Educ Inf Technol (2018) 23:1231–1252
DOI 10.1007/s10639-017-9653-7

Educational electronic book activity supports language retention among children at risk for learning disabilities

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Received: 17 May 2017 / Accepted: 27 September 2017 / Published online: 4 November 2017
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Abstract The main purpose of the present study was to examine the effect of an activity with an educational electronic book (e-book) on language retention among children at risk for learning disabilities (LD) (seven weeks after the intervention). Two modes of the educational e-book were investigated: with and without metacognitive guidance. Seventy seven kindergarteners aged 4.5–7 were randomly divided into three groups: (1) reading an e-book which included metacognitive guidance (EBM); (2) reading an e-book which did not include metacognitive guidance (EB); (3) receiving the regular kindergarten program (control). The children's vocabulary was assessed before the intervention, immediately after the intervention (post 1) and seven weeks later (post 2). Story comprehension was assessed only following the intervention (post 1 and 2). The findings showed a long-term effect of the activity with the e-book on vocabulary. However, for story comprehension, a decrease in recall of words and quotes and an increase in the recall of main ideas from the story were found seven weeks after the activity with the e-book. No significant difference in retention was found between the two intervention groups (with and without metacognitive guidance). The implications of these results for kindergarteners at risk for LD are discussed.

Keywords Electronic book · Language skills · Young children at risk for learning disabilities · Metacognitive guidance

1 Introduction

Learning disabilities (LD) are the most common disabilities exhibited by children attending school (APA 2013; Fuchs et al. 2013). Children with LD often perform less well in

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academic fields (Swanson et al. 2003) due to neurologically-based developmental delays in perception and memory (Breznitz 1997; Swanson 2016). These brain disorders interfere with basic cognitive functioning and are expressed in low response characteristics, poor short-term and working memory, delayed automatic processing, perceptual problems, problems with spatial and temporal orientation and self-regulation (Geary 2009). The first signs of their presence appear by kindergarten age (Jordan et al. 2009). However, the appearance of these behaviors does not guarantee their continuation into school. This group of kindergarteners is therefore designated as only at risk for LD (Margalit 2000; Van Luit 2011). One of the main risk signs for LD is low language skills. The literature shows that children at risk for LD exhibit lower vocabulary and story listening comprehension already at an early age (Gersten et al. 2001). The literature also shows that children at risk for LD have difficulties in retaining learning (NJCLD 2007), which is an ability related to metacognitive skills (Glaser and Brunstein 2007; McKenna and Violato 2003; Son 2005). It is therefore important to find early interventions for promoting these children's language in a way that can increase retention of what they learn. In this spirit, the current study has two goals: 1) To examine the contribution of an electronic book (e-book) to children's retention of vocabulary and story comprehension; and 2) To study the contribution of metacognitive guidance to children's retention of vocabulary and story comprehension.

1.1 Language skills in early childhood

The acquisition of language is one of the most important achievements of early childhood. Because the current study focuses on vocabulary and story comprehension, we will expand on these skills. Vocabulary development occurs rapidly in early childhood (Hiebert and Kamil 2005). Young children differ enormously in the size of their vocabulary, and this is correlated with the enrichment of language and support to which they are exposed (Neuman and Dickinson 2011). Sustaining children's vocabulary before formal schooling is considered a vital vehicle to success in reading and reading comprehension in the school years (Sénéchal and LeFevre 2002; Storch and Whitehurst 2002). For example, vocabulary measured at the beginning of kindergarten predicted reading comprehension at the end of third grade (Sénéchal and LeFevre 2002).

The narrative ability, i.e. the ability to understand stories and produce them, develops over the course of life. It begins in kindergarten and progresses and is elaborated over the years of elementary school and on. Young children usually first understand stories at a concrete level of details and information, and as they grow they become more aware of the hidden knowledge found in the story (Carlisle and Rice 2002). The stories which children tell over the years reflect a cognitive and linguistic developmental process which includes various abilities. Re-telling of a story by the child requires retention of content from the story, the plot and remembering words and grammatical structures that appeared in the story (Kaufman et al. 2008; Segal 2008).

Difficulties in retention of language skills, such as expressing and understanding, is a risk factor for LD (NJCLD 2007). A correlation between early childhood language impairment and reading difficulties, learning disabilities, and low academic achievement at school was found in many studies (Lewis et al. 2000; Ouellette et al. 2013). Language difficulties in early childhood can be expressed in slow development of understanding and expressing vocabulary, lack of interest in listening to stories, difficulty in understanding instructions and monitoring them, poor speech comprehension, inadequate syntax and

naming difficulties (Margalit 2014; Whiteley et al. 2007). Children at risk for LD were found to have a poorer vocabulary compared to their peers with typical development (TD) (Gersten et al. 2001). One factor for the vocabulary deficit of children at risk for LD is their difficulty to exploit random learning opportunities for learning new words. Learning in context, as in random learning, is not effective for these children because it requires the integration of verbal and nonverbal information, a complex task for children at risk for LD (Beck and McKeown 1991). They thus need direct intervention. Another reason for a vocabulary deficit among children at risk for LD is the lack of memory processes which characterizes this population (Swanson 2016). Because memory mechanisms participate in the process of acquiring a new word, the ability of children at risk for LD to learn a new word is impaired, and they need more repetitions of new words to acquire them (Bryant et al. 2003). The memory difficulties of children at risk for LD also adversely affect the ability to retain new words which were learned (Gathercole et al. 2008). New words which are learned in conventional ways are later forgotten and do not serve children at risk for LD in various language activities, including listening to stories.

One of the main reasons for the difficulty in story comprehension among children at risk for LD is a lack of knowledge on the use of metacognitive strategies aimed at promoting control over the quality of understanding and repetition of the text if necessary. Other reasons are a vocabulary deficit, difficulty in drawing conclusions and difficulty in finding a central idea (Gersten et al. 2001). Furthermore, a correlation was found between low memory abilities and difficulties in understanding a story among children at risk for LD (Dodwell and Bavin 2008). This is because the understanding of a story is based on the ability to process the information while preserving it in memory, and as the text is longer, the task requirements are greater in terms of memory and information processing processes.

Interventions in the field of language among children at risk for LD have indicated that appropriate treatments have the power to improve pre-language abilities and reduce the academic gap between children who have difficulties and children who do not have difficulties in these skills (Schiff and Joshi 2016; Whiteley et al. 2007). Educators and researchers in the field therefore emphasize the importance of finding effective ways for supporting the development of language skills among children at risk for LD and over time (NJCLD 2007). Such early interventions can combine new technological tools (Shamir and Margalit 2011).

1.2 Learning with new technological tools

The growing variety of technological platforms, including computers, tablets, mobile phones, etc. are increasingly used by people from all walks of life and all ages. Both researchers and educators have looked at these technologies as venues that may support children's learning in general, and the learning of children with special needs in particular. These tools are regarded as "assistive technologies" for students with special needs. Assistive technologies are tools that can support and enhance direct traditional teaching. They supply training and practice through interactive activities and simulations (Felicia et al. 2014). It has been argued that many of the new technologies facilitate multi-sensory learning, since they may have numerous input channels (e.g., interconnected visual, sensory and auditory representations) which are necessary for effective learning (Shamir and Margalit 2011). This is particularly true for children with

LD (Bouck et al. 2012; Stock et al. 2010; Xin and Jitendra 2006). Most of the studies carried out to date support this assumption (Maor et al. 2011; Shamir and Margalit 2011). Indeed, the few studies that examined use of the computer among kindergarteners at risk for LD reported that learning accompanied by computerized operations improved their reading and writing more effectively than traditional teaching (Mioduser et al. 2000; Vernadakis et al. 2005).

Research findings indicate that computer use in learning may also support retention of learning outcomes (Vernadakis et al. 2005). For example, Segers et al. (2006) examined the effect of a computerized intervention on the vocabulary of preschoolers with special needs one month after the end of the intervention. The children were divided into two groups. One group heard a computer story and played with computer games on vocabulary and the other group listened to the same story read by the teacher. One month after the end of the intervention, the improvement in vocabulary among the children who were exposed to the computer intervention was found to be greater than among the children who were exposed to the intervention by the teacher. One of the main technological products that can be used for a computerized intervention is the e-book.

1.3 Electronic books

E-books are computerized versions of printed books. They can be read independently by children, without the need for an adult. In e-books, the story is usually read aloud by a narrator, and may be accompanied by multimedia effects (e.g., animations, music, sound). Children reading the e-book can activate the multimedia effects by clicking on "hotspots". The hotspots are identified by words or illustrations from the text which appear on the screen. When the child clicks on hotspots and initiates a visual or auditory effect, he or she is actively (interactively) participating in the storytelling (de Jong and Bus 2003; Shamir and Korat 2007). Since these e-books are used mainly as entertainment, their effectiveness in supporting language was investigated by several researchers (de Jong and Bus 2003; Korat and Shamir 2004; Roskos et al. 2009). Many of the e-books currently available on the market were found to include multimedia effects (colors, sounds, graphics) and games. However, although these multimedia effects and games are integrated into the story reading, they are not suitable for promoting young children's language. Most of the multimedia features of the e-books (animations, hotspots) were inappropriate in terms of the frequency and quality of elements that may support language learning and storyline understanding (de Jong and Bus 2003; Korat and Shamir 2004; Roskos et al. 2009). These findings led some researchers to develop educational e-books for research purposes.

This endeavor has resulted in the development of a "model" for educational e-books. This model posits that educational e-books should contain stories that have a narrative structure taken from the child's world of content and experience, such that they will increase the child's curiosity and motivation to read. The language used in the book must be aimed at the child's age. Clear instructions should be included and the font size should be appropriate. The text should be accompanied by illustrations. However, the number of illustrations should not be too large, in order to avoid distracting the child from the reading task. The child should be able to independently control the multimedia functions. This will give the child a sense of discovery as well as competence. The book should include automatic, interactive and content-supporting activities that will contribute to story comprehension and narrative implications.

Studies on educational e-books have demonstrated that they can support language among young children with typical development (TD) in pre-school and in the early grades. These achievements were found to persist for the longer run (Korat and Segal-Drori 2016; Korat et al. 2014). However, there is a scarcity of studies on the effectiveness of e-books for kindergarteners with special needs, including kindergartners at risk for LD (e.g., Zucker et al. 2009). In recent meta-analyses on e-books, Takacs et al. (2014, 2015) found that multimedia features such as animations, music and sound effects, as well as pictures that closely illustrate the story's content, facilitate children's story understanding, probably by depicting and concretizing the story's abstract language and directing the readers' attention to key details in the illustrations. Such nonverbal information was found to be especially helpful for children who experience problems in understanding the storyline due to delays in language acquisition. The small amount of research conducted to date among young children at risk for LD has shown that exposing these children to educational e-book activities benefited their vocabulary, but did little to promote story comprehension (Shamir et al. 2012; Shamir et al. 2011). It is important to note that it has not been ascertained whether the improvement in vocabulary observed in these studies will be sustained over time. Greater light should be shed on these issues in order to facilitate the development of language and language-enhancing pedagogies. Very few studies investigated educational computer programs and e-books' lasting effects on language achievements among young children (Chera and Wood 2003; Segers and Verhoeven 2002, 2005) and they did not include children at risk for LD. Skills that support long-term retention are metacognitive skills. Therefore, researchers recommend a combination of metacognition and learning to encourage long-term retention of achievements (Glaser and Brunstein 2007; Lovett et al. 2000; McKenna and Violato 2003; Son 2005).

1.4 Metacognitive skills in learning

Metacognition is defined as knowledge about how to think as well as understanding about how to regulate thinking (Flavell 1979). Metacognitive abilities affect children's learning achievements in basic academic skills, such as reading (Mevarech & Fridkin, 2006; Schunk 2008; Veenman et al. 2006; Whitebread 2014). Some researchers are convinced that the lack of metacognitive skills is a powerful predictor of LD (Garrett et al. 2006; Sideridis et al. 2006) and a relatively large number of researchers have indicated that metacognition is correlated with children's success in school (Dignath et al. 2008; Flavell 2000; Kramarski et al. 2010). However, very little research has been conducted on metacognition among young children (Shamir et al. 2009; Whitebread 2014; Whitebread et al. 2009), and especially among children at risk for LD.

Use of metacognitive skills has been found in various studies as contributing to the retention of learning outcomes. Researchers therefore recommend the integration of cognitive training in order to encourage long-term retention of achievements (Lovett et al. 2000; McKenna and Violato 2003). Studies also indicated that the combination of cognitive supports in computerized learning environments may contribute to more effective learning (Kramarski and Michalski 2009; Schraw 2007; Winters et al. 2008; Zimmerman and Tsikalas 2005). Based on these findings, we examined whether metacognitive guidance embedded in an e-book would further promote language acquisition as opposed to an activity with an e-book without metacognitive guidance and compared to the regular kindergarten language activity without an e-book.

In conclusion, the research literature points to the power of early interventions for promoting the readiness of children at risk for LD to acquire good language skills. However, the memory difficulties of many of these children have implications for their ability to retain learning achievements. It is therefore very important to develop research-based educational tools, including technological tools, that will support the promotion of long-term language skills for this population. To the best of our knowledge, very few studies have been conducted to test the effects of computerized interventions on the retention of achievements in the field of language skills among kindergarteners and these studies did not include children at risk for LD. As far as we know, no research has examined the effect of an intervention with metacognitive characteristics on the retention of learning outcomes among kindergarteners at risk for LD.

The two language skills which were chosen for investigation, vocabulary and story comprehension, have been found to contain high predictive value for future academic success (Sénéchal and LeFevre 2002; Storch and Whitehurst 2002). We hypothesized that our specially-designed educational e-book would support vocabulary retention, an issue resulting from the memory deficits often observed among these children, because it permits multiple activations in addition to multisensory (oral and visual) presentations of words. Based on previous findings that showed the power of metacognition in promoting learning achievements (Schunk 2008; Veenman et al. 2006; Whitebread 2014), we decided to compare the children's vocabulary retention after exposure to each of the two main settings (i.e., with and without metacognitive guidance).

Two research questions were formulated: (a) To what extent does an activity with an educational e-book affect the promotion of language (vocabulary and story comprehension) among kindergarteners at risk for LD over time? (b) To what extent does an activity with an educational e-book that is integrated with metacognitive guidance (EBM) further contribute to language retention over time, compared to an activity with the e-book without metacognitive guidance (EB) and compared to a control group that received the regular class language activities? It was impossible to formulate an hypothesis for predicting the direction of the study's outcomes due to the scant available research on this issue.

2 Method

2.1 Participants

A total of 77 children aged 4.5 to 7 (M = 5.88; SD = 0.67) participated in this study. 72.7% of the participants were boys and 27.3% were girls, as expected in populations of children at risk for LD (Johnson and Breslau 2000). The children had been previously identified by the Ministry of Education's Psychological Services as exhibiting the developmental delays that placed them at risk for LD. According to Ministry of Education policy, all young children identified as having developmental delays are classified as "being at risk for LD," rather than as disabled in a particular area (Margalit 2000). The inclusion criteria for selecting the children at risk for LD were: (a) had been diagnosed as "at risk for LD" as per the stated policy; (b) did not exhibit other cognitive (an IQ below 85), sensory, or emotional limitations that would preclude them from being classified as "at risk for LD" as defined by the National Joint Committee on Learning Disabilities

(NJCLD) (2007); (c) exhibited lower verbal than nonverbal ability levels, a criterion established by the NJCLD (2007) for classification as being at risk for LD. This study utilized a randomized control trial (RCT) design and the children were randomly assigned to treatments (with/without metacognition) and control conditions.

2.2 Research tools

Cognitive level Two tests were used to create groups of a sufficiently homogenous cognitive level: the TONI and the ITPA. The TONI (Test of Nonverbal Intelligence), conceived by Brown et al. (1997), tests nonverbal intelligence, abstract reasoning, and problem-solving aptitudes of children aged 5 through 8. The 50-item test is organized by level of difficulty. It uses abstract content devoid of linguistic components. For example, one item presents a row of 6 shapes, each containing a different pattern of lines. The same page presents a box with 6 squares, 5 of which contain representations of 5 of the shapes in the row. One square is left blank. The child is asked to find the missing shape from the row of 6 shapes, a task requiring the child to recognize similarities and differences between the shapes and their internal patterns. Some TONI items have 6 shapes, others have 4 shapes. Every correct answer receives one point, with total raw scores ranging from 0 to 50. A ceiling is reached after the child has made 3 errors in 5 items. Brown et al. (1997) reported the TONI's internal reliability among children with LD as ranging from $\alpha = .89$ to .97, with a correlation of .63 with the WISC-3 test. Each raw score is transformed into a standard score according to age, providing the TONI quotient (TQ) and the percentile. For example, in the 5.0 through 5.11 age range, a raw score of 7 equals a standard score of 106 in the 66th percentile; in the 7.0 through 7.11 age range, the same raw score (7) equals a standard score of 85 in the 16th percentile. The standard scores typically range from 85 to 115. Scores lower than 85 are below the norm, scores between 116 and 130 are within the norm, and scores between 131and 145 are above the norm.

The ITPA (Illinois Test of Psycholinguistic Abilities), developed by Kirk and Kirk (1971), tests children's verbal aptitude by asking them to retrieve a word using an "auditory association", the ability to respond to an auditory stimulus in a meaningful way. Auditory association requires verbal ability, conceptualization, memory and the ability to organize linguistic symbols in a meaningful way. The test contains 42 questions which are read aloud to the child. The child is then asked to give a verbal analogy. For example, if the tester states: "I sit on a chair, I sleep in …", the child is expected to answer "bed". The test is stopped after the child makes 3 consecutive mistakes. Up to this point, the child receives one point for each correct answer. The test's target population is children with typical intelligence, aged 4 through 10 years. The test's reliability is $\alpha = .90$ (Paraskevopoulos and Kirk 1969), with raw scores ranging from 0 to 42, which are used to determine the child's linguistic age.

In accordance with the above-described definitions for LD, a significant difference, $F(1,74) = 207.36$, $p < .001$, $\eta^2 = .74$, was found between the participants' chronological age ($M = 5.88$, $SD = .67$) and their linguistic age ($M = 4.60$, $SD = .80$) as reflected by the ITPA, as expected, where their linguistic age was lower than their chronological age. However, no difference was found between the participants' achievements in nonverbal intelligence according to the TONI ($M = 100.40$, $SD = 9.94$) and the mean of the population ($M = 100$), $F(1,74) = .11$, $p > .05$ (see Table 1).

Table 1 Verbal and nonverbal cognitive level (ITPA/ TONI) of the 3 groups: means and standard deviations

	DB		DBM		Control		
	M	SD	M	SD	M	SD	F(2,74)
ITPA	4.62	.80	4.61	.89	4.56	.74	.05
TONI	103.8	9.87	98.20	9.87	99.11	10.32	2.44

These findings indicate that the characteristics of the participants in the present study are compatible with the definition of LD, which refers to the existence of a gap between the chronological age and the verbal intelligence level, without a gap between the chronological age and nonverbal intelligence (NJCLD 2007).

2.3 Children's language

Vocabulary The test was developed for the present study, based on previous studies of activity with an e-book among young children at risk for LD (Shamir et al. 2012, 2011). The children were asked to give the meanings of 20 words by pointing to the picture in a set of four that they thought best expressed the word's meaning. Eleven words were from the e-book to which the children were exposed in the intervention and nine words accompanied by their images were taken from the Peabody (Dunn and Dunn 1981) vocabulary comprehension test. The nine words which were selected from the Peabody test were three words suitable for ages 5:6–7:5, three words suitable for ages 4:3–5:5 and three words suitable for ages 3:4–4:2. Easy words from the Peabody test were included in order to provide a sense of success. More difficult words were included in order to test whether there is a difference in achievement level between the words to which the children were exposed and words to which the children were not exposed during the intervention.

Story comprehension The participants' story comprehension was assessed using a story retelling method which has been found to be more reliable than other methods when testing kindergarteners (e.g., de Jong and Bus 2003; Shamir et al. 2011). The children were asked to relate the story from its electronic format, which included the same text and illustrations but without accompanying animations, narration and sound effects. Their accounts were audiotaped, transcribed and encoded according to the similarity to the original story based on de Jong and Bus (2004). Each page was coded separately according to the following indices: (1) Recalling the main idea of each page; (2) The number of citations that the child quoted accurately from the original story; (3) The number of words which were from the original story. In order to validate the process, two raters first analyzed the protocols of 10 participants. Only after 90% agreement was reached were the remaining protocols reviewed.

2.4 The educational e-book

The story told in the educational e-book *Grandfather's Minibus* is read by a narrator. It includes a plot focusing on an amiable grandfather who takes his young grandson to

school on a minibus. As they drive toward their destination, they collect others along the way: the grandson's friends, animals, and the kindergarten teacher. The story aims at arousing children's reading motivation and curiosity by describing familiar characters and actions relevant to young children's experiences. Contrary to the printed version, the e-book includes activations related to the book's content, as in previous educational e-books we have written (Shamir et al. 2011; Shamir and Shlafer 2011). The book itself can be read in three different modes: (a) the *Read Story Only* mode enables reading or listening to the book without the activations that can distract children; (b) the *Dictionary* mode, which includes a dictionary, allows kindergarteners to repeatedly activate hotspots that provide explanations for the difficult words appearing in the story; and (c) the *Read with Hotspots* mode, which is designed to enhance phonological awareness (rhyming) and story comprehension which is enriched by initiating a playful interactive discourse with the main characters with the aid of voice and sound effects.

Metacognitive guidance The e-book version with metacognitive guidance is the same as the version without metacognitive guidance, as described above. However, it includes metacognitive guidance. In this version of the educational e-book, the instructions are activated automatically, by activity per screen page and at the conclusion of each page. Prior to initiating the activity on each screen, the narrator says: "Say to yourself: 'I am planning, listening, and observing.'" The narration is simultaneously accompanied by visual and vocal supports (e.g., the "Stop" symbol and the "gong" sound). After each activity and the related narration, the child presses on an icon that enables proceeding to the next screen. Before the screen actually changes, metacognitive guidance automatically appears in the form of instructions spoken by the narrator: "Ask yourself: did I understand? If I did, I can go on to the next page. If I did not, I will return to the current page". This verbal guidance is also supported visually (e.g., the "Stop" symbol) and vocally (the "gong" sound). At this stage, the participants can choose to reactivate the hotspots and either listen to the explanation once more (a conversation between characters, voices and sounds) or go to the e-book's next page.

2.5 Procedure

The procedure included six stages: (1) In the first (pre-intervention) stage, all participants were individually tested to assess their (verbal and nonverbal) cognitive level prior to determining their suitability for the research. (2) In the second (pre-intervention) stage, the selected participants were administered a vocabulary test. (3) In the third stage, the participants were randomly divided into three groups: an experimental group in which the children engaged in the educational e-book activity which included metacognitive guidance (EBM), an experimental group in which the children engaged in the educational e-book activity which did not include metacognitive guidance (EB), and a control group in which the children participated in the regular kindergarten program. (4) In the fourth (intervention) stage, children in the experimental groups experienced five independent sessions with the e-book, each lasting about 15–25 min for each of the three modes: in first and second sessions they

read using the *Read Story Only* mode, in third session they read using the *Dictionary* mode and in fourth and fifth sessions they read using the *Read with Hotspots* mode. (e) In the fifth (post-intervention 1) stage, which was conducted together with the last exposure to the software and no later than three days after the end of the intervention, the participants were individually administered the same vocabulary test that was administered in the first pre-intervention stage. Children's story comprehension was also tested for the first time during this stage. (f) In the sixth (post-intervention 2) stage, which was conducted seven weeks after the intervention, the participants were again individually administered the two tests (vocabulary and story comprehension) they had encountered in the post-intervention 1 stage.

3 Results

The results are presented according to the study's goals: the long-term effects of an e-book activity (EB/EBM – with/without metacognitive guidance) on: (a) vocabulary; (b) story recall (comprehension).

3.1 Long-term effect of an e-book activity on vocabulary

The children's pre-intervention vocabulary scores showed no significant group differences ($F(2,74) = .04$, $p > .0$) between the experimental groups exposed to the e-book (EB/EBM) activity and the control group that did not engage in it. There were also no differences between the groups in verbal and nonverbal abilities ($F(4148) = 1.24$, $p > .05$). The means and standard deviations of the pre- and post-intervention 1 and 2 vocabulary scores for the three groups are presented in Table 2.

A 3 × 3 repeated-measures ANOVA of *group* (EB/EBM/control) x *time* (pre- and post-intervention1 and post-intervention 2) was computed, with time as a repeated-measures variable, in order to test the effect of the e-book activity on vocabulary. A significant main effect was obtained for time ($F(2148) = 27.65$, $p < .001$, $\eta^2 = .(27$, indicating that the children's post- interventions scores were higher than their pre-intervention scores. There was also a significant *group* x *time* interaction ($F(4148) = 2.41$, $p < .05$, $\eta^2 = .06$), indicating that the pre- to post-intervention differences varied among the three groups (see Fig. 1).

As can be seen in Fig. 1, an improvement between pre- and post-intervention 1 was found in vocabulary among both the EB and EBM groups and a smaller one in the

Table 2 Vocabulary: pre, post1 & 2, means and standard deviations

Time							
Condition	Groups	Pre		Post1		Post2	
		M	SD	M	SD	M	SD
Vocabulary (0–20)	DBM	4.61	1.96	6.53	1.63	6.23	1.86
	DB	4.84	2.35	6.95	1.74	6.39	2.30
	Control	4.42	2.00	5.08	2.10	5.03	2.10

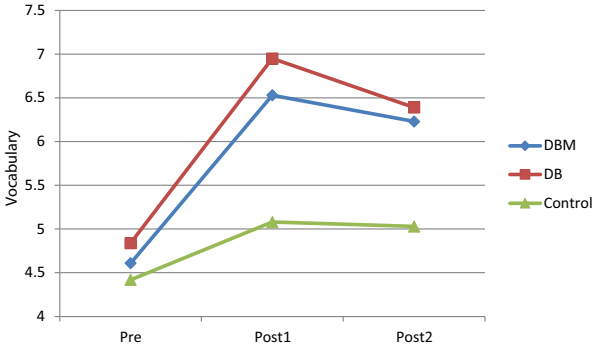

Fig. 1 Interaction effect of groups (DB/DBM/ Control) by time (Pre/ Post 1/ Post 2)

control group. As noted, no differences were found between the three research groups before the intervention. However, significant differences in vocabulary were found from pre-intervention to post 1 between the three research groups) $F(2,74) = 7.75$, $p < .01$, $\eta^2 = .17$). A Scheffe analysis showed significant differences between the two intervention groups and the control group. Further analysis for investigating differences between post 1 to post 2 showed significant differences between the two experimental groups and the control group ($F(2,74) = 3.22$, $p < .05$, $\eta^2 = .08$).

Simple effects analysis for analyzing the differences among the three groups between the pre to post 2 measurements showed significant differences among the EBM group ($F(1,25) = 16.94$, $p < .001$, $\eta^2 = .40$), the EB ($F(1,24) = 25.11$, $p < .001$, $\eta^2 = .51$) and according to the η^2, a small improvement among the control group ($F(1,25) = 2.12$, $p < .05$, $\eta^2 = .15$). It is important to note that the improvement from pre to post 2 among the control group is due to the improvement in vocabulary from pre to post 1, because no improvement was found between post 1 and post 2.

In conclusion, the findings show that although the three research groups showed higher vocabulary scores in post-intervention 1 and post 2, the EB and EBM groups' vocabulary scores were significantly higher in both post 1 and post 2. However, no differences were found between the EB and EBM groups. These findings imply that the improvement in vocabulary skills in the experimental groups exceeded that of the control group at post 1 and was still significantly higher than the control group at post 2.

3.2 Long-term effect of the e-book activity on story comprehension

The children's story recall (comprehension) was assessed only following the e-book activity among the two experimental groups. As noted, the story recall tool included three variables: recall of words, recall of quotes and recall of main ideas. A 2 × 2 MANOVA (groups x time) was computed with time as a repeated-measures variable in order to test possible differences between post-intervention 1 and 2 among the two groups (EB and EBM). Significant differences were found between time 1 and time 2 ($F(3, 46) = 10.43$, $p < .001$, $\eta^2 = .41$). However, no differences were found between the two research groups and no group x time interaction ($F(3, 46) = 1.07$, $p > .05$). The means and standard deviations of the post-intervention 1 and 2 story recall scores for the two experimental groups are presented in Table 3.

Table 3 Story Comprehension: Post 1 & 2, Means and Standard Deviations

Time						
Condition	Post1		Post2			
	M	SD	M	SD	F(1,48)	ŋ2
Words	34.92	30.90	28.98	24.68	6.38*	.12
Quotes	4.32	6.92	2.56	4.47	10.62**	.18
Main Idea	16.44	8.20	19.44	9.54	14.95**	.24

*$p < .05$ **$p < .01$

As can be seen from Table 3, analysis of each variable separately showed significant differences between post 1 and post 2 in each of the three variables. In the words and quotes variables there was a significant decrease, whereas improvement from post 1 to 2 was found in the main ideas variable. Since the SDs were higher than the mean scores for the variables of words and quotes, we also conducted a non-parametric analysis which showed the same results for words ($Z = 2.14$, $p < .05$) and quotes ($Z = 3.35$, $p < .001$).

In conclusion, the findings show that there were no differences in story comprehension between the two research groups. Both groups showed a decrease in word and quotes recall from post 1 to post 2 and an improvement in recall of main ideas.

4 Discussion

The main purpose of the present study was to investigate whether children at risk for LD retain language skills (vocabulary and story comprehension) which were acquired following an activity with an educational e-book. Since the literature shows that children with LD show a deficit not only in language but also in metacognition, we investigated whether metacognitive guidance embedded in an e-book would afford additional support compared to a regular educational e-book. The discussion of the main findings will be presented in three parts: Long-term effect of the e-book activity on vocabulary, long-term effect of the e-book activity on story comprehension and the effects of the metacognitive guidance embedded in the e-book on the children's language skills.

4.1 Long-term effect of the e-book activity on vocabulary

The findings show that the vocabulary level seven weeks after the first assessment was significantly higher among the intervention group without the metacognitive guidance than among the control group. However, no difference was found between the two intervention groups which read the e-book (with and without metacognitive guidance). This finding suggests that an educational e-book such as the one used in the current study has the potential to support vocabulary retention among children at risk for LD. It is important to note that the children in the current study exhibited lower verbal ability than expected for their age. The fact that the children at risk for LD retained the new vocabulary acquired following the five e-book activities is significant, because academic success in

school relies to a large extent on a large vocabulary in kindergarten (NICHD 2000). One of the main goals of teaching vocabulary in kindergarten is to acquire vocabulary that will be retained over time and will serve the child in learning to read and understand reading (Loftus et al. 2010). This is particularly important for children at risk for LD, since they often demonstrate low vocabulary (Gersten et al. 2001). Moreover, the literature indicates that children with LD are characterized by memory difficulties that negatively affect the ability to retain new words which were learned (Bryant et al. 2003; Swanson 2016). One of the challenges in early intervention for this population is therefore to find ways to promote retention of achievements. The finding of the current study is important because it indicates long-term retention of the new vocabulary among this population following the e-book activity. Perhaps e-books have the potential to support vocabulary retention due to their unique features. One of these features is the child's repeated exposure to new words in the e-book. It was found that multiple repetitions of new words support the retention of a new vocabulary (Bryant et al. 2003). In addition, e-books illustrate and dramatize the plot and the new words and thus probably help internalize the new vocabulary in the context of the story line (de Jong and Bus 2002; Matthew 1996). Another explanation for the research findings relates to the structure of the educational e-book used in the current study. This e-book allows the child to be exposed to the definition of the new word in the dictionary mode, as well within the context of the story. The child can reactivate the vocabulary function and can listen to the explanations as many times as he/she chooses. Teaching vocabulary in such a way that includes the definition of a word in addition to combining the new word in context has been found to be very effective in expanding children's vocabulary (Bryant et al. 2003; NICHD 2000). It seems that this way of learning may contribute to the retention of a new vocabulary among children at risk for LD. It is recommended that future studies further investigate the effect of exposure to e-books with and without reactivation of the vocabulary hotspots.

4.2 Long-term effect of the e-book activity on story comprehension

Although there was a decrease in recall of words and quotes from the story, the findings demonstrate an increase in the ability to recall the main idea from the story after seven weeks (post 2) in both intervention groups compared to the measurement immediately after the e-book intervention (post 1). These findings suggest that an activity with an e-book may support the recall of main ideas not only immediately after the intervention but also after seven weeks. The finding regarding the recall of main ideas immediately after the intervention is consistent with the findings of previous studies, which found that activity with an educational e-book supports story comprehension (de Jong and Bus 2004; Korat and Shamir 2007; Shamir et al. 2008). The unique contribution of the current study is in providing additional information on the impact of an activity with the e-book on story understanding over time. It seems that after seven weeks, the children can no longer use the exact words and quotes of the story, but can recall the main ideas of the story line. Story comprehension is based on abilities in various areas, including memory (Swanson 2016), knowledge of vocabulary (Neuman and Dickinson 2011) and the ability to draw conclusions. Children with LD and children at risk for LD are deficient in these areas compared to their peers with TD, and often exhibit difficulties in story line comprehension (Dodwell and Bavin 2008; Gersten et al. 2001; Kaderavek and Sulzby 2000). It should be noted that the improvement in recall of the main idea of

the story occurred despite the fact that there was no further exposure to the e-book in the seven weeks between the post 1 and the post 2 measurements. The fact that the level of understanding as reflected in story comprehension seven weeks after the end of the intervention improved without additional exposure to the story from the post 1 measurement may indicate the efficacy of this tool for children at risk for LD. As noted, contrary to the improvement in the idea recall, the recall of words and quotes was lower than in the first measurement after the intervention. The various findings regarding the main idea recall and the recall of words and quotes raise the need to examine whether it is possible to rely on the main idea recall in drawing conclusions about the children's story comprehension level The choice of story recall and its analysis according to the criteria of the main idea and the number of words and quotes was based on previous studies which examined the effect of reading an e-book on story comprehension and used the same criteria for evaluating recall (de Jong and Bus 2002, 2004; Korat 2010; Shamir et al. 2012). An examination of other studies which evaluated children's story comprehension through recall analysis suggests that the criteria used in these studies reflect the recall of the content and the plot, but do not refer to the recall of specific words and quotations (Dodwell and Bavin 2008; Doty et al. 2001; Glaubman et al. 1997; Matthew 1997; Morrow et al. 1990; Ricci and Beal 2002). Based on these studies, the criterion for recall of the main idea appears to be a criterion that also reflects story comprehension, and it is therefore possible to draw conclusions on the story comprehension level among children.

The question that arises is why was an improvement in the children's achievement level in the recall of the main idea found, but a decrease in the recall of words and quotations from the story over time. Frith (1989) argued that human beings tend to process information globally while paying attention to the meaning component and called it "central coherence". The human tendency to process information is received as a whole and the increased attention of the listener to the meaning component usually comes at the expense of attention and memory for details such as syntax and clauses for lexicons (Happe and Frith 2006). The representation of certain words and syntactic structures in memory thus diminishes over time (Cameron et al. 2005; Potter and Lombardi 1998). Similarly, the results obtained in the post 2 measurement in the present study indicated a decline in the retention of lexical components (words recall) and syntactic components (recall quotations) and retention of the meaning component (a main idea). According to neuropsychological models, the human tendency to process information as a whole and to focus attention on the element of meaning enables efficient storing of a large amount of information in memory. Retaining linguistic information consisting of phonological, semantic, syntactic and other units as a complete episodic representation reduces the burden on the cognitive system and enables storage of large amounts of information in the long-term memory (Baddeley 2003; Baddeley and Wilson 2002). It can be assumed that there was a decrease in the achievement level of words and quotations recall due to the tendency to process information as a whole and to focus attention on the meaning component.

The fact that many children at risk for LD have difficulty in phonological memory should be taken into account (Gathercole et al. 2008; Swanson and Saez 2003). This difficulty may have affected the level of words and quotations recall because the ability to recall words relies to a great extent on phonological memory. This is in contrast to recall of main ideas in a story that relies more on an entire episodic representation that exists in memory (Baddeley 2003).

The educational e-book used in the current study includes unique features that support story comprehension. For example, the possibility of being exposed to several repetitions of the story advances story understanding and the ability to recall the story (Korat 2010; Verhallen et al. 2006). Furthermore, previous findings showed that the presence of hotspots which included carefully-designed animations and effects to support the story plot contributed to understanding (Korat and Shamir 2007; Labbo and Kuhn 2000; Segal-Drori et al. 2009) and recall of the story (Verhallen et al. 2006). It is reasonable to assume that these unique characteristics of the specially-designed educational e-book used in the current study may have contributed to the understanding level and recall of the story over time. However, it is still necessary to explain what contributed to an increase, not just retention, in the recall of the main idea from post 1 to post 2. An explanation for this can be found in Morrow et al. (1990) who studied the contribution of reading books to kindergarteners at risk for LD. These researchers claim that a child's recall is not only a diagnostic tool, but also a therapeutic tool that can improve the narrative abilities of young children. A recall task requires the child to recall the story narrative actively, thereby promoting understanding skills, developing knowledge about story structure and oral language (Dickinson and Smith 1994; Sénéchal and LeFevre 2001). It is therefore possible that the request to recall the story as part of the children's assessment in the post 1 measurement was a factor that contributed to an improvement in the recall of the main idea in the post 2 measurement which took place seven weeks later. Based on the results of previous studies on story comprehension, Dickinson and Smith (1994) concluded that two main conditions are necessary for improving story understanding skills: significant exposure to a linked text and active construction of the element of meaning in the story. The present study included both of these conditions. The children who participated in the study were exposed to the story in the e-book several times, thus allowing them to be exposed significantly to a linked text. Recall of the story by the children from the two intervention groups enabled active recall of the meaning component in the story. In the present study, we used only one story, but it appears that the post 2 achievement was the result of the combination of repeated exposures to the story and the children's active recall of the story after post 1. These findings imply that an e-book may be an effective tool for retention and for promoting the ability to understand and recall a story when two conditions are met: repeated exposure to the narrative and active understanding of the story afterwards. It is important to note that seven weeks elapsed between the post 1 and post 2 measurements. It is possible that some maturity in the ability to understand and recall a story occurred during this period. However, time alone is probably not sufficient for a significant improvement in this area among young children at risk for LD. It seems that additional factors were needed (repeated exposure to the book and recall of the story) in order to improve the understanding level of the story from the post 1 to the post 2 measurement. Based on Dickinson and Smith (1994), it can be assumed that story recall after a small number of exposures to the story in the e-book will result in a lower level of achievement over time than after a larger number of exposures. Further studies are recommended for examining whether the number of repeated exposures to the story promotes its understanding by recall over time, also based on Dickinson and Smith (1994) who claimed that the assessment phase in which the children are asked to recall the exposed story may advance story understanding. It is thus possible that the children not only retained the main ideas in the story but increased

their achievement in post 2 because of the assessment in post 1. This assumption should be investigated in future studies.

4.3 Metacognitive guidance of the e-book

As mentioned, the guidance embedded in the second version of the e-book did not contribute to vocabulary and story retention. No differences were found between the achievement levels of the two intervention groups even in the post 1 measurement. There are several explanations for these findings. The first is related to the children's young age. Much of the research on metacognition.

Carried out to date was performed among adults and adult children (Whitebread et al. 2009; Whitebread 2014). The study on young children is still in its infancy and there is no consensus on the age at which it can be expected to improve in this area as a result of intervention. There is also no consensus among researchers on the development of metacognitive abilities in this age group (Shamir et al. 2009; Whitebread et al. 2009). It is possible that young children require metacognitive guidance that focuses specifically on vocabulary and specifically on the main ideas of the story line. As indicated by Veenman and Spaans (2005), metacognitive ability first develops while experimenting within each field of knowledge separately, and then gradually develops over time and becomes more and more general until an adult has the ability to use general metacognitive skills for a variety of domains. The extent to which specific metacognitive intent in the area of knowledge which is studied contributes to the advancement of language among young children should be investigated in further studies.

The absence of an effect of the metacognitive guidance incorporated in the e-book on language can be explained by the "cognitive load" theory. According to this theory, the capacity of an individual's working memory is limited, such that a complex task that requires many resources from the working memory capacity contributes to cognitive overload and impairs learning (Clark and Mayer 2008; de Jong 2010; Moreno 2004). One of the factors that affect the complexity of the task is the level of integration that must be carried out among the task components. When the material studied includes individual items and the level of integration required for learning is low, the cognitive load is small. As the number of items increases, the level of integration required of the learner is higher, and the workload increases. One of the main characteristics of the children involved in this study is that they are children at risk for LD who exhibit low verbal ability. This population is characterized by a low working memory capacity compared to peers with TD and are able to process relatively little information in a given time (e.g., Swanson and Saez 2003). In the intervention sessions in the present study, the children in the metacognitive guidance group were exposed to content on the subject of language and metacognitive guidance. The level of integration which was required of the children may have been too great and may have created cognitive overload, especially given their risk for LD. It can be assumed that the increased cognitive load impaired the children's ability to use metacognitive guidance in order to optimize learning, and therefore no difference in the level of achievement was found between the two intervention groups over time. Another factor that affects the cognitive load is previous knowledge about the field of learning. Knowledge in memory is organized in a cognitive structure called a schema. Based on the existing memory agreement, the new information can be processed more efficiently. When there

is previous knowledge about the learning domain, the cognitive load decreases because the new information can be processed more efficiently according to existing agreement (Mayer 2005). The children in the current study who are at risk for LD and have low verbal ability may lack prior language knowledge (Martini and Shore 2008). This may increase the cognitive load in tasks in this field. It can be assumed that the cognitive load generated during the children's activity with the e-book in this study was too great, especially in view of the limited processing resources available to children at risk for LD. The children were therefore unable to learn from the guidance and therefore the retention observed in the metacognitive guidance group was not greater than in the non-metacognitive guidance group.

Various researchers found evidence that young children are able to perform metacognitive activity more effectively when the task is significant for them (Deloache et al. 1985) and when the task and the context are known to them (Ceci and Bronfenbrenner 1985). Exposing children to a guidance activation before starting the e-book activity, in order to reduce the cognitive load, should therefore be considered. It is possible that in a situation where the metacognitive guidance is familiar to the children even before the beginning the activity with the e-book, they will be able to use it more efficiently when exposed to it. Further studies of gender and children's background are recommended in order to investigate additional possible explanation for this issue.

In conclusion, integrating metacognitive guidance in computer programs for children at risk for LD is very innovative. The present study found no support for the contribution of metacognitive guidance embedded in the e-book to retention of learning achievements. Children at risk for LD who exhibit low verbal ability have difficulties in retaining new information. The results of the present study, which show the retention of vocabulary and main ideas following the intervention with the educational e-book, are thus of special significance. The potential benefits of the e-book for learning, which exist under certain circumstances, especially for children with literacy deficits, and the findings that suggest that learning with computers supports metacognitive learning (Perry and Winne 2006), emphasize the importance of continuing research in this area.

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