyed reading the RF best of all three genres. As the RF books/letters were the first completed in the program, it could be that increased experience with writing or repeated interactions with the pen pal letters contributed to higher writing performance on the SS and Bio letters. In addition, Lyons noted that for the SS unit of study, she integrated many more Social Studies content lessons about the topic Westward Expansion into the In2Books reading/writing activities. As a result, she concluded, "Students were not only learning about westward expansion from their pen pal and from their In2Books book, but they were also learning additional content from our shared readings and content lessons. I believe that this integration contributed to my students' high scores in the area of Comprehension (on their letters)…. I plan to integrate more literacy and social studies and science content lessons next year."

- Lyons also presented portraits of six focal students purposefully sampled from the class to represent a range of achievement levels and motivational profiles, as well as a range of responses to the I2B instructional activities and pen pal letters. Summary information on the students is presented in Table 9.2. From the scores, work samples, and student interviews, she created portraits of different student responses and learning trajectories.
  - From the students' responses to the pen pal experience, for example, she identified two categories of students: Go Getters and Slow to Trust. "The students I labeled as Go Getters were immediately attracted to the idea of having a pen pal…. Go Getters wrote detailed introductory letters and could not wait to share their pen pal's response letters with me, their peers, and their families. Slow to Trust students did not initially demonstrate this excitement and were reluctant to exchange letters, especially letters with any elaborate written information about themselves or about their interest in reading and writing." She also found that "each of my Slow to Trust students developed into Go Getter students as they began to trust their pen pal and enjoy the process of engaging in online discussions about their books."
  - With respect to achievement patterns, she examined the progress that the students made in both standardized test scores and the Comprehension section of the rubric to see if the "level" of questions asked by adult pen pals was in any way related to the complexity of response exhibited in the student letters or students' overall achievement gains. She found, however, that "the pen pals' level of questioning did not necessarily affect whether the student produced a high level or low level response in the written letter."
  - Finally, Lyons concluded that another "area that emerged throughout the year from within the letters that encouraged several of the focal students to deeply engage in the I2Bs process and improve their literacy skills…was the interpersonal connections that developed between the student and the adult pen pal." She described the case of her student Tara, who in her fourth letter to her adult pen pal Kayla stated, "I just want to say you are a life saver to me." As a result of the interpersonal interaction with her pen pal, Lyons notes that Tara "finally felt comfortable sharing both with her pen pal and with me a situation of severe bullying that had been going on for three years.…I believe that it was the relationship that developed between Tara and Kayla that helped Tara gather the courage to confront this situation and ask for my help."

In summary, what this study provided was a teacher perspective on the implementation and impact of the In2Books intervention in an urban, high-poverty setting. Lyons concludes that the interpersonal relations and the give-and-take about

Table 9.2 Descriptive information on focal students (Lyons 2010)

Focal student	Beginning-of-year student demeanor regarding pen pal activity	Teacher description of students' beginning-of-year literacy characteristics	Beginning-of-year ↓ End-of-year changes on ISAT/MAP reading achievement tests (exceeds, meets, below, warning)
Kara	Go Getter	Book lover, hard worker, enjoys writing but struggles with including elaboration	Meets (late 5th grade equivalent)* ↓ Meets (early 6th grade equivalent) (*This is a midyear score; Kara transferred to this class after school year began)
Mike	Slow to Trust	Interested in specific books, completes class work independently, dislikes school writing	Meets (early 5th grade equivalent) ↓ Meets (early 6th grade equivalent)
DiDi	Go Getter	Book lover, hard worker, struggles with inferential thinking, enjoys writing but writing lacks organization	Below (3rd grade equivalent) ↓ Exceeds (early 8th grade equivalent)
Adam	Go Getter	Interested in specific books, distracted reader, stream of consciousness writer	Below (early 3rd grade equivalent) ↓ Meets (late 5th grade equivalent)
Terrieon	Slow to Trust	Reluctant reader and writer, writing lacks elaboration and structure	Below (middle 3rd grade equivalent) ↓ Below (middle 3rd grade equivalent)
Avon	Slow to Trust	Reluctant reader and writer, writing lacks coherent focus, elaboration, and structure	Below (2nd grade equivalent) ↓ Below (middle 3rd grade equivalent)

content forged through this technology-enhanced pen pal experience promoted both positive attitudes toward literacy and opportunity for growth in literacy achievement for her students.

Lessons Learned

We have used data and findings from these studies to reflect on the larger topic of the role that technology can play in addressing literacy achievement among children considered to be at risk. The following "lessons learned" relate to both theoretical and practical issues in the literacy education of such children.

The Technology-Enabled Learning Community Created Instructional and Learning Opportunities That Contributed to Literacy Success for Many Children Who Participated

The digital community organized around intergenerational discussion of literature (both narrative and informational) fostered learning exchanges among students, adult pen pals, and teachers that could not have existed without the affordances of technology. In short, the digital environment made possible a learning community that both existed within the walls of the classroom and extended beyond it, encompassing other classrooms as well as the larger world outside of the school. This community brought a number of affordances to students' literacy learning and content learning. It provided interpersonal support and motivation, lent a real-world authenticity to students' in school experiences, and scaffolded student learning of specific content and a variety of reading and writing skills.

Additionally, the digital platform helped classroom teachers in several ways. For one thing, they were readily able to maintain communication with the pen pals, providing them with feedback as to the appropriateness of their letters for the particular student in question (e.g., language level in the letter, number/difficulty of questions asked, need for more timely responses). In this way, the teacher could "fine-tune" the scaffolding that a student was receiving from the pen pal. Also, the technology platform made it easy for teachers to provide feedback to students, advising them about the appropriateness of their book selections and especially facilitating the conferencing part of writing workshop through commenting on drafts of letters so students could improve them.

We are planning to explore other aspects of learning communities not touched on in the studies to date. For example, although the Lyons study provided some indication of how ongoing teacher assessments could contribute to appropriate differentiation of literacy instruction, Cosner's recent work on grade-level data-based collaboration suggests that even stronger effects on teacher skill and student achievement can be realized with a sustained approach that involves ongoing examinations of data with grade-level teams of teachers supported by school leadership personnel (Cosner 2011a, 2011b). This suggests additional ways that a central guiding principle of In2Books—the assessment-instruction cycle (http://in2books.epals.com/content/info.aspx?caid=Reading_Strategy&divid=Planning)—can become an even more robust part of a teacher's daily practice. When teachers collaborate to examine assessment data and plan instruction based on those data—especially in situations where the school principal is supporting such work school-wide—a powerful community of practice ethos can take root across the school. Technology can play a central role in promoting such a community.

Online Professional Development Communities

Closely associated with the idea of a learning community that directly supports students in the classroom is the teacher learning community that we observed within In2Books. The teacher professional development (PD) involved in the program was not directly studied in any of the three research projects discussed above, but observations, informal interviews, and focus group feedback sessions indicated that the professional interactions occurring among the teachers were extremely important. Both the DCPS project and the Gambrell et al. project involved face-to-face professional development sessions, and during the actual sessions and beyond, there was considerable sharing of teaching and assessment ideas. Such teacher-to-teacher interaction was central to building a teacher learning community that enhanced professionalism and, we suspect, also contributed to higher-quality classroom instruction.

The face-to-face PD enabled I2B professional development providers a degree of "control" over the establishment of a learning community among the teachers. We all met together periodically over the course of the entire school year. These meetings provided not only opportunities for the I2B staff to share planning, teaching, and assessment strategies with teachers, they also were rich opportunities for professional dialogue among teachers across different grade levels and from different schools. We found that such experiences raised the level of teacher involvement and professional development, especially among teachers at schools with a history of large numbers of students performing below grade level in literacy.

The program is now focusing on how to replicate these types of interactions in the online environment. During the past year, informal mechanisms built into Teacher Place like blogs, forums on significant or provocative issues, and contest-like activities did not result in much active teacher participation. During the 2010–2011 school year, In2Books has been examining the effects of having, at various school sites, groups of teachers headed by an experienced In2Books teacher engaging in a summer professional mentoring course and teacher mentor group exchanges. These teachers will also work to establish a stronger exchange with their volunteer pen pals and stay closely connected with central I2B staff through messaging, interactive professional development, forums, and exchanges in new online sites Teachers' Lounge and Pen Pals' Lounge.

Technology Can Create Opportunities for Authentic, Purposeful Literacy Instructional Activities That Otherwise May Not Be Possible

In working with "at-risk" students, authentic literacy activities may be especially important (Teale et al. 2007). Typically, students struggling with reading and writing have negative attitudes toward engaging in reading or writing (Kucan and Palincsar 2011). The acts of reading and rereading deeply for comprehension, as well as writing a letter about what you read, seemed for a sizable number of students in the studies to be a task they willingly approached because they knew they were writing to a real audience. Thus, the authentic and purposeful nature of the pen pal exchange with an adult may carry sufficient social value for students that they perceive a utilitarian value for engaging in the classroom reading, discussion, and writing activities. In other words, the authentic exchange with an adult may provide significant motivation and scaffolding for the school-related tasks of creating, revising, and communicating personal interpretations related to the book that was read.

Frequently, those who write about instruction for reluctant readers/writers discuss the importance of making activities fun so the students will want to engage in them. We see it differently. What we noticed in the In2Books experience was that students often worked very hard to understand, annotate, and respond to their pen pals' letters, as well as comprehend the books they were reading. In other words, it was not always fun for them. But what seemed to sustain students was the perceived importance and purpose to what they were doing—communicating with a real audience. Thus, engagement was key, and purpose was a significant factor associated with continuing engagement.

Academically Challenging Work Is Important for the Literacy Education "At-Risk" Learners

Programs for 9–12-year-old students experiencing difficulties in literacy often focus on code-related skills such as phonics, word recognition, spelling, and reading fluency. These skills are extremely important because they are typically underdeveloped among such learners and therefore should feature prominently in their literacy instruction. But, our research findings have led us to believe that an instructional focus on such skills, while necessary, is not sufficient for helping struggling students at these age levels. Students also need to experience what it is to read and write at grade level. This means that even students having difficulty with literacy need to encounter content that is commensurate with their grade level, and they need to engage in the more complex reading and writing skills and strategies that are necessary for processing that content.

"Acceleration" is key to getting intermediate grade students back on track for long-term success in reading and writing. By *acceleration*, we mean that students who are behind need to accomplish more than one year of progress in reading and writing over the course of one school year. Such success cannot be achieved with curriculum and instruction that focuses only on foundational skills at the word and letter-sound levels. Nor does it work to take the position that this particular year of schooling can focus on getting children up to speed on their foundational skills so that next year we can address higher-level skills. Such a position is shortsighted education from our perspective. Even students experiencing difficulty in literacy need a comprehensive approach to learning that stresses the interdependence of content and literacy skills for reading and writing achievement.

Hence, the focus on experiencing reading and writing in different genres and ensuring that thematically and informationally rich topics were explored were of central importance to the effects of In2Books for the students. "Higher-level" literacy activities were a consistent aim instructionally in I2B classrooms. It has been our experience that it is much more difficult to create online literacy learning activities that foster reading comprehension, writing skill, and higher-level thinking than it is to develop foundational activities in areas such as phonological awareness, decoding, and even reading fluency, which is typically treated in such activities as involving only word reading accuracy and speed. But, we hope the above examples demonstrate that it is quite feasible to create instructionally appropriate, higher-level learning experiences for struggling readers.

The Adult-Child Relationship Can Play a Pivotal Role in the Impact of a Program on Engagement and Learning for Struggling Students

The importance of the interpersonal aspect of the literacy activities in In2Books could be seen most specifically in the data from Lyons' case studies and the Gambrell et al. research. Both of these studies clearly indicated that one of the most motivating aspects of the program for the students was getting to know the adult pen pals. This bond between the student and the adult developed as personal information was requested and shared in both directions. Content analyses of letters written in the Gambrell et al. study showed that whereas the adults saw their role in the exchange to be primarily academic in nature (focusing on critical literacy, as indicated by their attention to asking questions about the books), the students valued the personal interaction with an adult who was not a teacher and who would not be grading their performance. Lyons' case studies of specific students also bore out the importance of such relationships.

In addition, as nonempirical support for this conclusion, we heard time after time from teachers during 3 years of conducting face-to-face professional development in the District of Columbia Public Schools that the student-pen pal relationship was key to motivating many of their students to read, reread, and study their books carefully and to engage in the extended process of writing and revising their letters. These comments, and our examination of hundreds of student letters in developing and field testing the rubric for assessing letters (Glasswell and Teale 2007), led to the inclusion of "Connecting with Pen Pal" as one of the seven features of writing assessed with the rubric because it seemed to be so important a feature for many students.

Conclusions

Data gathered from the three research projects described above have helped us to reflect on what played a role in the impact that a technology-centered program had on student learning, teacher practices, and community involvement in the literacy education of at-risk students. It has always been challenging to help students who are behind in reading and writing during the intermediate grades and beyond. We do not see that challenge lessening in the immediate future. However, our work convinces us that innovative applications of technology as well as new technologies themselves afford promising ways of addressing the educational needs of students struggling with literacy. We intend to apply the lessons learned to our continuing work and look forward to incorporating insights from a myriad of other projects that are examining the affordances of technology for literacy learning and instruction.

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Chapter 10
Stimulating Self-Regulated Learning in Hypermedia to Support Mathematical Literacy of Lower-Achieving Students

Bracha Kramarski

Introduction

Reform standards emphasize the importance of mathematical literacy as part of a comprehensive curriculum for developing meaningful learning (National Council of Teachers of Mathematics (NCTM) and Programme for International Student Assessment (PISA), 2003). Mathematical literacy is the individual's capacity to solve and use mathematics, to reason mathematically in a variety of contexts, and to identify the role that mathematics plays in the world by describing, modeling, explaining, and predicting real-life phenomena (PISA 2003). Modeling real-life phenomena involves transmuting the phenomenon into a mathematical problem, solving the mathematical problem (e.g., calculations), then applying the solution to the original real-life context, and interpreting and verifying the results (PISA 2003). In addition to performing routine computations and manipulating mathematical symbols, mathematically literate individuals should be able to handle authentic tasks with varying degrees of complexity. These tasks (a) are often presented in story format, (b) contain mathematical data, (c) can be solved in different ways, (d) are based on many types of mathematical knowledge (e.g., change and relationships) and skills (e.g., strategies, representations, communication), and (e) often require justification.

These multi-processes are difficult for many students to handle (PISA 2003), especially for lower achievers, who have difficulty coping with mathematical texts or indeed with any text that must be read and understood. They do not realize that there may be more than one correct way to solve the task, and they are not sure how to calculate and verify the solution (Desoete et al. 2003; Jitendra et al. 2007; Schoenfeld 1992). They also have trouble differentiating between relevant and

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irrelevant information (Verschaffel et al. 2000). Higher achievers face different problems: they often have trouble applying their knowledge to the demands of novel tasks presented in unfamiliar contexts (PISA 2003).

Research has shown that the training given to students in order to meet the reform standards in mathematics education mainly influences the performance of higher and average achievers (Schoenfeld 2002). The needs of lower achievers are often not fully addressed (Jitendra et al. 2007). Therefore, there is a need for alternative training programs to help lower achievers to conceptualize mathematics topics and to increase engagement and experiences of success (Kramarski et al. 2010). It is believed that computer technology has great potential for bolstering mathematical literacy (NCTM 2000; PISA 2003). An ideal program, it has been suggested, would emphasize self-discovery of new ideas, help receive feedback about them, and encourage their assessment. This type of that technology-based instruction program may help produce individuals who know how to learn and will continue learning on their own. This study focuses on instruction programs in a hypermedia environment.

Hypermedia Environment

Hypermedia is a tool that provides students a wide range of links to information (i.e., Internet, forums, or course site) represented as text, graphics, animation, audio, and video. Hypermedia is dynamic, interactive, and nonlinear; it provides access to relevant data that can be explored in multiple ways and offers many features that can support the solution process. There are also new item formats that allow a wider range of response types (e.g., drag-and-drop items, hot spots), and they may allow students to respond to more items nonverbally, thus providing instructors with a more complete picture of the student's mathematical literacy that is less language based. Hypermedia strengthens domain learning and provides help when needed (e.g., pop-ups, scripts). It allows students to focus on problem-solving strategies, concepts, and structures rather than mechanical procedures and so may facilitate conceptual knowledge development (Azevedo and Cromley 2004). Furthermore, hypermedia helps students obtain mathematical and conceptual knowledge by providing them with the tools to discuss and share information on online communication forums – it gives them a platform on which they may understand the text problem and decide *how* to solve the problem, *when* to change strategies, and *when* to increase their effort. By critically examining others' reasoning and resolving disagreements, students learn to monitor their own thinking, which in turn fosters learning (e.g., Kramarski 2011; Kramarski and Dudai 2009; Kramarski and Mizrachi 2006).

However, research has indicated that although the technological environment appears to inherently promote active engagement in learning, little study is actually gained by its use. Learners do not know how to take advantage of what the environment has to offer efficiently (e.g., Azevedo and Cromley 2004; Kramarski 2011; Kramarski and Dudai 2009; Kramarski and Mizrachi 2006; Michalsky et al. 2007).

Students have trouble coordinating the numerous representations of information, planning, using effective strategies, and monitoring their progress. These findings suggest that technological learning environments should incorporate support for self-regulated learning (SRL). Therefore, providing SRL support for the lower-achieving students should help them access and interact with the content productively and consider the connections between different mathematical ideas.

This study aimed to design an instructional environment based on stimulating SRL in a self-directed hypermedia environment with features geared toward lower-achieving students.

Supporting SRL in Hypermedia

Self-regulated learning is defined as the extent to which the students are active participants in their own learning processes – cognitively (i.e., goal setting, strategic thinking), metacognitively (i.e., planning, monitoring, and evaluating the solution process), motivationally (i.e., investing effort, self-efficacy), and behaviorally (i.e., help-seeking) (Pintrich 2000; Zimmerman 2000).

Developing SRL is generally defined as learning how to learn. Consequently, educators and researchers have suggested (e.g., Kramarski 2011; Kramarski and Dudai 2009; Kramarski and Mizrachi 2006; Michalsky et al. 2007) that programs to enhance students' mathematical literacy should incorporate training practices that explicitly guide all kinds of students (i.e., lower and higher achievers) to learn how to learn – to understand – *what* the required knowledge base is (i.e., linguistic, mathematic, or strategic), *which* strategies to select, *when* and *why* to implement them in the solution process, and *how* to reflect on such actions. One promising type of SRL support seems to be the use of self-questioning prompts, which are effective in fostering domain knowledge and self-regulatory cognitive strategies (e.g., King 1998; Kramarski and Mevarech 2003; Mevarech and Kramarski 1997; Schoenfeld. 1992).

IMPROVE Self-Questioning Model

The IMPROVE self-questioning model (Kramarski and Mevarech 2003; Mevarech and Kramarski 1997) aims to support key aspects of self-regulation by using four generic self-questioning prompts: comprehension, connection, strategy, and reflection. *Comprehension* questions help learners understand necessary information (e.g., "What is the task/problem?"). *Connection* questions prompt learners to understand the task's deeper-level relational structures by focusing on prior knowledge and by articulating thoughts and explanations (e.g., "What is the difference/similarity?" and "How do I justify my conclusion?"). *Strategy* questions encourage learners to plan and select the appropriate strategy (e.g., "What is the strategy?" and "Why?"). *Reflection* questions play an important role in helping learners monitor and evaluate their solution processes by encouraging learners to consider various perspectives and values regarding their selected solutions (e.g., "Does the solution make sense?" "Can the task be solved otherwise?" "Am I satisfied from the way I faced the task?").

Generally speaking, research has reported positive effects on students' mathematical learning outcomes and SRL skills in technology environments when SRL was supported by the IMPROVE self-questioning approach (e.g., Kramarski 2011; Kramarski and Dudai 2009; Kramarski and Mizrachi 2006). However, these studies examined the effects of supporting SRL with the IMPROVE approach on average and higher-achieving students. There has been no research to determine the benefits and pitfalls of supporting SRL with the IMPROVE approach embedded in hypermedia for enhancing mathematical literacy and SRL processes of lower-achieving students.

The purpose of the present study is twofold: (a) to investigate the mathematical literacy of lower-achieving students who were exposed either to the hypermedia with SRL support (H_SRL) or hypermedia with no SRL support (H_NS) and (b) to examine the ability of SRL among lower-achieving students in both groups (H_SRL and H_NS). Mathematical literacy is determined by different task complexity, and SRL is observed in forum discussions related to online feedback. Furthermore, to achieve a more comprehensive understanding of the lower achievers' performance, we compared these outcomes to those of the higher achievers. Due to the potential of supporting SRL in hypermedia, we expected that H_SRL (both lower and higher achievers) would enhance mathematical literacy and SRL more than H_NS (both lower and higher achievers). We postulated that this effect would be greatest among the H_SRL lower achievers.

Method

This study investigated 64 Israeli seventh graders attending two classes within one junior higher school in central Israel. We assigned randomly each class to one of the two instructional methods: H_SRL ($n = 32$, $n = 16$ for lower and higher achievers) or H_NS ($n = 32$; $n = 16$ for lower and higher achievers). The two classes were heterogeneous in terms of math ability and taught by the same teacher. At the outset of the study, there were no significant differences between the two groups in their prior knowledge of mathematics (see result section). The lower-achieving students were selected according to their scores (below the median score – 55.4) on the Ministry of Education's standardized test administered in the beginning of the year. The test included standard tasks (8 items) and complex tasks (14 items). Cronbach's alpha reliability coefficient was .79.

Shared Structure and Curriculum

Students from both groups (H_SRL and H_NS) were exposed to a hypermedia self-directed course focused on mathematical literacy unit and applied over 8 weeks. Hypermedia was based on the Moodle *(Modular Object-Oriented Dynamic Learning*

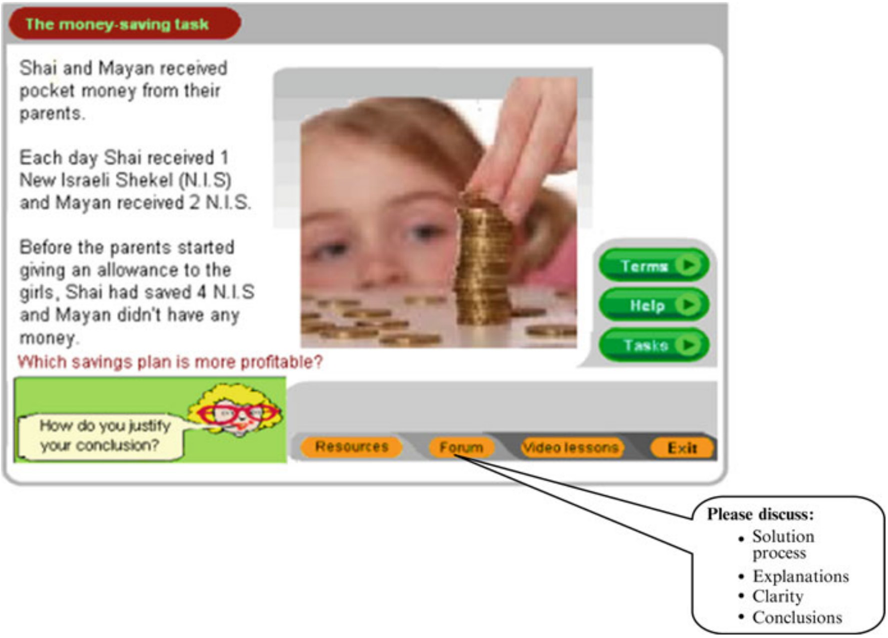


Fig. 10.1 The money saving plan task developed by the authors

Environment) open e-learning software platform that is both proactive and collaborative. The goal was to enhance mathematical literacy as defined by the new curriculum standards (NCTM 2000; PISA 2003). The hypermedia mathematical literacy unit was an online autonomous course, which included eight tasks of varying degrees of complexity (see Fig. 10.1 and Appendix for task examples). Figure 10.1 presents an example of a hypermedia screen. Tasks were available in the on-screen link to mathematical "Tasks." In order to receive clarifications of mathematical terms, definitions, and rules, participants could click on-screen links for clarifying "Terms" (e.g., variable, mean), using "Resources" (i.e., Internet, Excel for multiply and dynamically linked representations as a table or graph), viewing video "Lessons" (i.e., authentic classroom events of teachers' problem solving, explanations, and instructions for both groups, and a screen modeling the use of IMPROVE model for H_SRL), and accessing additional "Help" (e.g., worked-out examples). The "Forum" link enabled discussing solutions and providing/receiving feedback. Pop-up prompts provided guidance for both groups, highlighting the solution process, explanations, clarity, and conclusions in the feedback discussion.

Before studying the unit, the teacher presented the subject of the unit to the students, modeled the use of learning with the hypermedia, and emphasized the importance of forum practice. A class discussion was then held about working in a group and how to provide peer feedback. Students from both groups completed the same practice sets in small heterogeneous online forums of four participants set by the teacher. Each student in both groups was asked to solve the weekly task, send his/her solution to the forum, provide feedback for the forum partners' solutions, receive feedback for his/her own solution, and adjust his/her solution (if needed) according to the peers' suggestions. At the end of each week, every group sent their solutions and their peer feedback exchanges to the teacher, and the teacher then provided online feedback within 24 h to each student in the group. The teacher encouraged each student to provide feedback to the other three students in the forum about their solution process. The teacher's feedback included comments regarding both the accuracy of the solution, the problem-solving process, and feedback discussion.

H_SRL vs. H_NS Group

Students in the H_SRL group received SRL support for mathematical literacy, based on the IMPROVE self-questioning approach (Kramarski and Mevarech 2003). The metacognitive questions were presented and explained on the "IMPROVE screen" in the link of "Lessons"; question prompts were embedded in students' tasks (see Fig. 10.1). The students were encouraged to answer these questions while solving their tasks and to use them when providing explanations and peer feedback in the forum. The aim of the H_NS group was to improve students' mathematical literacy by sharing knowledge in the forum. Small groups discussed mathematical literacy by referencing solutions, mathematical explanations, and difficulties. The teacher explained that by sharing methods, discussing written work, and exchanging peer feedback on problems and solutions, students could improve their understanding of problem solving.

Measures

Mathematical Literacy

A 46-item pre/post paper-and-pencil test was implemented before and at the end of the study. The test was based on the Israeli Ministry of Education's standardized test and PISA items. The pre-/posttest had different items but assessed the same skills. The test included 14 procedural multiple choice tasks demanding one-step calculations without justifications, 27 routine tasks demanding several manipulation steps and justifications of the solution focusing mainly on the intra-mathematically work, and 5 complex open tasks demanding higher-level modeling ability for validating mathematical results in context, using flexible strategies (i.e., different representations as tables/graphs or other visual forms) for the solution and justifications and conclusions. For each item, participants received a score of either 1 (correct answer) or 0 (incorrect answer), with the total score ranging from 0 to 46. We translated scores into percentages. Cronbach's alpha reliability coefficient was .80 for the pretest and .81 for the posttest. The following is an example of a complex task.

The Parking Lot Task

Shir and Shira need to park their cars in a public parking lot. There are two parking lots nearby. Read the signs at the entrance to the parking lots.

- Central Lot – every hour costs 6 shekels
- My Parking Lot – entrance costs 20 shekels + 2 shekels per hour

(a) Explain the factors that guide Shir and Shira in their choices; what is your choice?
(b) Suggest a mathematical model to support your answer. Explain in detail.

This is an open task. Students are asked to suggest a solution and to validate their conclusion. They may choose different models: algebraic expression, presenting data in a table, or drawing a graph.

Online Forum Discussion

Online discussion was assessed on the SRL process scheme index (Kramarski 2011) related to cognitive, metacognitive, motivational, and social categories by analyzing the peer feedback exchanges in the forum. Cognitive feedback refers to mathematical solution (i.e., accuracy), *strategies* (i.e., representations, principles), and *explanations* (i.e., reasons, examples, conclusions). Metacognitive feedback refers to *planning* (i.e., goals, prior knowledge activation), *monitoring* progress toward goals, debugging errors, *evaluating* the whole process, and providing suggestions for modifications. Motivational feedback refers to *effort*, *interest,* and *self-efficacy*, and social feedback refers to *interaction* style (i.e., asking for help, criticizing, appraising).

On each solving task forum, each student received a score of 1 (using the category once) to 3 (using the category three or more times, see some scoring examples in the Appendix). Furthermore, a mean score for each category was calculated for all the online discussions (8 tasks). Participants' responses were coded by two trained raters with expertise in mathematics and SRL categories. Inter-rater reliability, calculated with Cohen's kappa coded by both raters, yielded higher reliability coefficients for the feedback (cognitive, .93; metacognitive, .89; motivational and social, .92). Disagreements on coding of discourse feedback were resolved through discussion.

Results

Two-way MANOVA (Table 10.1) for the pretest mathematical literacy indicated no significant differences between the two groups and interaction of group and level of achievement, simultaneous for the three criteria F (3, 57) < 1, p > .05. A MANOVA test followed by univariate ANOVAs for the posttest indicated a significant difference

Table 10.1 Mathematical literacy means (M) and standard deviation (SD) for lower-/higher-achiever students by criteria of literacy, group, and time

Task/time		Non-SRL support (H_NS); $n=32$ Lower achievers	Higher achievers	SRL support (H_SRL); $n=32$ Lower achievers	Higher achievers
Procedural tasks					
Before	M	36.18	67.08	37.07	65.66
	SD	21.23	14.90	22.86	19.13
After	M	76.09	87.45	56.07	74.68
	SD	9.04	8.99	16.79	15.94
Routine tasks					
Before	M	40.35	65.76	38.96	64.07
	SD	18.93	10.77	23.75	9.54
After	M	70.43	80.67	56.30	72.50
	SD	18.61	15.42	18.92	17.05
Complex tasks					
Before	M	32.77	70.83	28.69	71.53
	SD	23.90	17.92	22.68	25.49
After	M	62.55	85.33	35.61	72.61
	SD	21.14	15.43	19.47	22.48

Note: Scores ranged from 0 to 100

between the groups [F (1, 61), $p<.001$] for procedural $F=16.34$, $\eta^2=0.18$; routine $F=7.76$, $\eta^2=0.12$; and complex $F=12.78$, $\eta^2=0.13$ tasks, and levels of achievement for procedural $F=8.56$, $\eta^2=0.09$; routine $F=19.26$, $\eta^2=0.21$; and complex $F=21.48$, $\eta^2=0.23$ tasks. Furthermore, a significant interaction between groups and levels of achievement was found on the procedural $F=14.23$, $\eta^2=0.19$; routine $F=17.11$, $\eta^2=0.16$; and complex $F=9.34$, $\eta^2=0.09$ tasks.

The effect sizes (Cohen's d was calculated in each kind of tasks as the ratio between the differences of the two groups and the standard deviation of the H_NS) indicated that the H_SRL students outperformed significantly the N_NS students on the three kinds of mathematical literacy tasks: procedural ($d=1.12$), routine ($d=0.62$), and complex ($d=0.95$). The interaction's effect sizes show that the H_SRL lower achievers outperformed significantly the lower achievers of the H_NS on mathematical literacy of the three kinds of tasks ($d=1.19$; 0.75; 1.38 for the procedural, routine, and complex tasks). These differences were larger than the differences between the higher achievers of the H_SRL and H_NS ($d=0.80$; 0.48; 0.56, respectively, for each kind of tasks).

A MANOVA test followed by univariate ANOVAs for online feedback discussion criteria (Table 10.2) indicated a significant difference between the groups along the four criteria [F (1,61), $p<.001$] for cognitive $F=21.32$, $\eta^2=0.18$; metacognitive $F=9.78$, $\eta^2=0.16$; motivation $F=17.08$, $\eta^2=0.08$; and social $F=25.78$, $\eta^2=0.19$ feedback, and levels of achievement for cognitive $F=9.36$, $\eta^2=0.07$; metacognitive $F=12.05$, $\eta^2=0.19$; motivation $F=14.03$, $\eta^2=0.12$; and social $F=6.7$, $\eta^2=0.04$ feedback. Furthermore, a significant interaction between groups and levels of achievement was found only on cognitive ($F=15.18$, $\eta^2=0.22$) and metacognitive feedback ($F=7.\ 18$, $\eta^2=0.12$).

Table 10.2 Online discussion means (M) and standard deviation (SD) for lower-/higher-achieving students by criteria of providing feedback and group

	SRL support (H_SRL); $n=32$		Non-SRL support (H_NS); $n=32$	
	Lower achievers	Higher achievers	Lower achievers	Higher achievers
Cognitive feedback				
M	2.45	2.50	2.10	2.35
SD	.47	.23	.35	.41
Metacognitive feedback				
M	2.14	2.54	1.89	2.23
SD	.42	.38	.28	.51
Motivational feedback				
M	2.72	2.70	1.62	1.70
SD	.29	.26	.53	.56
Social feedback				
M	2.46	2.70	1.47	1.86
SD	.60	.40	.50	.70

Note: Scores ranged from 1 to 3

Post-hoc analysis of Cohen's *d* effect sizes (calculated in each kind of feedback as the ratio between the differences of the two groups and the standard deviation of the H_NS) indicated that the H_SRL students outperformed significantly the H_NS students on the four criteria of online feedback: cognitive ($d=0.61$), metacognitive ($d=0.70$), motivation ($d=1.9$), and social ($d=0.67$). We found that the H_SRL lower achievers outperformed significantly the lower achievers of H_NS for the two criteria: cognitive feedback ($d=1.0$) and metacognitive feedback ($d=0.89$). Again, these differences were larger than the differences between the higher achievers of the H_SRL and H_NS ($d=0.37$; 0.61, respectively, for the cognitive and metacognitive feedback).

Discussion and Conclusions

The present study investigated the benefits of stimulating SRL using a hypermedia intervention (H_SRL) for fostering students' (lower and higher achievers) mathematical literacy (i.e., problem solving in a context). On the one hand, H_SRL does use self-directed instruction embedded in the hypermedia; however, it also emphasizes SRL processes that highlight the underlying structure of the problems as an aid to mathematical literacy. The present results indicated that the H_SRL intervention led to significant gains in mathematical literacy for students of varying ability levels (lower- and higher-achieving students) suggesting that it represents a promising approach to teaching mathematical literacy of basic, routine, and complex tasks. The use of IMPROVE self-directed questions advanced students beyond rote memorization of conventional problem-solving procedures to developing deep understanding of the mathematical problem structure (i.e., linguistic, mathematic, and strategic), fostering their reasoning and flexible solution strategies. In addition, our results indicate that the benefits of H_SRL persisted in online SRL feedback related to cognitive (i.e., mathematics references), metacognitive (i.e., planning, monitoring, and evaluation of solution approaches), motivation (i.e., encouragement), and social (i.e., communication) feedback.

Several possible reasons may explain the beneficial effect of IMPROVE support in mathematical literacy and SRL feedback. First, it seems that performing online problem solving, using IMPROVE tools, can help students think about the steps they need to take in their solution to the problem and can help them articulate their mathematical thoughts. This, in turn, helps them to provide a mathematical clear feedback. This conclusion is in line with Wenger's (1998) communities in practice in which students not only help each other activate relevant knowledge but also share and process the knowledge together.

How can it be explained that the IMPROVE support in hypermedia was particularly beneficial to the lower-achieving students? Our findings indicated that H_SRL students provided exploratory feedback; they pointed out the good and bad parts of the solution (cognitive feedback) and suggested alternatives and different perspectives to the solution under revised (metacognitive feedback). Research findings have shown that exploratory feedback is effective in reducing the cognitive load from the solution process (Moreno 2004), which is in particular important for the lower-achieving students (Kramarski et al. 2010).

Furthermore, research indicates that self-regulation and learning performance are related (Zimmerman 2000). Accordingly, average and above average students are presumably at a higher level of regulation and hence able to apply strategies and complete tasks by using their better developed mathematical literacy skills. As a result, they would benefit less from additional support of monitoring or metacognitive awareness, at least within the eight trials of the practice phase in our study. In contrast, we can assume that the lower-achieving students in the present study function at a lower level of regulation. These students may have significantly benefited from just a few trials of SRL feedback because it enhanced their awareness of the task requirements, increased the quality of their self-monitoring, and strengthened their motivation and confidence in social interactions, as was indicated from the online forum discussion findings.

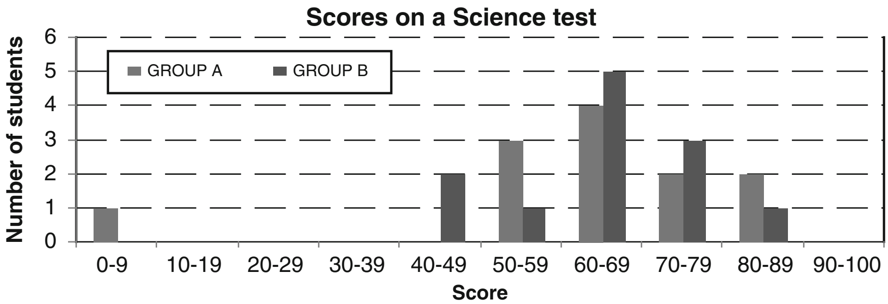
There are some reservations about the validity of our findings. There were a small number of participants in the lower-achieving and the higher-achieving groups. Furthermore, we did not examine skill transfer nor did we conduct a follow-up survey to observe long-term effects. We suggest that future studies examine lower- and higher-achieving students' performance in larger sample groups under different conditions, for example, online feedback vs. face-to-face discussion groups, and different types of SRL support. Another future possibility would be to check the log-files of lower-achieving students in order to examine how they used the hypermedia environment (e.g., links, help).

In conclusion, the present study calls for further scrutiny of how lower-achieving students' SRL in hypermedia emerges in the context of mathematical literacy. This call for research reflects the urgency of the new goals in reform standards. These goals suggest that student training should find ways to help lower-achieving students construct mathematical literacy through self-directed approaches in diverse technology environments (NCTM 2000; PISA 2003).

Appendix

(a) Example of an Online Mathematical Literacy Task (PISA 2009)

The diagram below shows the results on a Science test for two groups, labeled as group A and group B. The mean score for group A is 62.0 and the mean for group B is 64.5. Students pass this test when their score is 50 or above.



Looking at the diagram, the teacher claims that group B did better than group A in this test.

The students in group A do not agree with their teacher. They try to convince the teacher that group B may not necessarily have done better.

(a) Give one mathematical argument, using the graph, that the students in group A could use.
(b) Ask 3 questions in different levels of complexity that the answer could be found on the graph. Explain.

(b) Examples of Students' Online Feedback Exchanges and Its Feedback-Type Evaluation

Feedback	Examples	Feedback type
Cognitive feedback	S1: Look! More group A students than group B students scored 80 or over.	Strategy use, explanations
	S2: your explanation was clear	

(continued)

(continued)

Feedback	Examples	Feedback type
Metacognitive feedback	S3: "You wrote that group A students are normally better than group B students in science." You did not refer to the data on the graph.	Monitoring
	S4: I suggest to ignore the weakest group A student	Planning
	S2: You formulated three similar questions	Evaluation
Motivational feedback	S6: I just understand the graph	Self-efficacy
Social feedback	S8: I really like your interpretation of the graph	Appraising

Note: S1–S8 refer to different students.

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Part III
Special Educational Needs

Chapter 11
Promoting Emergent Literacy of Children at Risk for Learning Disabilities: Do E-Books Make a Difference?

Adina Shamir, Ofra Korat, and Renat Fellah

Joint adult-child reading (Bus et al. 1995) represents the traditional and classic method for introducing children to the world of literacy, both oral and written. However, as computers increasingly become part of everyday items in the home and the kindergarten, young children are increasingly exposed to an emerging reading medium, the electronic book ("e-books," "living book," or "CD-ROM storybook"). At first glance, e-books are little more than technically enhanced digital versions of children's books generally obtainable in print format. They are available in different languages and can be readily accessed through the Internet, a fact that has spurred their popularity. A second glance at the e-book soon reveals a deeper level, one that transforms this relatively new medium into a promising opportunity for the promotion of emergent literacy among young children, including those at risk for learning disabilities, before they have reached school age. Given the high expectations, the literature exploring the e-book's effectiveness for supporting children's language and literacy development (Chera and Wood 2003; de Jong and Bus 2003, 2004; Labbo and Kuhn 2000; Leferver-Davis and Pearman 2005; Wood 2005) is burgeoning. Yet, similar studies on its effectiveness for students at risk remain limited in number and scope (Zucker et al. 2009).

In the current chapter, we review two recent studies belonging to the second group of studies. The studies, conducted by the authors, were initiated to test the potential of Hebrew educational e-books for enhancing emergent literacy among preschool Israeli children at risk for learning disabilities (ALD). The first study compared the effect of activity with an educational e-book developed specifically for the study with the effect of an adult reading a printed version of the same book. The literacy dimensions compared were vocabulary, phonological awareness, and

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concepts about print (CAP). In the second study, we conducted a comparison of the same e-book's effect on emergent literacy among ALD children as opposed to typically developing children, using the same measures.

Promoting Emergent Literacy: Why E-Books?

The US National Joint Committee on Learning Disabilities (NJCLD 2006) applies the term *learning disabilities* when referring to a group of diverse disorders assumed to be neurological in origin and developmental in character. As a result of the neurological foundations of the observed developmental delays in perception and memory, these disorders interfere with basic cognitive functioning. The children affected therefore tend to exhibit low response rates; disrupted phonological awareness; poor short-term and working memory; delayed automatic processing; visual, auditory, and sensory perception problems; and poor self-regulation, in addition to spatial and temporal orientation issues (Breznitz 2008). Such manifestations impede the young child's acquisition of those basic reading and writing skills – for example, vocabulary acquisition, phonological awareness, and concepts about print – that underlie later successful learning in school (Aram and Levin 2001; Hutinger et al. 2005; NJCLD 2006; Sénéchal 2006). In light of the range of neurological symptoms, it has been suggested that teaching programs targeted at the children incorporate multisensory learning features that provide compensatory multisensory (visual, auditory, and sensory) events (Hezroni 2004; Lipka et al. 2006).

E-books, thanks to their technology, are capable of embedding amusing reading/listening events with multimedia features (e.g., animation, music, sound, illuminated text, and text narration). Underwood and Underwood (1998) have applied the term "edutainment" to this combination of playful activities and educational goals. E-books that belong to this category, if properly planned and programmed, may thus represent an effective tool for promoting the emergent literacy of ALD children.

In order to frame the research reported here, we turn to the literature for explanations of why computerized and multimedia learning environments promote literacy. Van Daal and Reitsma (2000) have attributed the positive learning impacts to the more structured nature of computer-based learning (when compared to regular classroom instruction). Mayer (2003) has proposed a theory of multimedia learning rooted in cognitive processes. He argues that multimedia platforms make several symbolic systems available simultaneously; this synchronization promotes cognition more effectively than does exposure to monomedia (exclusively visual) platforms. Neuman (2009) has turned to the synergetic effects of exposure to an array of coordinated media – computers, television, and radio in addition to printed materials – rather than a single medium. Eshet-Alkalai (2004) has sought a response to this issue in the multiple representations (text, voices, pictures, and animations) of related content made possible by multimedia platforms, whereas Moreno and Duran (2004) have cited the mutually referring sources of information made available by those same platforms. All these approaches reflect the technologically profuse and dynamic multisensory environment available to the contemporary child to some degree. We therefore feel confident in stating that printed books transmit a story's meanings through static visual media (e.g., printed text and fixed pictures), whereas e-books activate stories through dynamic (multimedia) elements: text and pictures linked with animated visuals and auditory elements (e.g., narration, background music and sounds, conversations between characters). The synergetic effect of this array (Neuman 2009) is reflected in the progress made by ALD children when using appropriate multimedia materials. Once presented with such an array, children at risk for reading disabilities tend to make greater strides in acquiring reading skills, sometimes more than typically developing children (NJCLD 2006).

We hypothesized that e-books, precisely because they are characterized by multiple representations of knowledge and amenable to programming representations to serve learning purposes, could serve as more effective support tools for the instruction of ALD students**.** In addition to the mutually referenced sources of information they can provide (Moreno and Duran 2004), e-books offer ALD students numerous opportunities to practice the selected skills in emotionally neutral environments (Shamir and Margalit 2011).

Once we accept the e-book's potential for supporting emergent literacy, the weight shifts to deciding exactly which skills are to be supported. Young typically developing children have been found to improve their verbal knowledge (Lewin 2000; Segers and Verhoeven 2002) and phonological awareness (Chera and Wood 2003; Wise et al. 1989) after e-book use. School beginners (Miller et al. 1994) and kindergarten children (de Jong and Bus 2002; Lewin 2000) also improved their word reading following such activities. Quality e-books also appear to have contributed to the relevant skills when they contained hotspots that were congruent with and integrated into the story's content. As a result of their work with these "considerate" e-books, children were found to exhibit better understanding of the story line (Labbo and Kuhn 2000) and story recall (Underwood and Underwood 1998).

Turning to children at risk, most studies of e-book effectiveness have focused on the e-book's contribution to advancing children lagging behind in language proficiency as a result of their immigrant or low SES status (Korat and Shamir 2007; Littleton et al. 2006; Shamir 2009; Shamir and Korat 2009; Shamir et al. 2008; Verhallen et al. 2006). Research on phonological awareness (Shamir 2009; Shamir and Korat 2007) and CAP (Shamir et al. 2008) has also been conducted among these same two populations. Other studies have focused on children with physical disabilities (Segers et al. 2006). When viewed in tandem, these results provide encouraging signs regarding our e-book's potential applicability to the needs of preschool children at risk for LD as they acquire emergent literacy.

Yuval Hamebulbal: An Educational E-Book

To ensure that our educational e-book would be appealing to the young children who would participate in our experiment, we chose to adapt an already popular children's printed book, the 15-page *Yuval Hamebulbal*" (*Confused Yuval*) by Miriam Roth (2000). The book's electronic features, designed to foster emergent literacy among young children having a range of academic needs, were based on the results reported in the literature on e-books (Chera and Wood 2003; Doty et al. 2001; Lewin 2000; Segers and Verhoeven 2002; Wood 2005). At the same time, we attempted to overcome the drawbacks reported typical of standard e-books (de Jong and Bus 2003; Korat and Shamir 2004; Shamir and Korat 2006). Our overall design thus adhered to the idea that e-books for young children should take advantage of interactivity's attractions while concomitantly supporting language development, story understanding, and exploration of the written text.

Our design was guided by the belief that children need direct support when acquiring literacy skills, and that this support should be embedded in a meaningful, motivating, and authentic context such as book reading (as compared to working on drills and skills; see Labbo and Reinking 1999). The chosen story's structure and simple narrative elements – characters, familiar setting, narrative trigger, problem, and solution/ending (Mandler and Johnson 1977) – made it amenable to our purposes: The narrative concerns a young boy named Yuval who receives a hat specially made for him by his grandmother to help him remember everyday behaviors and thus avoid the confusion he regularly faced. The 15-page e-book had large colored drawings on each page; a page's 3–5 sentences totaled not more than 40 words. Pointed fonts (*nekudot* in Hebrew, indicating vowels) were used for the benefit of beginning readers.

We also took into consideration the research literature indicating that e-book activation while reading/listening to a story can distract children from the story line. To compensate for this possibility, the e-book included three interactive modes of operation: (1) read story only, (2) read story with dictionary, and (3) read story and play (focusing on phonological awareness activations). Each mode included an audio recording of an adult, the narrator, reading the printed text. Dynamic automatic visuals dramatized story elements; extra music and film effects transformed the e-book into a living book. A limited number of hotspots were included per screen. These hotspots were programmed to act as sources of support for vocabulary, phonological awareness, and concepts about print, skills the research was designed to test (for more details on the e-book, see Segal-Droroi et al. 2010; Shamir 2009). The coordination of pedagogical goals with the necessity to keep the children involved qualified this e-book as an example of edutainment (Underwood and Underwood 1998).

The dictionary mode offered readings and explanations for 10 difficult words; these appeared automatically on the screen following the narration's completion (children could reactivate this mode at will). The narrator then clearly pronounced the word as supportive pictures were shown on the screen. The read story and play mode promoted phonological awareness. By clicking on hotspots, children activated the story. Activation initiated a discourse between characters and voice/sound effects and thus attracted attention to the word's syllables and subsyllables. For example, when the word the hero's name (Yuval) was shown, pressing on the hotspot revealed the word divided into its syllables and subsyllables, simultaneously read aloud by the narrator. All hotspots could be activated only after the page's text had been read.

In the current chapter, we present the results of two studies conducted to investigate the efficacy of our educational e-book among preschoolers at risk for LD. The emergent literacy skills targeted in the research were vocabulary, phonological awareness, and concepts about print (CAP). These skills were selected for two reasons. They are fundamental to literacy development as well as necessary for constructing the transition from listening to reading within the learning process. Based on previous studies with typically developing (TD) kindergarteners (for a study on low SES children aged 5–6, see Korat and Shamir 2008; Shamir 2009), we concluded that the emergence of these skills at a very young age, before children are formally taught to read and write, may reflect their evolving cognitive receptiveness to the logic of language and the relationship between spoken words and written text. Although the e-book was not specifically designed to encourage CAP, we hypothesized that visual similarities between the e-book and written books, such as page numbers and the right/left screen change buttons, could replicate children's experiences with printed books (see Clay 1989; Roskos et al. 2009; Whitehurst and Lonigan 2001). In addition, we hypothesized that self-activated hotspots, when programmed to enable exposure to vocabulary and phonemic segmentation, would be sufficiently authentic and enjoyable – and thus more motivating and effective – to function as learning tools.

The Studies

Study 1

In light of the importance of fostering literacy during a child's early years, especially among ALD children (NJCLD 2006), we considered it necessary to test our e-book's impact among ALD preschoolers shown to be lagging behind in the selected skills. The first study therefore compared the effects of exposure to the specially designed e-book with exposure to the same story in its printed version when read by an adult. This comparison was considered requisite due to the e-book's unique features (e.g., the ability to visually follow the highlighted text while it is being read, exposure to the dictionary, and phonological awareness aids) regarding our pedagogical goals. Hence, the study's objective was to identify the similarities and differences in emergent literacy acquisition that might appear following exposure to this type of software versus adult mediation, that is, of adults engaging in joint hardcover book reading with children.

Given our objective, we chose to focus on vocabulary, phonological awareness, and CAP due to their significance for emergent literacy. The main research questions addressed were the following: (1) How much does educational e-book activity foster improved emergent literacy (vocabulary, phonological awareness, CAP) among preschoolers at risk for LD? (2) Is there any variation in literacy improvement as a function of learning context (e-book activity vs. reading a printed book vs. no targeted reading activity)?

The research was conducted with the participation of 110 children aged 5–7; they had previously been identified as exhibiting the developmental delays placing them at risk for learning disabilities. Additional selection criteria applied were the following: (1) They did not evidence other potential causes of learning problems (e.g., low general intelligence (an IQ below 80), sensory or emotional impairment), a criterion required to eliminate causes other than the neurological basis of LD (NJCLD 2006); (2) they were Hebrew speakers; and (3) they exhibited lower verbal than nonverbal ability, typical of populations at risk for learning disabilities (NJCLD 2006).

The sample was randomly assigned to three groups: Children in the first group ($n=42$) activated the e-book; in the second group ($n=34$), they heard the same story read from a printed book by an adult, while in the third (the control) group ($n=34$), they participated in the regular kindergarten program. The e-book intervention was administered in six structured sessions, two per mode, with each session lasting 20–35 min. The experimenter read the printed version of the story to the children in the reading-as-usual format for the same number of sessions (two) as in the e-book intervention. Each of these sessions lasted about 20 min. Children in the control group did not experience any structured intervention although participation in games involving syllabic segmentation and rhyming, aimed at promoting phonemic awareness, does take place. All three groups were tested, pre and post, for the targeted emergent literacy skills (vocabulary, phonological awareness, and CAP). The Kaufman Assessment Battery for Children (KABC), constructed of a series of verbal and nonverbal subtests targeted at cognitive assessment (Kaufman and Kaufman 1983), was administered only before the intervention.

The vocabulary test employed 10 words, with the test format designed with our population in mind. We asked the children to point to the one out of a set of four pictures presented that best illustrated a word's meaning; these pictures, unlike the words themselves, differed from those found in the e-book's dictionary mode. A correct answer received 1 point (total score range: 0–10). This measure's reliability was $\alpha=.71$ because the words varied by difficulty level, from easy words like *meihal* (a big bottle) to very difficult words like *lirtom (*to harness).

Phonological awareness was measured using 12 new two-syllable words not found in the e-book. After each individual word's aural presentation, the children were asked to repeat them in a subsyllabic format (three-part segmentations, with the last part including a subsyllabic division, as in *Yu-va-l*, with the word's last phoneme, the "l," separated from the other subsyllables). The scores for each word in the subsyllabic subtest ranged from 0 to 5, depending on the accuracy of syllabication. All told, scores could range from 0 to 60. Inter-rater reliability of this part's scoring was first tested on a subsample of children ($n=10$), using two raters who rated each child using the described scoring method. Only after 90% agreement had been reached did one rater score the remaining participants' responses. The alpha score for this measure was .93.

To assess the children's CAP, we used a version of the CAP test specially adapted to the Hebrew language (Shatil 2001). This test asks children to answer 16 questions about print concepts such as page, line, writing, drawing, knowledge of book, and text handling, as well as reading direction (in Hebrew, reading proceeds from right to left). Each correct answer was given a score of 1, with incorrect answers scored 0 (total score range: 0–16). According to Shatil (2001), the Cronbach alpha reliability coefficient for this test is .81.

Analysis of the intervention's effect was conducted for each measure separately. A preliminary analysis of the children's pre-intervention emergent literacy scores, by measure, indicated no significant group differences (e-book activation/printed book/control) in vocabulary ($F(2, 107)=.93$, $p>.05$), phonological awareness ($F(4, 212)=.18$, $p>.05$), and CAP ($F(2,107)=0.69$, $p<.05$).

However, as anticipated, the pre- to post-intervention scores did differ by group. First, the vocabulary score of the e-book group ($F(1,41)=262.99$, $p<.001$, $\eta_p^2=.87$) was higher than that obtained by the printed book group ($F(1,33)=89.23$, $p<.001$, $\eta_p^2=.30$), with both higher than that obtained by the control group ($F(1,33)=15.35$, $p<.001$, $\eta_p^2=.32$). Second, only the e-book group showed significant improvement in phonological awareness (subsyllabic awareness) between the pre- and post-intervention phases ($F(1,41)=22.80$, $p<.001$, $\eta_p^2=.36$). Such an improvement was not indicated by either the printed book group ($F(1,32)=.1.02$, $p>.05$) or the control group ($F(1,33)=.75$, $p>.05$). Finally, significant differences between the e-book and the control group ($F(1,74)=10.79$, $p<.01$, $\eta_p^2=.93$) and between the printed book and the control group ($F(1,65)=5.94$, $p<.01$, $\eta_p^2=.08$) appeared with respect to CAP. Nonetheless, no significant differences were found between the e-book and the printed book group ($F(1,73)=0.70$, $p<.05$) on the CAP measure.

The findings thus indicated that the children exposed to the e-book displayed significantly greater improvement in vocabulary and phonological awareness when compared with the children in the other two groups (printed book and control) who had not been exposed to the e-book. The lack of any significant differences between the e-book and the printed book group with respect to CAP was an interesting and unexpected finding. We should note that the e-book was targeted at improving all three skills (vocabulary, phonological awareness, and CAP). It appears that improvement in vocabulary and phonological awareness occurred as a result of exposure to the text in addition to the possibility of activating hotspots targeted at these skills. The children's exposure to CAP ability, however, was limited to viewing the screens, which resembled a book's pages (e.g., text arrangement and page numbers). Hence, it is quite likely that hotspot activation (an action that can be frequently repeated) was more powerful in its effect than was indirect exposure to the print layout. In the wake of these findings, we continued our explorations in study 2, which was aimed at investigating whether ALD children can benefit from the use of our e-book to the same degree as TD children.

Study 2

Given the previous study's findings and the challenge of developing emergent literacy tools that can be applied as early as possible, we designed a study that we hoped would provide indications of whether ALD children could benefit from e-book use to the same degree as did typically developing children. In doing so, the identical educational e-book and the same measures of emergent literacy (vocabulary, phonological awareness, and CAP) were again used. Two research questions were consequently formulated: (1) Will exposure to the educational e-book improve both groups' vocabulary scores from the pre- to the post-intervention state? (2) Can any of the differences in the level of improvement in the three measures (vocabulary, phonological awareness, and CAP) be attributed to the influence of group type (ALD vs. TD)?

The study included 136 children aged 5–7 ($M=71.2$; SD=5.64, in months), 75 ALD and 60 TD children. The children in each group were randomly assigned to either the e-book intervention or the control group, which experienced the regular kindergarten program, a total of four groups. Children in each experimental group experienced 6 e-book sessions of 25 min each. The control groups experienced the regular class activity. No structured intervention was introduced in these sessions, but the children did participate in games involving syllabic segmentation and rhyming, aimed at promoting phonemic awareness. As expected, preliminary analyses of the participants' verbal and nonverbal ability KABC subtest results showed significant differences in verbal ability between the ALD and TD children ($F_{(1,132)}=29.19$, $p<.001$, $\eta_p^2=.12$). Verbal ability was tested with 18 common Hebrew words, with the children asked to provide the antonyms for each word mentioned. Also as expected, no differences were observed in nonverbal ability ($F_{(1,132)}=0.06$, $p>.05$), measured by means of a test that examines the child's ability to select the picture or form most appropriate for completing 2×2 visual parallels. All the measurement findings confirmed that all the participants in the ALD group did comply with the definition of populations at risk for learning disabilities (NJCLD 2006).

The children's vocabulary, phonological awareness, and CAP levels were tested before and after the e-book intervention activity with the same measures employed in the previous study. Verbal and nonverbal abilities, as previously mentioned, were tested only before the intervention. Vocabulary, phonological awareness, and CAP improvements were analyzed by comparing the pre- and posttest scores of the treatment groups (e-book/control) by type of children (ALD and TD).

Preliminary analyses of the pre-intervention differences in each of the emergent literacy measure scores revealed no significant differences in pre-intervention vocabulary ($F_{(1,132)}=2.41$, $p>.05$) or phonological awareness ($F_{(2,131)}=.84$, $p>.05$) among the ALD and TD children by treatment group (e-book vs. control). However, significant differences in CAP scores were observed between the treatment groups (e-book/control) ($F_{(1,132)}=4.12$, $p<.001$; $\eta_p^2=.12$).

As expected, significant group differences between the ALD and TD children were found with respect to pre-intervention vocabulary ($F_{(1,132)}=25.13$, $p<.001$; $\eta_p^2=.16$), phonological awareness ($F_{(2,131)}=9.13$, $p<.001$; $\eta_p^2=.12$), and CAP ($F_{(1,132)}=4.12$, $p<.001$; $\eta_p^2=.12$) scores. That is, the pre-intervention emergent literacy scores were higher among TD than among ALD children in all measures, as expected.

To determine the effect of the e-book intervention activity on the children's emergent literacy, we used an ANCOVA (2×2) treatment (experimental/control) by type of child (ALD/TD) for each measure separately (vocabulary, phonological awareness, and CAP). In each case, the dependent variable was the post-intervention emergent literacy score, with the pre-intervention test scores functioning as the covariant due to the significant differences in scores between the ALD and TD groups.

As to vocabulary improvement, significant differences ($F_{(1,131)}=239.49, p<001, \eta_p^2=.64$) were in fact found between the two treatment groups ($F_{(1,131)}=4.96, p<.05, \eta_p^2=.36$) . However, no interaction effect of treatment by type of child was obtained ($F_{(1,131)}=.284, p>.05$).

Each of the four groups likewise showed pretest to posttest improvement in vocabulary although the e-book groups showed greater improvement ($F_{(1,70)}=448.57, p<.001, \eta^2=.87$) than did the control groups ($F_{(1,64)}=24.10, p<.001, \eta^2=.27$), indicated by the groups' higher η^2. The ALD group also showed greater pre- to post-intervention improvement in vocabulary ($F_{(1,75)}=107.83, p<.001, \eta^2=.59$) than did the TD group ($F_{(1,59)}=60.40, p<.05; \eta_p^2=.50$), again indicated by the groups' higher η^2. The latter finding supports our hypothesis regarding the e-book's contribution to vocabulary acquisition.

With respect to the intervention's effect on the children's phonological awareness, all four groups showed pre- to post-intervention improvements. A review of the subsyllabic phonological awareness scores revealed significant differences ($F_{(2,129)}=8.75, p<.001; \eta_p^2=.12$) in improvement levels between the e-book and the control groups. Yet, no significant differences ($F_{(2, 129)}=.75, p>.005$) in subsyllabic improvement were found between the two types of children (i.e., ALD and TD). Nor were any interaction effects of treatment by type of child obtained ($F_{(2,129)} = 1.57, p>.05$). Based on these findings, we concluded that our hypothesis that activities with the educational e-book could conclude in higher gains in phonological awareness was confirmed.

The findings regarding CAP improvement again showed significant differences ($F_{(1,131)}=4.08, p<.05; \eta_p^2=.03$) between the e-book and the control groups; they also evidenced an interaction effect of treatment (e-book/control) by type of child (ALD/TD) ($F_{(1,131)}=5.66, p<.05, \eta_p^2=.04$). Further analysis indicated that among the four groups, the ALD experimental group showed the greatest improvement ($F_{(1,41)}=56.63, p<.001; \eta^2=.58$), with little improvement evidenced by the experimental ($F_{(1,28)}=15.91, p<.001, \eta^2=.36$) and the control ($F_{(1,30)}=12.63, p<.001, \eta^2=.30$) TD groups. The smallest improvement of all was evidenced by the ALD control group ($F_{(1,33)}=4.53, p<.05, \eta^2=.12$).

These findings support our hypothesis predicting that improvements in CAP scores would be obtained by children of both types (ALD and TD) subsequent to their exposure to the e-book intervention. However, they also indicated that the improvements in vocabulary and CAP achieved by ALD children were greater than those achieved by the TD children. These results require further explanation.

Educational E-Books Do Make a Difference

In this concluding section of this chapter, we explain and link the findings of the two described studies. What these studies show is that despite the initial disadvantages exhibited by ALD children in vocabulary, phonological awareness, and CAP (Swanson et al. 2003) when compared to TD children, they are clearly capable of making strides in the emergent literacy skills tested after exposure to an educational e-book of the type employed. Study 1 showed that when compared to an adult reading a printed book, reading/listening to an e-book programmed to promote emergent literacy can be a more fruitful learning context for ALD children – at least with respect to the measures tested. Study 2 demonstrated that ALD, like TD children, can benefit from educational e-book use. Both groups' vocabulary and phonological awareness improved in similar ways following a relatively short intervention (six e-book sessions). The findings regarding CAP were even more striking as they indicate the greater progress made by ALD preschoolers when compared to their TD peers. It therefore seems that overall exposure to a dictionary, phonological awareness activations, and written text accompanied by multimedia features provides an especially supportive learning context for ALD children. All of this depends, we should stress, on employment of an e-book designed to focus on educational goals while maintaining uniform and high educational quality (de Jong and Bus 2002; Korat and Shamir 2004).

Against the background of the current findings and the available literature, e-books designers should bear in mind the specific provided by the technologies they employ. Appropriate integration of multimedia effects apparently illustrate (or elaborate) the contributions of printed text to emergent literacy. Perhaps most important of all, we suggest, is the opportunity that an e-book provides to synchronize the highlighting of words with the narrator's reading of the respective text. Also crucial is the provision of optional hotspots that activate features supporting vocabulary acquisition and phonological awareness. These supplements appear to help children keep track of the written text, behavior that may promote understanding of the connection between print and reading among typically developing as well as several types of children at risk (see, e.g., Lewin 2000; Littleton et al. 2006; Segers et al. 2006; Shamir 2009; Shamir and Korat 2007; Shamir et al. 2008; Verhallen et al. 2006).

These findings are especially significant when taking the needs of our targeted population, ALD preschoolers, into consideration. Unlike other children at risk (e.g., low SES children), children at risk specifically for LD face neurological barriers to learning. To be overcome, such barriers required educational tools that help the children focus on compensatory multisensory events (visual, auditory, and sensory) at very early stages of their educational experience (Bulgren and Carta 1993; Hezroni 2004; Lipka et al. 2006; NJCLD 2006).

The findings of these studies thus show that well-designed e-books, if based on well-defined educational purposes, may serve as good supplemental sources for the enhancement of emergent literacy in the classroom. Educators should therefore use these results to guide them in their selection of the most appropriate e-books to meet their pedagogical goals (Shamir and Korat 2006).

In concluding this chapter, we urge program designers to remain alert to the educational potential implicit in multimedia technologies when planning e-books. Such awareness can direct them toward developing the best tools possible for promoting the emergent literacy of all children but especially for children at risk for learning disabilities.

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Chapter 12
Early Literacy Interventions Using ICT in Children with SLI

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Introduction

Children with a specific language impairment (SLI) are characterized by speech and language difficulties that cannot be accounted for by intelligence, environment, or physical handicaps (Bishop 1992). These children are at high risk of developing reading problems or dyslexia, and there is an urgent need for evidence-based interventions in preschool and kindergarten to kick-start their formal reading education. In predictors for success of learning to read in first grade, the most important variables are phonological awareness and letter knowledge (Hulme et al. 2005). In addition, for children with SLI, speech perception is a particularly strong predictor for phonological awareness (Rvachew and Grawburg 2006). In the present chapter, we will give an overview of ICT (information and communication technology) interventions, targeting phonological awareness and letter knowledge that have been conducted regarding this specific group and present an experiment we conducted to enhance grapheme knowledge in children with SLI (a grapheme corresponds to a phoneme and can thus consist of two letters; in Dutch, e.g. 'aa').

Children with SLI have been reported to have problems in phonological awareness and letter knowledge, important predictors of reading problems. Because of their weak linguistic representations (i.e. long-term language knowledge, Mainela-Arnold and Evans 2005), they could especially benefit from intensive training that uses different modalities in order to stimulate different paths in the brain (Mayer 2001). Children with SLI have also been reported to have speech perception problems, but discrimination abilities usually reach normal levels when the speech signal is manipulated (see Verhoeven and Segers 2004, for an overview).

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Because of their specific problems, ICT-based interventions could be particularly interesting for children with SLI, as the computer has many advantages: one can stimulate different modalities by accompanying written or spoken text with pictures (Mayer 2001); exercises can be rehearsed over and over again making a training intensive; speech can be manipulated (e.g. slowed down) (e.g. Segers and Verhoeven 2004); the computer always gives direct feedback; exercises can be adapted to the individual needs of the child; and the computer can be much more fun in presenting exercises in the form of games (cf. Segers and Verhoeven 2002).

However, it is surprising to see how little intervention research has been conducted regarding the stimulation of phonological awareness (either as an individual construct or via speech manipulation) in children with SLI and then especially on the use of ICT for this particular group. Law et al. (2004) conducted a meta-analysis including only eleven studies spanning 25 years. They found an overall effect size of .44 for interventions on expressive phonology, with an increase to .78 when interventions shorter than 8 weeks were removed. None of the interventions seem to have used ICT.

Cirrin and Gillam (2006) reported on five studies on language instruction between 1985 and 2005 that used ICT: Tallal et al. (1996), Merzenich et al. (1996), Gillam et al. (2001), Segers and Verhoeven (2004), and Cohen et al. (2005). The review by Al Otaiba et al. (2009) on 19 interventions regarding children with SLI between 1996 and 2006 only mentioned 2 ICT interventions: one by Segers and Verhoeven (2004) and one by Pokorni et al. (2004) which was not in the Cirrin and Gillam review.

Tallal et al. (1996) implemented an early version of the Fast ForWord (FFW) program, now available via Scientific Learning Company. In this intervention, eleven dyspraxic children received up to 100 h of training in a few weeks time. There were two experimental groups. The first experimental group received manipulated speech, in which the signal was slowed down by 200% and the fast formant transitions were enhanced by 20 dB. The manipulation slowly tapered off during the course of the intervention. The second experimental group received the same intervention but with normal speech. Especially the manipulated speech group showed remarkable training effects of up to 2 years. The other experimental group also showed large effects. One could argue that those 100 h of intervention are somewhat equal to what a child would receive in an average school on phonological awareness in 2 years time, or that the program trained to the test, but that does not account for the extra effect of speech manipulation. Not just the speech was manipulated in the program, the discrimination of non-speech sounds was also trained, which leads to uncertainty about the origin of the effects.

The exact added value of the speech manipulation of the FFW program was investigated by Segers and Verhoeven (2004), in studying the effects of a Dutch computer program for kindergartners. A 3.5-h intervention was set up. In one condition, the speech was manipulated as in the FFW program. This speech manipulation, however, seemed to have a negative effect on the learning results. The normal-speech intervention group showed significant improvement, and the results of this intervention remained significant at a retention measure 18 weeks later. Segers and Verhoeven concluded that speech manipulation may only be effective in basic computer-generated speech, and not in natural speech (see also Segers and Verhoeven 2005, for further evidence).

In a study by Pokorni et al. (2004), FFW was compared to yet another ICT intervention: Earobics. These two experimental groups were next compared to a non-ICT intervention: the Lindamood Phonemic Sequencing program (LiPS). The intervention was conducted during summer camp in which the two computer groups worked individually for 3 h per day during 20 days, and the LiPS group worked for the same amount in groups of 4 with a teacher. Children were 7.5–9 years old and diagnosed with SLI. The LiPS group outperformed the two ICT groups at posttest, and the Earobics group outperformed the FFW group. The difference between the ICT groups and the LiPS group, however, cannot completely be ascribed to differences in intervention. It seems a result of other factors such as motivation, self-regulated learning, etc., as the ICT groups had to work individually for a serious amount of time each day, whereas the LiPS group worked in groups of 4 under supervision of a teacher. The latter may well have been more motivating for the children.

Cohen et al. (2005) also compared a group of 6–10-year-old children with SLI using FFW to a group using other computer programs to promote language development and a control group who received the standard intervention (intensive specialist therapy and educational support). The children used FFW as prescribed by the Scientific Learning Company, but the authors could not find an additional effect of both computer groups over the control group; all three groups made equal progress over time. Similar conclusions were drawn by Gillam et al. (2001), who compared the FFW intervention in two children with SLI to an intervention with Laureate Learning software in two other children with FFW.

All SLI ICT intervention studies that have been done were inspired by the work of Tallal and colleagues and focused on the combination of phonological awareness and speech manipulation. It is unfortunate to find that no studies seem to have been conducted on the use of ICT for children with SLI that were not driven by the impact of FFW. To the best of our knowledge, with regard to the enhancement of grapheme knowledge, the second main predictor of success in learning to read, there seem no ICT intervention studies for children with SLI. In the present chapter, we will try to fill precisely this gap.

Experimental Study: The Use of Mnemonics in Learning Grapheme-Phoneme Connections in Children with SLI

Introduction

Ehri et al. (1984) studied the effect of a first-sound mnemonics training to teach children in regular education grapheme sounds. This procedure entails the presentation of a grapheme embedded in a drawing which displays a salient feature of which the name starts with the first sound of the embedded grapheme (e.g. the grapheme

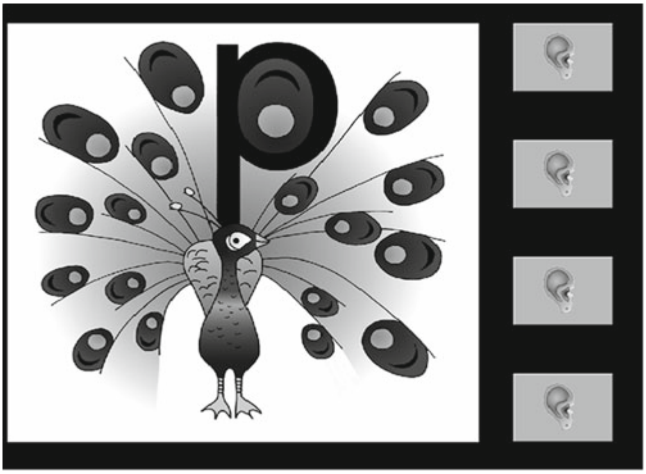

Fig. 12.1 Screen shot of the 'embedded' condition. The 'P' of peacock. Children had to pick the correct sound out of four ears on the *right* of the screen (Picture used with kind permission from Saskia de Graaff)

'L' is embedded in a drawing of a lamp). Pre-readers were able to learn the grapheme sounds more effectively than children who studied the grapheme sounds in a no-picture condition. Hoogeveen et al. (1989) used a similar technique with children with mild mental retardation, but added a fading procedure, that is, the picture slowly disappeared when the child responded correctly.

Recently, de Graaff et al. (2007) followed up on first-sound mnemonics as a means to teach grapheme sounds. They conducted a study on the enhancement of grapheme knowledge in normal language achieving (NLA) kindergartners by the use of ICT. In this computer intervention, children were trained in grapheme-phoneme correspondences in three blocks of 2 weeks with four graphemes per block. Each of these blocks represented a different condition: naked, fading, or embedded. In the 'naked' condition, children just learned the grapheme sound of the presented grapheme. In the 'fading' condition, the grapheme was depicted in a mnemonic picture, with the picture fading out in six consecutive steps. In the 'embedded' condition, the mnemonic picture remained (see Fig. 12.1).

The authors found positive effects of the intervention for active grapheme knowledge; the fading condition outperformed the embedded condition at both posttest and retention 4 weeks later. The fading condition also scored higher than the naked condition at retention, but not at posttest.

For children with SLI, learning the grapheme-phoneme connections is a challenge when they enter first grade. In the present study, we studied first graders, because, contrary to normal language achieving children, this group starts formal reading education with little or no grapheme-sound knowledge. We included both children with a normal non-verbal IQ and with a lower non-verbal IQ in our study and expected that the SLI group would benefit more from the conditions with pictures than the NLA group. We expected the lower-achieving children to benefit most from these conditions, because especially this group has problems with learning to respond to abstract stimuli (cf. Hoogeveen et al. 1989) and has lower working memory capacity (Schuchardt et al. 2010).

Methods

Participants

Participants were 10 children (7 boys, 3 girls) with SLI with a normal non-verbal IQ (SLI_N) and 10 children (5 boys, 5 girls) with SLI with a lower non-verbal IQ (SLI_L). The average age of the SLI_N group was 80.4 months (SD = 7.2) and of the SLI_L 86.2 (SD = 7.9). Difference in age between the two groups was not significant ($p = .1$). The Raven standard score of the SLI_N group was 4.53 (SD = 1.75) and of the SLI_L group 2.20 (SD = 1.85), a difference which was significant ($p = .01$).

The two groups of children went to two different locations of the same special school for children with speech and language problems in the southern part of the Netherlands. SLI had been diagnosed by an interdisciplinary team consisting of clinical linguists and school psychologists. In the Netherlands, the diagnosis of SLI is given when the child has severe problems in receptive or productive language domains (>1.5 SD on a minimum of two subtests out of a standardized series of tests). These problems should not be the direct result of intellectual, sensory, motor, or physical impairments. In the present study, children with hearing impairments (> 30 *dB*) were not included.

Materials and Procedure

All children received 3 weeks of computer training, with two sessions of maximum 15 min every week. All children learned graphemes in all three conditions, and all children learned the same 12 graphemes they all did not know at pretest (i.e. ‘o’, ‘ei’, ‘v’, ‘h’, ‘e’, ‘ui’, ‘w’, ‘l’, ‘a’, ‘au’, ‘z’, ‘b’). The four graphemes within each condition were randomized over the participants, and the order of the three conditions was also randomized. During the computer intervention, the children sat in a quiet room inside their school, together with the experimenter.

The computer program presented the child with a grapheme. The child then had to pick the right sound out of four different sounds (see Fig. 12.1). When a mistake was made, the program told the child that this was not the right answer and that the child should try again. When the second answer was also incorrect, the computer gave the right answer. After six consecutive times where the computer gave the answer, the grapheme was removed from the training session. In the fading condition, the grapheme moved to a next phase when there was a correct answer. After six phases, the child was done with that grapheme in that training session. The same procedure was used in the 'naked' and 'embedded' conditions, but there were no differences between the six phases.

Active grapheme knowledge was measured by presenting the child with a card with most Dutch graphemes: all 12 Dutch bigraphs (i.e. aa, ee, oo, uu, ie, ei, ij, ou, au, oe, eu, ui) and 22 single-letter graphemes; the remaining letters c, q, and y were not included. The child had to name each grapheme.

Results

Effect of the Intervention for Children with SLI

At pretest, all children scored 0 at the active grapheme knowledge test; they did not know any of the 12 graphemes that were taught in the intervention. A GLM repeated measures analysis taking the multivariate approach was conducted with time (posttest, retention) and condition (naked, fading, embedded) as within-subjects factors and non-verbal intelligence (average, low) as between-subjects variable. Descriptive statistics can be found in Table 12.1. We found a significant main effect of time, $F(1, 18)=63.93$, $p<.001$, $\eta^2_p=.78$; a trend for the main effect of condition, $F(2, 17)=2.81$, $p=.09$, $\eta^2_p=.25$; an interaction between time and condition, $F(2, 17)=6.01$, $p=.01$, $\eta^2_p=.41$; and a main effect of non-verbal IQ, $F(1, 18)=10.14$, $p=.005$, $\eta^2_p=.36$. In general, children with a normal non-verbal IQ had higher training effects than children with a low non-verbal IQ. The time × condition interaction can be explained by the fact that whereas at posttest the two picture conditions (fading, embedded) outperformed the naked condition ($p=.002$ and .001, respectively), this effect was gone at retention 2 weeks later ($p>.60$). The effect is depicted in Fig. 12.2.

Comparison of Children with SLI Versus Normal Language Achieving Children

For children with SLI, there was a main effect of time from posttest to retention. The SLI children in general scored lower at retention 2 weeks later. In the de Graaff et al. (2007) study, with 39 kindergartners (average age 72 months), there was no such effect of time; their grapheme knowledge did not decline. Even though the two SLI groups did not show a differential effect in forgetting, it is interesting to compare the three groups (see Table 12.1). The SLI_L group ends up with a below .5 grapheme knowledge in each condition, with effect sizes of decline of 1.14, 2.44, and 1.84 for the naked, fading, and embedded conditions from posttest to retention. The SLI_N group also has high effect sizes in decline, especially in the two picture conditions (.4, 3.42, and 1.44, respectively). The effect sizes in decline for the NLA group all remain below .1.

Table 12.1 Descriptive statistics (means and standard deviations) of the two groups of children with SLI ($n=20$) for the three conditions at posttest and retention, as well as of normal language achieving (NLA) children

	Naked		Fading		Embedded	
	Posttest	Retention	Posttest	Retention	Posttest	Retention
SLI_L	1.40 (1.26)	.30 (.67)	2.20 (1.22)	.20 (.42)	2.20 (1.40)	.30 (.67)
SLI_N	1.90 (.99)	1.40 (1.50)	3.50 (.53)	1.30 (1.34)	2.70 (.95)	1.00 (1.41)
NLA	1.95 (1.03)	1.85 (1.09)	2.38 (1.02)	2.31 (1.13)	1.36 (1.16)	1.36 (1.22)

Taken from de Graaff et al. (2007)

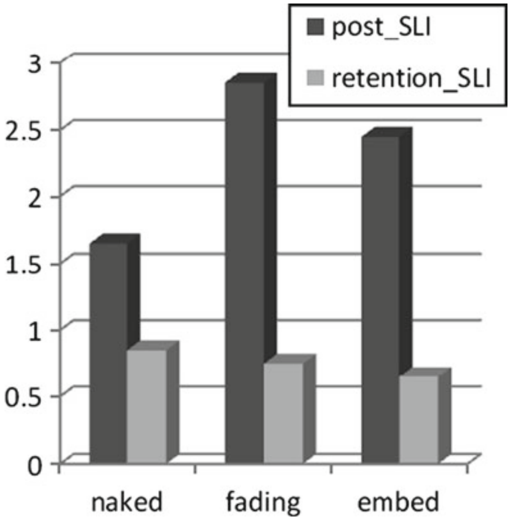

Fig. 12.2 Scores at active grapheme knowledge in naked, fading, or embedded condition, for all 20 children with SLI. Maximum score for each condition is 4

Discussion

The intervention for first grade children with SLI turned out to be successful and comparable to a group of normal language achieving kindergartners directly after training at posttest. Significant retention effects were still found 2 weeks later, but there was a large significant decrease in grapheme knowledge from posttest to retention. As expected, the two conditions that included pictures (fading, embedded) turned out to be most effective for this special group of children, but these were also the conditions that showed most decline, and differences between the three conditions were not significant anymore at retention. Children with SLI showed a decrease in grapheme knowledge over time, whereas NLA kindergartners did not.

There are three issues that need to be discussed. First, why did both picture conditions have a positive effect for the SLI group, whereas only the fading condition was most positive for the NLA group? Children in the SLI group might rely more on the picture to remember the grapheme sound and not on the grapheme itself. So in the test, they would take the route via the picture (see the p, remember the peacock, then deduce the first sound, and then say 'P'). This route would not differ between fading or embedded. The question then is, however, why was the fading condition slightly more positive than the embedded one for NLA children? The reason might be that memory skills of normal-achieving children is better than of children with SLI (Pickering and Gathercole 2004; Mainela-Arnold and Evans 2005). The assumption that the SLI children still relied on the picture as a means to remember the abstract letter sound is in accordance with that. Normal-achieving children's memory, on the other hand, is adequate and profits from the fading procedure, because they are able to learn the letter name in 4–6 presentations, whereas the embedded condition may prevent the emergence of clear letter-sound relationships. After all, there is no need to automatize, because the picture always presents the letter sound; it could cause a lazy learner.

The second issue that remains is why there was a significant drop in knowledge for the SLI group and not for the NLA group. This is an effect that is often noticed in children with learning problems and can be ascribed to their general problems in retaining information, which are again closely related to their storage problems (cf. Pickering and Gathercole 2004). Intensive interventions are therefore a necessity, as Law et al. (2004) already indicated.

The third issue is why the three conditions did not differ anymore at retention, whereas there was a difference at posttest. This could be due to floor effects, as can be seen in Table 12.1; standard deviations are quite high, whereas the mean scores are low. Because of the small group sizes and the few graphemes that were trained, these results need to be interpreted with caution.

Although positive effects were found, there are limitations to this study that should be kept in mind. First, the groups were small, and results may not be generalized to the larger population. Second, unlike de Graaff et al. (2007), we did not register the process of gaining grapheme knowledge during the intervention and so are unable to compare the trajectories of the different groups of children. Third, the comparison of SLI and NLA children should be interpreted with caution, as the groups differ in age (with the SLI group being 8 months older), and we did not, for example, take measures of working memory. Finally, one could argue that the pictures we used were not optimal mnemonics, and that the effects would have been just the same when the grapheme had been presented next to the picture.

Future research should take these limitations into consideration. Furthermore, enhancement of grapheme knowledge for this specific group may not optimally benefit from an extra visual path since retrieval problems remain. Perhaps using gestures in a more embodied approach is more beneficial. Sound gestures that mimic the shape of a grapheme have been shown to enhance grapheme learning. For example, when children use their thumb and index finger to form the sound of the grapheme O when they pronounce the grapheme sound, it appears to aid the memory of the grapheme not only in children with normal IQs (Bosman 2007) but also in children with mild mental retardation (Lankhorst et al. 2008). Finally, it would be interesting to find out how letter learning and learning to read simple words could reinforce each other, in line with Share's (1995) self-teaching hypothesis.

General Conclusion

The aim of the present chapter was to give an overview of ICT interventions that have been conducted regarding children with SLI and present an experiment on enhancing grapheme knowledge in children with SLI. We found few interventions studies that used ICT, whereas the added value of ICT could be large, particularly for this population. The studies that have been conducted concerned computer programs that were not tailor-made for this target group. Perhaps children with SLI do not need tailor-made interventions and just need more time and longer interventions. That would be in line with conclusions from Law et al. (2004), who found that especially the longer interventions were more effective. On the other hand, as we suggested in the discussion of the experimental study in this chapter, it may well be that children who have problems in remembering grapheme-phoneme connections may benefit from extra modalities. The pictures we used in our study did not 'do the trick', but perhaps using gestures can have an added value. Again, the computer could be useful in such an intervention, as movie clips from each gesture can be placed next to each grapheme and can be repeated over and over again.

As a suggestion for future research, more attention should be paid to using the specific added value and possibilities of the computer and to keep searching and evaluating interventions that are powerful enough to help children with SLI to reach normal reading levels.

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Chapter 13
Making a Difference: Using Laptops as a Support for Spelling Improvement Among Students with Learning Disability

Sigal Eden, Adina Shamir, and Maayan Fershtman

Introduction

In recent years, access to computers in schools has increased significantly (Hohlfeld et al. 2008; Spektor-Levy et al. 2010). However, teachers and students still report using computers in school only a small amount of time each day (Bebell and Kay 2009; Bebell et al. 2004). In Israel, only one third of the schools have reached the ratio of one desktop computer per ten students: the objective set by the Ministry of Education. In some of the schools, the ratio stands at one desktop computer per 20 students (Mioduser and Nachmias 2008).

Integrating laptops into the classroom teaching process can change this ratio significantly (Livingston 2007). The trend of integrating laptop computers into classrooms in Israel is on the increase, and it enables meeting the desired student/laptop computer ratio of one-to-one in schools. The first one-to-one laptop computer program to be reported took place at Australia in 1989. From the mid-1990s, schools in the United States incorporated programs that integrated mobile technology into their classrooms, mainly using laptop computers. As time passes, more and more one-to-one laptop computer programs are underway, and the trend seems to be gaining momentum (Donovan et al. 2007; Lei et al. 2008; Livingston 2007) these laptop computer programs exist in countries, such as France, Spain, Northern Ireland, Germany, and Israel (Livingston 2007). Since 2004, the "KATOM" program (computer for every class, student, and teacher) has been implemented in Israel, in which laptop computers are integrated into the classroom. This program is managed by the Davidson Institute of Science Education of the Weizmann Institute of Science, with the cooperation of the Ministry of Education and the local authorities.

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Early research suggests several positive outcomes from one-to-one laptop initiatives including increased student engagement (Cromwell 1999; MEPRI 2003), decreased disciplinary problems (Baldwin 1999; MEPRI 2003), enhanced student motivation (Bebell and Kay 2010), enabling a broader curriculum, promoting higher order cognitive skills such as make meaning by interpreting information or forming and applying concepts, changing teaching methods, self-regulated learning on the part of the learner (Dunleavy et al. 2007; Fairman 2004; Zucker and McGee 2005), and increased use of computers for writing, analysis, and research (Baldwin 1999; Cromwell 1999; Russell et al. 2004). Regarding academic skills, Gulek and Demirtas (2005) found all students' academic area achievement increased by laptop program participation. On the contrary, Bebell and Kay (2010) found that laptops helped students achieve higher marks in the language arts, but not in math or science. Dunleavy and Heinecke (2008) found that laptops helped increase students achievement in science, but not math.

Despite the growing interest in one-to-one laptop computing, there is a lack of evidence that connects use of technology in these settings with measures of student achievement. This is a particularly salient issue in light of the high cost of implementing and maintaining one-to-one laptop initiatives (Bebell and Kay 2009). Gulek and Demirtas (2005) examined the influence of a voluntary one-to-one laptop program on middle-school student achievement, specifically for grade point averages, end-of-year grades, essay writing skills, and standardized test scores. A significant difference in test scores was found in favor of students participating in the laptop program. They concluded that students who participated in the laptop program obtained significantly higher achievement values for writing, language, mathematics, and GPA.

This current study focuses on a specific population: children with learning disabilities (LD) placed in special education classes, 7th–9th grades in Israel.

Children with Learning Disabilities: Can Computers Help?

Computer use has made a particularly important contribution to children with special needs. It is part of the assistive technologies defined as tools, products, or objects that improve, increase, and maintain the functional abilities of people with difficulties, disabilities, limitations, or disorders (Lewis 1998). Lewis (ibid.) concludes that while not systematic, there is research support for the benefits of technologies such as word processing, videodisc-based anchored instruction, hypermedia-supported text, and text to speech for students with learning disabilities. Roblyer (2003) defines assistive technology as a combination of the processes and tools involved in addressing educational needs and problems of students with disabilities with an emphasis on applying the most current tools: computers and their related technologies. Dell et al. (2008) state that the use of assistive technology refers primarily to technology that meets the learning and communication needs of students with disabilities.

Laptops are part of the complex assistive technologies, and it is important to adapt them to the purpose and the accessibility needed for each user (Bryant and Bryant 1998). The laptop, as differentiated from the desktop computer in schools, belongs to a specific individual, and its content and interface functions can be adjusted for specific student needs. Moreover, the laptop is available to the student who can use it at any time, enabling plenty of practice, while the continuous use of a desktop computer in the school depends on external factors, such as the school timetable.

In special education, it seems that the use of laptops among students with special needs is an effective learning tool that offers the kind of success that might not otherwise be available. The digital media makes it possible to adapt the learning experience to the student, taking into consideration individual factors (Mioduser et al. 2004). Students with dyslexia, for example, can be helped by word processing, such as spellers and word finders (Bryant and Bryant 1998). Word processors contain many functions – that of an electronic dictionary, possibilities of translation, and a corrector of spelling and syntax errors – and is particularly effective for students who have difficulty writing by hand. Hezroni and Shrieber (2004) examined the effect of the word processor on the reading and writing abilities of students with motor dysgraphia and on the number of errors they made. They found that students made fewer errors when reading aloud the material they had written with the word processor and their reading was more fluent. The printed outcomes were neater on the page, and they could find their way around the text more easily. Following this line of findings, computer software can meaningfully contribute to the acquisition of basic literacy skills by students with LD. We therefore assumed that working with laptop can provide exposure to the written text through various learning events focusing on the compensatory multisensory activities needed by students with LD (Adams and Gathercole 2000; Bulgren and Carta 1993; Lipka et al. 2006).

Based on these studies, in the current study, we focused on the effect of the use of laptop computers on the Hebrew spelling of students with LD studying in special education classes.

Are You a Poor Speller?

Spelling is a set of written symbols that represent the speech sounds of a language. The spelling system, just as any other linguistic system, is arbitrary on the one hand and based on regularity on the other (Levin and Ravid 2001). Hebrew spelling without vowel signs does not fully present all the phonological information provided in the spoken language. In addition, there is potential for spelling mistakes among inexperienced writers since there are homophonous letters (about a third of Hebrew letters are homophonic; e.g., the letters *TAF* and *TET* both mark the phoneme /t/). Hebrew's synthetic morphological structure helps resolve this spelling ambiguity because affixed letters representing function words such as *to, from, as,* and *in* are always spelled consistently (Ravid 2001). A skilled writer will choose the correct homophonous letter even though there is no difference in pronunciation, but the homophonous letters cause spelling errors among unskilled writers such as students with LD (Levin and Ravid 2001).

While most children with LD have significant deficits in reading, many have significant academic skill deficits in other areas, including writing and spelling, despite adequate intelligence and an average amount of instruction. Contrary to the common belief that spelling is a simple and basic academic ability, learning to spell depends on the integrity of multiple underlying skills (Moats 2009; Treiman and Bourassa 2000). The reasons for poor spelling range from difficulties with executing and regulating the processes, deficiency in phonological processing, slow learning pace, attention deficits, general motor coordination deficiencies and intersensory integration disorders, reading and writing difficulties, and motivational factors (Ramus 2001; Schumaker and Deshler 2009; Siegel 1998).

Computers have created a revolution that affects writing, a contribution that lies in the availability and accessibility for everyone to produce and distribute written material. One of the meaningful functions that the computer revolution generated lies in turning the written text into something that can be manipulated (Goldberg et al. 2003). People who write with spelling errors might improve their spelling if they type into a computer, which would oblige them to pay more attention to the words. They can check for errors and get corrective feedback such as list of possible words (Seok et al. 2010). The spell checkers present a list of correct spellings from which to choose, so that students do not have to try to generate the correct spelling themselves. Choosing the correct spelling of a homophone is a particularly difficult task for those with reading difficulties because the decision cannot be made based on the sound of the word alone (MacArthur et al. 1996). The correct use of homophones requires a link between the printed word as a whole and its meaning, not just between the sounds and the letters. Therefore, being skillful in the correct usage of homophones is related to orthographic knowledge, which accounts for unique variance in word recognition (Cunningham et al. 2002). In addition, spell checkers do not generally identify homophone errors, because they are not spelling mistakes but rather errors of use.

In the current study, we examined whether there would be a change in the LD students' spelling in a special education class after a period during which they used laptop computers as opposed to students with LD who did not use laptops.

The Study

One hundred and four children participated in the study, aged 13–16 ($M = 14$, $SD = 1$), studying in 10 special education classes in 5 regular middle schools in Israel. All were Hebrew as first language speakers. All students had been independently identified by the Israeli Ministry of Education's Educational Psychological Services as having learning disabilities, based on their evaluation with a comprehensive psycho-educational assessment tests. In these special education classes of between 10 and 13 students, there is a special education teacher and an aide. In the sports and art lessons, social school activities, and others, the students with LD are integrated into the regular classes in the school, while the academic lessons are conducted separately. The students with LD are integrated into the regular classes as well in some academic lessons, according to their needs and abilities.

Seventy-four (71.1%) boys and 30 (28.9%) girls participated in the research, studding in 3 grades: 34 (32.7%) at the 7th, 41 (39.4%) at the 8th, and 29 (27.9%) at the 9th. Eleven (10.6%) students were identified as dyslexic, 22 (21.1%) identified as ADD or ADHD, and 71 (68.3%) as multiple problems such as dyslexic and ADHD.

The students were divided into two groups: (1) experimental group: 56 students with LD in special education classes using laptops and (2) control group: 48 students with LD in special education classes not using laptops.

In order to examine the students' spelling performance, we used a dictation. Each class was given a dictation of 10 words taken from their studies that had possibilities for various kinds of spelling errors common among unskilled writers of Hebrew. The students were asked to write the words by *hand* and not by computer. The dictation contained the same words in both examinations, before and after the intervention. The spelling errors were calculated quantitatively, and the score range was 0–10.

The teachers completed a demographic questionnaire about each student with twenty questions regarding age, gender, type of diagnoses disability, etc. Also, in order to make sure that there were no significant gaps in computer literacy among the students, they completed at the start of the study a usability questionnaire which included questions such as: "How many hours you use the computer every day?" "How is your proficiency in using Word/PowerPoint/Excel…?"

In the KATOM program, all students and teachers in these classes were equipped with a laptop for their own use both at school and at home throughout the day. All the students with LD using laptops in special education classes during the 2009 school year took part in the study. The use of laptops in the special education classes in this study follows the guidelines of the program. All the computers have wireless internet connection. The students work with the laptop throughout the day, and they complete assignments either on the server or on the school website and send them to the teacher and to their peers for feedback. Homework is also done on the laptop and then transferred to the class portfolio on the server. At the same time, the teachers integrate online materials into their teaching as they see fit, depending on the study material and the needs of the students.

All students in the experimental group as well as in the control group learned the same curriculum, while in the experimental group the students used laptops according to the project. As part of the research, the demographic and usability questionnaires were completed at the beginning of the research, and the dictations were given at the beginning of the research and at the end, four months later.

Findings

The findings of the usability questionnaire that the students in the experimental group completed revealed relative uniformity among the students. In light of these findings, none of the students in the experimental group was taken out of the research.

In order to examine before and after the study whether there were differences in the number of spelling errors made by students with LD, both in the experimental group and the control group, a differential analysis of repeated two-way measurements was conducted on each group separately. A significant difference was found in the experimental group on the number of errors before and after the intervention ($F(1,53)=7.01$, $p<.05$, $\eta^2=.11$). In further Bonferroni analyses, the average number of spelling errors before the intervention ($M=4.24$; SD=3.97) was found to be significantly *higher* than after the intervention ($M=3.24$; SD=2.88). In the control group, no significant difference was found between the number of errors before the intervention ($M=4.31$; SD=4.16) and after ($M=4.69$; SD=4.68), ($F(1,38)=2.04$, $p>.05$, $\eta^2=.05$) (Fig. 13.1).

In order to examine the effect of age as an intervening variable, repeated differential two-way analyses were performed. No significant difference was found between the age groups with regard to the number of errors ($F(1,90)=.80$, $p>.05$, $\eta^2=.00$). Significant interaction was found between time (before/after the intervention) and the experimental/control group and the number of spelling errors ($F(1,90)=5.36$, $p<.05$, $\eta^2=.05$). There was no interaction between the different age groups and the measurement time for the number of spelling errors ($F(1,90)=1.57$, $p>.01$, $\eta^2=.05$). In order to examine the source of the interaction, a repeated differential one-way analysis of the measurements was performed for each group separately to examine the differences between the numbers of errors at the different times paying attention to age. No significant difference was found in the experimental group in the number of spelling errors before and after the intervention ($F(1,52)=3.17$, $p>.05$, $\eta^2=.05$) or in the control group ($F(1,37)=.72$, $p>.01$, $\eta^2=.05$). A significant interaction was found in the experimental group between times and age in the number of spelling errors ($F(1,52)=5.08$, $p<.02$, $\eta^2=.05$), but there was no similar significant interaction for the control group ($F(1,37)=1.08$, $p>.02$, $\eta^2=.05$). In order to examine the source of the interaction in the experimental group, a repeated differential one-way analysis of the measurements was performed for each group separately to examine the differences between the numbers of errors at the different times. A significant difference was found in the number of spelling errors among 13-year-olds: before the intervention, the spelling errors were higher ($M=7.38$, SD=4.81) than after the intervention ($M=4.94$, SD=3.33) ($F(1,15)=6.36$, $p>.29$, $\eta^2=.05$). There were no significant differences between the number of spelling errors before and after the intervention for the other ages in the experimental group. For 14-year-olds, ($F(1,21)=0.19$, $p>.00$, $\eta^2=.05$), for 15-year-olds ($F(1,10)=3.75$, $p<.27$, $\eta^2=.05$), and for 16-year-olds ($F(1,4)=4.57$, $p<.53$, $\eta^2=.05$).

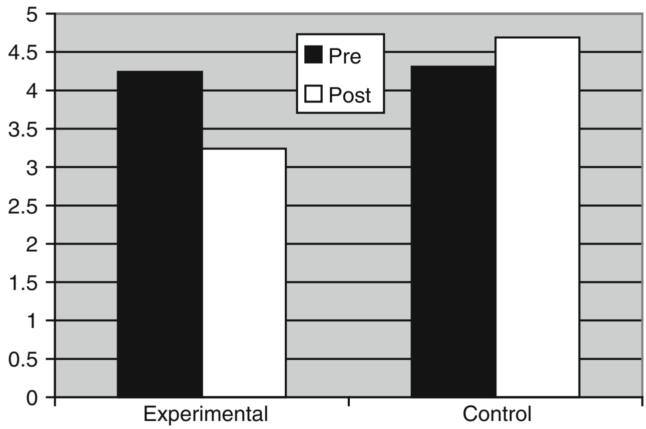

Fig. 13.1 Average number of spelling errors according to group and time

The influence of the average time use of the computer as an intervening variable, which was taken from the usability questionnaire, on spelling errors was examined with a repeated differential two-way analysis of the measurements. No significant difference was found in the numbers of spelling errors between students with different average time uses ($F(1,49)=0.20$, $p>0.05$, $\eta^2=0.00$). No significant interaction was found between the average use of the computer and time ($F(1,49)=.26$, $p>.05$, $\eta^2=.00$).

Laptop for Improving Spelling: What Can We Learn?

Using a computer might be an effective way to learn how to spell correctly (Vedora and Stromer 2007). In the current study, our findings show a similar effect on students with LD. We found that the average number of spelling errors among students with LD who used laptops decreased significantly after the intervention. Usually, students with LD tend to have significant difficulties in spelling, despite adequate intelligence and an average amount of instruction (Ramus 2001; Schumaker and Deshler 2009; Siegel 1998). It seems that using a laptop in school studies and beyond causes greater exposure to reading and writing, which leads to better spelling. Our findings reinforce the claim made by Seok et al. (2010) that people who write with spelling errors might improve their writing if they type into a computer, which would oblige them to pay more attention to the words. They can check for errors and get corrective feedback. Also, a computer may also require less attention and perhaps less processing from the student than remedial use (Lange et al. 2009).

Contrary to that, we need to refer to one of computer's disadvantages for the student with LD: spell checkers do not generally identify homophone errors, because they are not spelling mistakes but rather errors of use. Correct use of homophones requires links between the printed words as wholes and their meanings, not just between the sounds and the letters (Cunningham et al. 2002). Therefore, apparently, the intensive exposure to reading and writing was very meaningful. This explanation is also reinforced by Lange et al. (2009), who claimed that by using an assistive software tool that involves extensive exposure to text, aspects of literacy, such as spelling, may also improve.

An additional explanation to our findings refers to the physical aspect of writing. The use of a keyboard might be less burdensome than writing by hand for students with LD. With a computer, they can turn their efforts to spelling rather than the physical task of writing. Outhred's (1989) findings may support this claim. He found a noticeable decline in the percentage of students' spelling errors in essays typed on a word processor rather than written by hand.

Another interesting finding was the age variable. The number of spelling errors among 13-year-old students with LD working with the laptops significantly declined between the start and end of the intervention. In contrast, among the students who did not work with the laptops, there was no significant change. One may assume that the change occurred among the 13-year-old students because this was their first year in the project. Perhaps they were more enthusiastic to learn with the laptops than the older students, even though all classes were equally exposed to the laptops. Perhaps the enthusiastic was the partial cause for the decrease in the spelling errors.

Another explanation for the finding could be the motivation aspect – it is possible that the younger children were more motivated than the older children. Previous research found an increase in motivation to academic purposes with a computer (Beck 2004). Other findings showed an increase in motivation to write among students who use computers (Goldberg et al. 2003; Gulek and Demirtas 2005; Trimmel and Bachmann 2004).

The additional contribution of this research to the existing body of knowledge is the experience of working with laptops rather than desktop computers. The laptops were available to the students at all times and enabled repetitions that accelerated the expected changes after a short time. There is evidence that one-to-one laptop activities can increase engagement, active learning, and meaningful interaction among typically developing students and between them and the instructor (e.g., Barak et al. 2006; Demb et al. 2004; Driver 2002; Gay et al. 2001). Likewise, the dictation was carried out in handwriting and not on the computer. Thus, there was transfer of the spelling skill acquired through the use of the computer back to writing with pen and paper. This interesting finding will need further future studies in order to validate it.

It is important to note that the research lasted for only 4 months at the end of the school year, a very short time for examining a meaningful change in spelling errors. However, it appears that the rising trend of using laptops in the classrooms might have been even more meaningful if the research had continued for a longer period of time.

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Chapter 14
Nonliteral Comprehension Deficits in Children with Learning Disabilities: Implication of Brain Imaging Technology

Nira Mashal

Nonliteral Language in Typically Developed Children

Nonliteral language (often called "figurative" language) is a linguistic entity of speech forms that go beyond the literal meaning of the words and require the ability to process more than the literal meaning in order to grasp the speaker's intention in a given context (Giora 1997). Understanding figurative language thus requires the ability to distinguish between "what is said and what is meant" (Levorato and Cacciari 2002). Nonliteral language is composed of different types of linguistic constructions: metaphors, idioms, proverbs, irony, indirect requests, sarcasm, etc. Metaphors and idioms are prototypical forms of nonliteral language and are remarkably frequent in everyday discourse (Gibbs 1994). More specifically, a metaphor is a figure of speech that forms linkages between two seemingly unrelated domains. Idioms are defined as a composition of units whose global meaning cannot be reduced simply to the meanings of its individual units. The interpretation of most idioms seems to be conventional and fixed across everyday use. Cognitive psychology literature views figurative language as a powerful communicative and conceptual tool. Metaphors are, thus, useful in the context of teaching and learning academic skills, i.e., the skills required to study and write effectively in higher education domains.

What motivates the use of metaphors in communication? Ortony (1975) suggested that metaphors fulfill three necessary communication functions: a metaphor provides a compact way of representing our experiences; it enables us to talk about experiences which are hard to describe literally; it provides a vivid and memorable way for perceiving our experiences. Metaphoric language also contributes to shaping our understanding of the world and constructing our thinking (Lakoff and Johnson 1980). For example,

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the conceptual metaphor, *ideas as food*, yields a linguistic realization, i.e., metaphoric expressions such as "I try to digest the new idea," "I devour the book," etc. Thus, metaphors facilitate the understanding of an abstract domain (e.g., idea) through a more familiar and concrete conceptual domain (e.g., food). Therefore, according to Lakoff and Johnson's view, metaphors are a basic foundation of conceptual understanding and are not (mainly) tools for communication but are tools of thought.

Researchers have documented developmental changes in the ability to interpret metaphors (Berman and Ravid 2010; Thomas et al. 2010; for reviews, see Gardner et al. 1978). Young children seem to understand perceptual metaphors ("his cheeks are roses") before non-perceptual ones ("this prison guard is a hard rock"). Gentner (1988) proposed that children aged around 6 or 7 years interpret metaphorical comparisons first in terms of perceptual similarity (e.g., "the river is like a snake") and then in terms of relational similarity (e.g., "the sun is like an oven"). Children who are 9–10 years old can easily comprehend metaphors grounded on physical similarity (Billow 1975) and metaphors grounded on less immediate relations (e.g., Gentner 1988). By the age of 11–12, children can interpret most types of metaphors, even those that require fairly precise conceptualization (Winner et al. 1976). However, other researchers argued that children as young as 3 were able to correctly complete pictorial analogies based on familiar causal relations (Goswami 1996). It could be that the use of nonverbal matching measures had revealed metaphoric comprehension in this early age. Two main explanations have been suggested to account for this development. One is related to the change in the general cognitive capacity (Gentner 1988) and the second to the increased semantic knowledge (Keil 1986; Winner et al. 1980).

Some researchers suggested that the literal interpretations of nonliteral utterances are computed prior to or in parallel with the nonliteral interpretation and that children in the early elementary school years employ literal interpretive strategies. Ackerman (1978) demonstrated that first graders tend to have literal interpretations for ironic and other figurative expressions. In one study, first, third, and fifth graders and college students read short stories that ended with an idiomatic expression (e.g., "David's team was way behind. The coach called time out and began to send in substitutions. David said the coach was *throwing in the towel*"). Results showed that the frequency of correct idiomatic explanations increased with increasing grade. The first graders rarely made correct explanations, whereas the fifth graders and adults made the correct explanations most of the time. These results indicate that young children do not consistently understand a speaker's use of an idiom (Ackerman 1982). According to psycholinguistic perspective, thus, in the course of development, the correct nonliteral interpretation is gained when the literal interpretation is suppressed and the correct figurative interpretation is elaborated and becomes available.

Nonliteral Language in Children with Learning Disability

Nonliteral language poses considerable interpretive demands, especially for children with learning disabilities (LD). This is because understanding of nonliteral language requires going beyond the literal interpretation of the utterance and at the same time suppressing the emerging literal meaning. Metaphoric comprehension in children with LD and typically developed children (TDC) was examined in some studies. Seidenberg and Bernstein (1986) compared the comprehension of similes (e.g., "his face was like a beet") (Ortony 1993) and metaphors ("his face was a beet") in 80 children with LD and 80 TDC in grades 3–6. It should be noted that although metaphors and similes have the same semantic content, the simile conveys a comparison between two unrelated concepts, the topic of the metaphor (face) and the vehicle (beet), more explicitly than in a metaphor. The children read eight stories and were asked to complete the story with the best ending. The results pointed to significant differences between the two groups in both conditions at each grade level, with the performance of the older children with LD being similar to the performance of the younger TDC. Furthermore, the performance of children with LD was significantly better for the simile than for the metaphoric condition, probably due to the explicitness of the comparison in the simile.

Lee and Kamhi (1990) investigated metaphoric competence of children with LD, children with LD with a history of spoken language impairments, i.e., were identified as language impaired by a certified speech pathology and had been enrolled in language therapy during preschool, and TDC ranging in age from 9 to 11 years. Participants read a sentence ("I went into the kitchen and ate up a storm") followed by four possible interpretations ("1. I ate a lot; 2. I drank some white lightning from the refrigerator; 3. I ate so much it rained; 4. I like to eat when it's raining"). The results indicated that the performance of both LD groups in the comprehension task was poorer than the performance of the TD group. These findings are in agreement with other language impairments observed in children with LD: vocabulary (Fry et al. 1970), use of morphology (Vogel 1977), and word retrieval (German 1979).

The exact cause for the difficulty in acquiring metaphoric competence in children with LD is still unknown, not to mention the exact brain mechanisms underlying this difficulty. Understanding the brain bases of nonliteral comprehension in the normal brain can potentially lead to a better understanding of this communication difficulty. Using advance brain imaging technology can thus cast light on the exact neural correlates of nonliteral language comprehension.

Using fMRI Technology for Studying Nonliteral Language Processing in the Brain

fMRI is a noninvasive imaging technology which, unlike most of the imaging tools, does not expose participants to radiation. fMRI technology produces images of the brain with high spatial resolution by using the magnetic properties of blood, i.e., the iron in the hemoglobin that is affected by the magnetic field of the fMRI, to monitor hemodynamic changes in different regions of the brain. This enables researchers to accurately monitor the hemodynamic changes that are coupled with neural activity as participants perform a particular task. Researchers usually design a study in which the participant is asked to perform a task ("on" phase) with alternating periods of "rest" ("off" phase), during which the activity of the brain declines. One of the simplest methods for obtaining brain activation is to perform a simple subtraction by averaging together all the images acquired during the "on" phase of the task and subtracting the average of all the "off" images.

More and more researchers are using fMRI technology to investigate hemispheric differences in processing nonliteral language (for a review, see Schmidt et al. 2010). According to the semantic coding theory (Beeman 1998), the RH seems to weakly activate broad semantic fields including distant and nonconventional semantic features, whereas the LH activates a much smaller range of closely related concepts and salient aspects of word meanings. Thus, the LH is thought to focus on a small set of highly related semantic associates while suppressing the less salient and irrelevant ones. Contrary to the LH, the RH activates and maintains a much broader set of semantic associations, including subordinated, unusual, and less salient meanings (for reviews, see Beeman 1998; St. George et al. 1999). This qualitative difference between the two hemispheres may be crucial when language comprehension requires the simultaneous consideration of more than one plausible meaning, as in understanding linguistic ambiguity (Burgess and Simpson 1988; Faust and Chiarello 1998) and figurative language (Anaki et al. 1998; Brownell et al. 1990; Burgess and Chiarello 1996; Giora et al. 2000).

Support for these claims comes from recent fMRI studies (Mashal et al. 2005, 2007) that examined the brain bases of metaphor comprehension. Participants were presented with two-word phrases: literal expressions (*broken glass*), conventional metaphors (*iron fist*), novel metaphors (*imagination caves*), and unrelated word pairs (*laundry rabbit*) and were asked to silently read and decide which kind of semantic relation exists between the two words (literal, metaphoric, or unrelated). The results provided evidence for selective RH involvement in the processing of novel, nonsalient metaphoric meanings. More specifically, it seems that understanding novel metaphoric expressions, i.e., the creation of novel semantic connections between remotely associated words, requires the involvement of the right homologues (i.e., the corresponding area situated on the opposite hemisphere) of Wernicke's area and both Broca's area and its right homologues. This right lateralized activation, in addition to the classic left lateralized language area (i.e., Broca's area), is specific to the novel metaphors but not to the unrelated word pairs, although both are unfamiliar and both involve distant semantic relationships. Furthermore, processing novel metaphors compared to conventional metaphors yielded stronger activation for the novel metaphors in the right homologues of Wernicke's area and the right homologues of Broca's area.

Different cognitive mechanisms are engaged in the comprehension of conventional metaphors and new metaphors (Bowdle and Gentner 1999). The "career of metaphor" theory (Bowdle and Gentner 2005) postulates that the conventionalization of novel metaphors is a gradual process in which conventional metaphors are processed in fundamentally different ways than novel metaphors. Conventional metaphors are understood via categorization, in which the target term becomes a member in a superordinate metaphoric category, represented by the base term (Glucksberg 2001; Glucksberg and Keysar 1990). For example, in the metaphor *this idea is a gem,* the target term, "idea," becomes a member in the superordinate metaphoric category – prestigious, bright, and unique things – represented by the base term, "gem." Pairing the base term with different targets (e.g., *this solution is a gem*) will not change its meaning. Unlike novel bases which evoke different meanings in different contexts, familiar bases evoke stable metaphoric categories. Novel metaphors may be processed via comparison process (i.e., simple matching) in which the semantic features of one concept are mapped onto another concept (Bowdle and Gentner 2005).

When children encounter metaphors for the first time, the metaphors are processed as novel expressions in terms of brain processing. Thus, the first steps of understanding novel, unfamiliar, metaphors require, at least partly, both a comparison process and the involvement of a right lateralized brain mechanism, namely, the coarse semantic coding attributed to the RH (Beeman 1998; Jung-Beeman 2005). However, as metaphors become conventionalized, the role played by the RH is reduced, and empirical evidence indicates a shift to a left hemisphere brain mechanism (Mashal and Faust 2009). Furthermore, the comparison process, used for understanding novel metaphors, may be replaced by categorization, as the metaphors become conventionalized.

Based on these theoretical frameworks, i.e., the career of metaphors and the coarse semantic coding of the RH, and the data obtained from using the fMRI technology, we initiated an intervention program aimed at improving metaphoric language comprehension in children with LD.

Intervention Program Based on a Right Hemisphere Mode of Processing for Children with Learning Disabilities

The intervention program proposes a tool for improving the communication deficits associated with nonliteral language comprehension in children with LD. More specifically, the program aims to enhance metaphoric understanding among children who are unfamiliar with many metaphoric expressions, which are commonly used in everyday language. The program is motivated by previous pilot results that show that patients who displayed characteristics associated with right-sided brain injury improved their nonliteral comprehension (Lundgren et al. 2006) and on recent findings showing RH involvement in metaphor processing (e.g., Mashal et al. 2007). The intervention program is based on a simple visual mode of representing semantic relations between words using thinking maps. Thinking maps are visual-verbal learning tools that provide graphic representations of the features shared by both words that comprise the metaphoric expression (e.g., *train of thoughts*), thus providing an explicit basis for metaphor understanding. For example, the concepts "train" and "thought" each evokes several associations, as illustrated in Fig. 14.1.[1]

[1] "Train of thoughts" is not a conventional metaphor in Hebrew, but it is closest in meaning to the Hebrew expression "thought thread" (which is the literal translation of the Hebrew expression *hut machshava*) and was used in the intervention program. This expression is only given for illustration purpose.

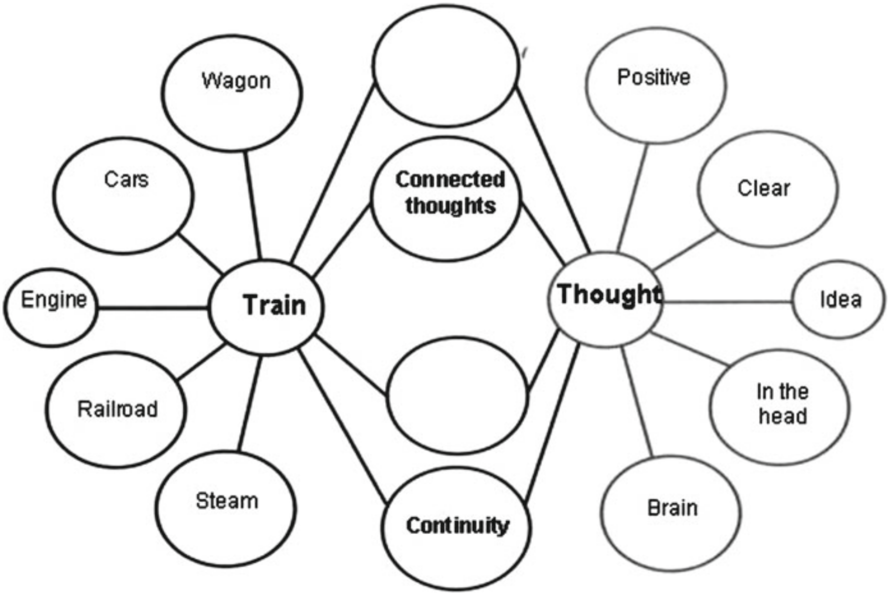

Fig. 14.1 An example of the thinking maps used to improve metaphoric understanding. The children write the concepts ("*train*," "*thought*") of the expression (*train of thoughts*) in the central bubbles and then their associations in the surrounding bubbles. The researcher instructs the children to write the appropriate shared associations (in the bubbles that connect to both concepts), such as "continuity" and "connected thoughts," in order to grasp the correct interpretation (a series of connected thoughts)

The participant is instructed to generate a broad range of associations for each concept and then to identify the appropriate shared associations that give rise to the correct interpretation (a series of connected thoughts).

Our intervention program was tested on twenty 11–12-year-old native Hebrew speakers diagnosed with LD. Only children with verbal IQ in the normal range participated in the study (MEAN = 102.8). The children were reading disabled and not dyscalculic. Students received an LD diagnosis based on the criteria in Israel for LD classification (in line with the Diagnostic and Statistical Manual of Mental Disorders–Text Revision [4th ed.]; American Psychiatric Association 2000), which includes (a) achievement test scores at least 2 years below grade level and (b) average or above-average intelligence with a marked deficit in academic achievement. Additional 20 TDC matched on age (11–12 years old) and verbal IQ (102.5) participated in the control group.

Prior to the intervention program, both groups were tested on metaphor understanding. Children were asked to write the meaning of five conventional metaphors. Four of the five conventional metaphors were in the form noun-noun (e.g., "cherry lips," meaning in Hebrew red and sweet lips) and one was in the form noun-adjective

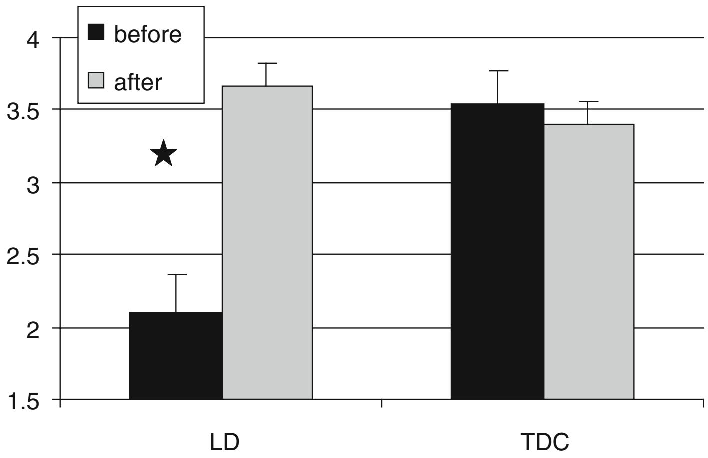

Fig. 14.2 Mean number of correct responses (and standard error) to metaphors before (*gray bars*) and after (*black bars*) the intervention program in the typically developed children (*TDC*) and children with learning disabilities (*LD*)

("limping explanation," in Hebrew, the adjective precedes the noun). As expected, the performance of the LD group was poorer than the performance of the TDC group ($M = 2.10$, SD = 1.21; $M = 3.40$, SD = .68, respectively) (t (19) = 7.29, $p < .01$). The same five metaphors were used in the pre- and posttest and in the intervention as well.

The intervention was performed on small groups of two to four children during two meetings during school time. Each meeting was 50-min long. In each meeting, children were using "thinking maps" (Lundgren et al. 2006) to study five different metaphoric expressions. The researcher wrote on the board the metaphoric expression (e.g., "train of thoughts," in Hebrew, "thought thread"), and the children wrote the words in the two central bubbles. Then they were encouraged to write associations for each word within the correct bubbles (e.g., "engine," "cars," "idea,"). Next, the researcher asked to think what possible words can share common features between the two words of the expressions (e.g., "continuity" and "connected") and write them on the central bubbles that are connected to both words (Fig. 14.1). Next, after establishing the common features, the researcher discussed with the children the whole expression's interpretation ("sequence of interconnected ideas").

Following the intervention program, the LD group exhibited a remarkable improvement in metaphor understanding ($M = 3.50$, SD = 1.00), compared to their performance before the intervention (t (19) = −6.29, $p < .01$). The TDC group, who did not participate in the intervention program, did not improve their metaphoric understanding (Fig. 14.2). However, it seems that the TDC control group performance was not close to ceiling. Thus, there is a likely possibility that TDC children can also benefit from training metaphoric understanding.

Conclusion

Our understanding of the special role played by the right hemisphere in the intact brain may have implications for the development of intervention programs that can be used to overcome communication deficits observed in children with learning disabilities and other special populations. Future studies can use the results of intervention programs as a platform for an fMRI study that will be able to examine hemisphere changes following intervention programs.

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Chapter 15
Use of Technology for Literacy Acquisition Among Children with Communication Difficulties

Orit E. Hetzroni

Children need communication to develop within a society and to maintain knowledge. They are dependent on their ability to comprehend, manipulate the environment, and transfer information for their development. In a literacy-based society, they also need to have a command of reading and writing. Language development is often impaired among children with special needs, especially those who have communication difficulties, such as children with physical impairments, intellectual disabilities, and developmental disabilities such as autism spectrum disorder (ASD). Their reading and writing skills tend to fall far behind, even in relation to their cognitive and educational abilities (Dahlgren et al. 2010; Foley 1993; Sturm and Koppenhaver 2000). While communication difficulties may inhibit children from learning language and literacy skills, technologies may assist and enhance opportunities to overcome those difficulties. This chapter will address some of the uses of this wide range of technologies that have been developed to enhance literacy skills by children with communication difficulties and reflect on the existing technologies and on the need to develop systematic instruction to enable skillful understanding of its potential.

Typically, developing children master language and demonstrate communication competence by the time they learn to read and write (Nelson and Kessler-Shaw 2002). However, for children with communication difficulties, this is not the case, as they often develop language abilities and literacy skills concurrently (Mineo Mollica 2003). Although it might seem as if one has to have some level of competence in language prior to attempting to resolve the puzzle of associating phonemes and the arbitrary graphic symbols we call letters, children with communication difficulties often depend on learning literacy skills for gaining competence in their language skills. Yet, language acquisition is an essential building block, critical for

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acquiring reading and writing. Language acquisition demands an ample amount of resources for building and establishing it as a foundation for literacy learning. Thus, children need to have an understanding of language and its rules, as well as sufficient vocabulary to unwrap the secrets of literacy. As speech is often impaired in children with communication difficulties, the use of other resources, such as literacy, is needed for gaining communicative competence and enriching vocabulary. Thus, some of these children use graphic and orthographic symbols for language learning as well as for mastering literacy skills (Smith 2005). This process of enhancing and enriching language competencies while learning to read and write is reciprocal and pertains also to typically developing children.

Language impairments preventing practice of new words as well as physical impairments preventing access to printed material have been found to be strongly related to reading and writing difficulties later detected in school-aged children (e.g., Kamhi and Catts 1986; Sevcik et al. 1991; Smith 2005; Wolff Heller and Coleman-Martin 2007). These difficulties that begin long before school starts become noticeable during preschool and kindergarten years. These barriers inhibit the child's exposure to opportunities for developing emergent literacy skills and later on reading and writing (Koppenhaver and Williams 2010; Koppenhaver and Yoder 1993).

One of the most important ingredients in the process encompassing language and literacy learning is the opportunity to develop, train, enrich, and practice knowledge gains over time (Hetzroni 2004; Smith 2005). Reading and writing usually do not develop naturally among children. Yet, those tools are critical for succeeding in the academic literacy-based society (Koppenhaver and Yoder 1993; Lonigan and Shanahan 2010). Children who have the opportunity to practice and enrich their knowledge at home and at school succeed in gaining a rich language, adapted to their abilities, learn to read and write, and use those skills to maintain academic achievements and an understanding of social codes (e.g., McKeough et al. 2006). Yet, for children with communication difficulties, obstacles may impede opportunities for normal literacy development. Those obstacles may result from physical limitations, cognitive disabilities, technological difficulties, and/or environmental barriers, as well as low expectations (e.g., Browning 2002; Kopenhaver and Erickson 2003; van Balkom and Verhoeven 2010).

Physical limitations may prevent a child from accessing a book and prevent opportunities to interact with written material, choose or select a desired story, or question an unclear topic (Koppenhaver and Yoder 1993). Physical difficulties, as well as developmental disabilities, often accompany language impairments. Those difficulties can encompass additional challenges such as preventing children from asking questions, clarifying a point of interest, or even requesting parents to read a favorite story (Hetzroni and Schanin 2002). Complex difficulties can prevent a child from viewing the text or hearing the story, understanding messages, or creating the needed associations for building upon common knowledge gains. Such difficulties also have an impact on the communication partner who tends to develop low expectations, speaks slower using limited vocabulary, refrains from using long and complex sentences, uses simple language, and limits conversation mainly for basic needs (Erickson and Koppenhaver 1995; Erickson and Sachse 2010; Fewell and Deutscher 2004). Additional cognitive impairments tend to delay language development and reduce exposure to literacy even more. As these children grow up, the gaps between them and typically developing children increase, and, thus, their distinctive needs expand.

The Technology of Graphic and Orthographic Symbols

Over the years, many strategies have been developed for teaching, reading, and writing. Some of the strategies incorporate the use of graphic symbols (see Fig. 15.1) for supporting orthographic symbols (i.e., alphabet letters). Those graphic symbols, used often in language acquisition, assist in associating between language and literacy, thus enhancing reading and writing acquisition and comprehension (Preis 2006; Sevcik et al. 1991; Sturm and Clendon 2004; van Balkom and Verhoeven 2010). Graphic symbols have also been used for the past few decades for teaching language and for enhancing and augmenting communication among children with communication disorders (Romski and Sevcik 2005; Soto and Hartmann 2006; Zangari et al. 1988). Many sets and systems of graphic symbols currently exist; some are more iconic, such as pictures of known objects, and some are opaque, such as line drawings of emotions and actions (see Lloyd and Kangas 1994; Mirenda 2001 for detailed information).

Augmentative and alternative communication (AAC) is a theory-based set of methods, technologies, and strategies, used for enhancing communication of individuals that do not develop it naturally (Lloyd and Kangas 1994; Mirenda 2001). AAC enables use of multisensory channels, such as visual and tactile, in addition to the auditory channel (speech) usually used for communication. It allows adaption of speed and level of message comprehension to the ability of the user and matching types of symbols to the user's needs (Koppenhaver and Erikson 2009).

Symbols used for delivering messages are usually transferred using auditory channel (speech) or visual channel (written text). However, when speech cannot be used as a preliminary form of transmission, reading and writing become even more essential as a verbal form of communication. When those are difficult to achieve, other methods should be considered. In such situations, pictures, drawings, and even objects can be used to convey messages and to enhance communication. Such methods should be adapted to the needs of the user and then used for applying and reinforcing the process of language and communication development (van Balkom and Verhoeven 2010). Symbol sets and systems have been developed over the past decades in order to assist in language acquisition and in the development of literacy skills (Fuller et al. 1992).

Graphic symbols represent ideas visually, have a varying degree of translucency, and can be used for conveying messages by individuals with different abilities (e.g., Angermeier et al. 2008). For example, a picture of one's mother can represent the concept "mother," a drawing of a cup can represent "I want to drink," and an abstract

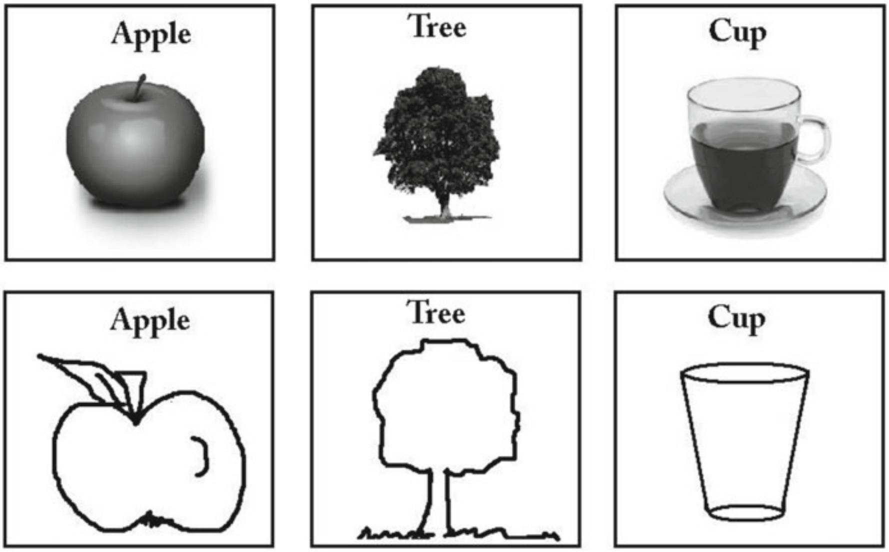

Fig. 15.1 Example of graphic symbols

line drawing can represent emotions such as "love" or "sadness" and concepts such as "dream" or "mind." Some graphic symbols have a wide set of rules that underline the logic of the system used for making them. Others have limited rules (Binger and light 2007). Orthographic symbols, such as the alphabet letters, are also abstract arbitrary symbols that require significant learning of the rules and the system underlying the logic behind them. They do not make sense until the rules are mastered through practice and understanding.

Several studies investigated use of graphic and orthographic symbols for different populations, addressing issues such as speed and learning efficiency and use and adaptation for the different needs of the users (e.g., Hetzroni and Lloyd 2000; Hetzroni and Ne'eman in press; Koul et al. 2005; Mizuko 1987; Schlosser 1997). Exposure to the symbols has been found to be effective for language acquisition and for preliminary exposure to its written form (Bishop et al. 1994; Jones et al. 2007; Sevcik et al. 1991). The printed graphic symbols (usually accompanied by written explanation of the symbol) can create a preliminary link between communication, language, and the symbols representing them, increasing understanding of the power of the word and its control over the environment. Graphic symbols, paired with printed words, were used in a study using stories presented to five kindergarten children with autism (Hetzroni and Ne'eman in press). The children learned the stories using a computer-based program in which they were exposed to the stories and to educational games teaching them vocabulary and symbol identification. By the end of the program, those children were able to identify most of the symbols and answer short questions about the stories. The stories used in the study were narratives of their daily activities, thus creating a link between the symbols, their meaning, and their everyday activities. Exposure to the material, adjusting over time from one symbol to several symbols representing several ideas, creates an understanding of the relationship between the sequencing of the symbols and the ideas they represent. Understanding the relationship between the symbols and the need to encode them creates a parallel to the encoding process and the rules that govern reading, thus building a basis for understanding literacy (Bishop et al. 1994). Building this power of understanding will later assist in manipulating literacy and using it to succeed within family, community, society, and work.

Assistive Technology

Any tool created to assist, enhance, preserve, or scaffold the functional abilities of individuals with special needs can be referred to as assistive technology (AT). The various applications that are currently available enable both teachers and students to enjoy the technologies that assist them in resolving their educational teaching and learning needs (King 1999). AT includes a wide range of unique and standard technologies aimed for improving the ability to learn, expand accessibility, and increase opportunities (Kaye et al. 2008; Lewis 1993). Tools ranging from chalk and ink, paper, and notebooks to word processors, calculators, computers, tablets, and smartphones that are used today can be referred to as AT. Using AT can compensate for severe difficulties and assist in communicating with the world, repair visual and hearing impairments, and rehabilitate damaged organs (Scherer 2002). Technologies such as cochlear implants, text enhancers, computers that can read aloud written text, as well as switches and voice-output communication devices have empowered many individuals, increasing their abilities and their quality of life.

The field of AT includes various types of technologies adapted to fit a wide range of needs, targets, and functions. Some of the technologies are basic (e.g., Edyburn 2000; Wasson et al. 1997); others are very complex (e.g., Koul et al. 2005; Quist and Lloyd 1997). Basic AT are usually compiled of simple means, easy to obtain and maintain, while complex AT include intricate and complicated technology that are more expensive and difficult to assemble, maintain, and obtain, thus requiring an understanding in the nature of the tool (Campbell et al. 2006; Cook and Hussey 1995). Basic AT may include a wide range of tools such as communication books, charts, basic switches and tape recorders, pointers, and even cards and folders with symbols drawn on them, colored markers, and rulers. Complex AT range from computers and speech-generating devices (SGD) to cochlear implants, complex mobility tools or handheld computers, tablets, smartphones, and virtual reality systems.

Over the years, with the adaptation of technology and the expansion of its use in education (Grabe and Grabe 1998; Watson et al. 2010), changes in the field of technology have enabled the development of tools that are complicated and complex, specific yet elaborated (Edyburn 2000; Hetzroni et al. 2009; Hetzroni and Shrieber 2004), which enables access of these resources by a wider range of populations. This development enhanced the creation of tools that have unique qualities, designated to serve the needs of individuals with communication difficulties as well as other populations with special requirements (Campbell et al. 2006).

The computer, for example, has developed over the years to become an effective tool in the educational system, effective for learning, obtaining knowledge, practicing, investigating new fields, exploring, simulating, and expressing new ideas and thoughts (Flippo et al. 1995; Judge and Lahm 1998; Judge and Parette 1998; Kozma 2003; Parette and Stoner 2008). Computer use is executed through input and output peripherals, ranging from the traditional mouse and keyboard for inputting and manipulating information and a screen and printer as output channels to more complex input and output measures such as speech activation, text enhancement, and touch screens. However, it seems as if those mechanisms, usually readily available for common use in most computer systems, remain a hidden secrete from many individuals with special needs that could benefit from using them. Research has demonstrated that exposure to the advantages of computer use as well as consistent dedicated instruction to the staff working with those individuals can increase use and expand the knowledge in the practical and technical aspects of using these technologies (e.g., Hetzroni and Ne'eman 2010).

Computers suffice use of traditional input and output peripherals in the educational system. However, for children with special needs, these input and output methods are often not enough (Lahm 1996; Lahm and Sizemore 2002). For example, physical difficulties may prevent the use of conventional input modes. Hearing or visual impairments may hinder use of auditory or visual modes of output. Cognitive disabilities or visual impairments may limit the abilities of encoding the text displayed on the screen. More so, the specific needs of each child require unique resources and specifications that evoke large expenses and make the programs complex, too specific or difficult to produce. Different needs also elicit various computer access solutions. For example, the need to access relevant information from the Internet may require modifications, either in content and language or in unique input and output devices.

Children with autism, for example, require unique adaptations (Pennington 2010). If the child has difficulties in retrieving information and using functional speech, a suitable SGD might be appropriate for use. However, this device should be light in weight, easy to carry, versatile and yet sturdy, complex in the number and type of messages it can produce, and adapted for the educational needs. More so, this device should have the capacity to be modified over the years, to be converted from one symbol system to another, and to be assisted in acquiring literacy skills. If the child has the capability to select directly, a computer-based system using a touch screen that is light enough to be used as a handheld computer and elaborate enough to satisfy the varying needs would be appropriate. On the other hand, children with physical disabilities that have communication difficulties due to their physical impairment might need to access SGD using switches adapted to their need (Beukelman and Mirenda 2005). For those children, literacy may not only be a key for academic achievement but also their access to communication and survival in the environment around them.

The unique individual needs described above intrigued the industry to use open tools that are flexible and adaptable enough for these unique needs. The industry has also begun to look at the needs of the child within the educational system when tending to the AT specifications (Watson et al. 2010). Computers, peripherals, and software programs can scaffold the educational process by creating a supported environment individually adapted for each child's needs. Thus, the computer can provide for active learning in a controlled environment tailored to the needs of the child, based on the specifics of their educational needs and abilities.

Literacy and Assistive Technology

One of the first challenges a child in the educational system faces is the need to learn to read and write (Kofsky-Scholnik 2002). The child is expected to develop competencies and sufficient literacy skills to enable success in fulfilling the requirements and adapting to the educational system. Research has investigated various ways for acquiring literacy skills among children who have varying difficulties using a wide range of technologies (e.g., Hetzroni et al. 2009; Hetzroni and Schanin 2002; Wilkins and Ratajczak 2009). The development of AT, especially computers, has broadened the range of educational possibilities, creating optimal tools adapted to the needs. The use of AT can enhance abilities and enable success. Using these technologies over time can improve abilities and assist in transforming acquired knowledge for use while learning to read and write (Lewis 1993). While some of the children will need to continue using AT all the time, others might be able to, after acquiring the required skills, reduce the need for using the technology or alter them to more adapted, conventional tools (Campbell et al. 2006). For example, a child with communication difficulties may use objects as a young toddler, transit to line drawings as a child, and use orthographic symbols in school, all using a SGD. A child with autism may need to use computer programs while learning to read and write. This child might learn to use these literacy abilities later for communication as well as for academic needs using traditional paper and pencil, a handheld computer, or a complex SGD. In one study, for example, orthographic and graphic symbols were taught to three girls with Rett syndrome using a computer equipped with a dedicated software program and switches as peripherals (Hetzroni et al. 2002). After the girls finished the learning process, the symbols became part of their communication used for both academic and communicative needs. They used the symbols to select preferred books to read, to select music, and to choose what food they wanted to eat. AT can be used directly for the child's needs as well as for the teacher. This interactive use of technology intensifies the importance of AT as a powerful tool in special education (Hetzroni and Schanin 2002; Kinsley and Langone 1995).

Some of the programs available for use with literacy include "speech recognition" and "text to speech." "Speech recognition" includes programs that can recognize speech, process it, and convert it to a written form. These programs can also identify spoken commands and activate the computer without touch. The efficiency of one such program was investigated with children that have been identified as having learning disabilities (Reece and Cummings 1996). The purpose of the study was to investigate whether simulating text reading is advantageous for the children by enabling them to view the words unfold as they read the text aloud. The effectiveness of the program was compared with the traditional method of listening to a tape that had the same text stored in it. Results of this study revealed that while for typically developing children both methods were similar, the ability to observe the unfolding of the text resulted in significantly higher scores both in quality and in quantity for the children with learning disabilities.

While these programs became available in the past decade, they still remain difficult to use, as they require a "teaching" process in which the software requires the user's voice to be recognized by the computer, through acquisition of patterns of voice and intonation. The process involves reading a specific text aloud to the computer until recognition is complete. The need to read out loud a specific text may hinder the possibility of a child with learning disabilities from reading such a text effectively with no mistakes, thus reducing the chance of enjoying the program. A child with physical difficulties may find it difficult to maintain the reading abilities for such a long text. Making these programs more "user friendly" may assist in turning them into more effective and more frequently used technologies (MacArthur 2000). The use of voice command has recently been implemented in a similar manner into technologies such as iPhones that enable individuals with special needs to use various applications such as Internet access without the need to write the command (Breen 2009). Such technology can assist children with physical disabilities or visual impairments in operating their phones, accessing the Internet, and manipulating their environment using this type of technology.

Another use of AT relates to "text to speech," or "speech synthesis," which assists in enabling the computer in identifying text, converting it to speech, and reading it out loud to the user. This type of technology often uses digitized speech, a pre-reordered human voice separated to phonemes and reassembled using simple typing on a keyboard. This complex mechanism, seemingly simple these days, can be used for decoding word documents as well as text directly taken from the Internet, thus producing it as a vocal digitized output. This system can be used by people with visual and hearing impairments as well as people with communication disorders who wish to vocally express their written ideas (Schlosser et al. 1998; Schlosser and Blischak 2004; Van Balkom and Verhoeven 2010). In a study investigating the use of this technology by children with autism, using voice-output "text to speech" activated by a computer enhanced spelling abilities of the children after practice with the software. When the children used the speech output as feedback, they were able to better spell the words presented to them (Schlosser et al. 1998). This technology also assisted students with learning disabilities who were able to detect more syntax and spelling errors using "text to speech" than when using no assistance or even when using a human reader (Dresang 2008; Raskind and Higgins 1998).

The use of digitized reading can be implemented at the end of every letter, word, sentence or paragraph, or any combination. This tool can be utilized for reading, text comprehension, and practice and for identifying spelling mistakes made while writing (Mills 2010). The computer "reads" the text, thus enabling the person to listen to the written text or, when needed, use it to express one's wishes aloud. Thus, although this technology was created to enable people with visual impairments and communication disorders decode a written text and voice it out, it has been found to be effective as a tool for literacy acquisition for individuals with learning disabilities or communication disorders, as a tool for literacy purposes, and as a compensatory tool for decoding text (MacArthur 2000; Raskind and Higgins 1998; Schlosser et al. 1998).

The use of "text to speech" has been used recently in developing AT programs for use as augmentative and as compensatory tools that have open and closed parameters. This technology can be used to scaffold learning to read and write and to assist children in decoding difficult words or complex text. While enabling students learning to read and write by converting written text to speech, thus assisting in reading acquisition and comprehension, the most unique feature of this type of program is the ability to use it for writing with symbols. The program has efficient environments that assist acquisition of reading and writing while using graphic and orthographic symbols. The symbols appear above or below the text and can be used for encoding or decoding text, as they can represent abstract as well as concrete ideas and messages. They enable children to use symbols to augment learning language, communication, and literacy, as well as a compensatory tool for conveying ideas using auditory and visual means (Parette et al. 2008). For example, "Writing with Symbols©," created by Widgit®, is a program that has joined a large body of technologies used to fulfill academic and communicative needs of children with complex limitations for literacy and communication purposes, thus enabling enhancement of both areas using orthographic and graphic symbols.

"Writing with Symbols©," a program developed for enhancing literacy, language, and communication skills, has a dynamic display and uses graphic and orthographic symbols for assisting in learning to read and write. The program was translated to several languages. One of the added advantages of this program and others that serve the same purpose is the ability to use it in a variety of ways, for translating orthographic to graphic symbols, while using it as a word or symbol processor, as well as for using this program for voicing the text out loud. This enables an explanation of a difficult word, making it possible to understand the text and verifying the reliability of a written text before finalizing it. As such, a child with learning disabilities or visual impairments can voice the text out loud and compare between the original intent and the actual output. A child can use it to clarify a word in order to prevent misunderstanding of a sentence or to select a graphic symbol when a word is missing in the vocabulary. This program can also be used for creating dynamic displays and communication boards to be used by children with communication difficulties. For example, a story board can be created for a child with autism, for planning, practicing, and simulating social situations using both graphic and orthographic symbols and voicing out the social stories as part of a school activity. A dynamic communication display can be created with or by a child with physical limitations, for expressing needs or participating in classroom discussions (Parette et al. 2008). However, most of the practitioners use this program as a word and symbol processor and therefore do not enjoy the program to its full potential.

The problem of practitioners not realizing the full potential of available technologies was addressed in a study which investigated the ability to maximize the use of assistive technologies for enhancing literacy and communication skills by children with various communication difficulties in the school system (Hetzroni et al. 2009). The study examined if providing the school with an instructional battery on technology as well as on the specifics of the program would increase the understanding of its unique possibilities as well as on the adaptations that the features of the program can prevail for use with various kinds of students. Following the understanding of the program and its features, the study investigated if this complex program could increase early literacy skills as well as language and communication skills of children with various communication needs.

Six schools participated in the study: two schools for children with autism (elementary and high school), two schools for children with physical disabilities (preschool/kindergarten and cross-age elementary and high school), one school for children with cognitive limitations (cross-age elementary and high school), and one school for children with hearing impairments and other complex disabilities (cross-age elementary and high school). Children ranged in age from 3–5 years in the preschool/kindergarten to 14–18 years in high school. Cross-age elementary and high schools included children ranging in age from 6 to 18.

Eighty children from the six schools were tested at the beginning and at the end of the school year to detect language and communication gains as well as early literacy skills. The children's teachers were also asked about the progress of those children during the school year. Twenty-eight teachers were asked about the use of the program as a direct tool for teaching literacy as well as its use as a communication tool and the use of "Writing with Symbols©" and other computer programs used for communication and literacy learning in school. Results of the study demonstrated a significant increase in the children's abilities between the beginning and the end of the school year. The results were higher in syntax, vocabulary, morphology, and context; the most significant difference was in vocabulary gains. Literacy and communication gains were significant in schools receiving intensive training and less significant in schools receiving partial training. The most significant change in vocabulary acquisition was apparent in the kindergarten children, a result that can be explained also in light of the vocabulary burst expected from children in that age range. Teachers reported that following instruction they began to understand how to use the program for direct and indirect purposes, for preparing materials for the students, and for working on literacy and communication activities.

Summary

AT has supported literacy acquisition and comprehension, used as scaffolds and prostheses tools by individuals with communication difficulties. Some of the technologies were created for the general population, while others were created specifically for use by individuals with special needs. Understanding the variability of the tools and the specifications as well as the understanding that such tools are available for use across various purposes can make AT visible, available, and effective for meeting the great myriad of distinct needs of individuals at different times and settings.

AT can assist from the very first stages of early literacy by learning to use a switch to choose a book to read, using a pointer to follow the text, and making comments and asking questions about the story throughout one's life in accordance with individual needs. Over the years, the selection process becomes evident as a powerful tool for manipulating the environment, participating in the discussion, and having the ability to converse through graphic and orthographic means. The use of technologies has empowered human beings to enhance abilities and achieve. Assistive technology has the power to enhance abilities, provide opportunities to achieve, and overcome barriers. Literacy is the key to success in present society. It holds knowledge that can enable the user to achieve and maintain competence from childhood to adulthood. Understanding the power of assistive technology, increasing knowledge in the field, and keeping informed on the technological innovations can act as a key to independence and success for those with communication and learning disabilities.

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