Educational Psychology Review
https://doi.org/10.1007/s10648-021-09617-6

INTERVENTION STUDY

Embodied Action Scaffolds Dialogic Reading

Danielle Wall[1] · Sarah Foltz[1] · Anne Kupfer[1] · Arthur M. Glenberg[1,2,3]

Accepted: 28 April 2021/Published online: 13 May 2021

Abstract
Might dialogic reading require previous or concurrent embodied activities to be effective? Twenty-nine preschool children, ages 3–5 years, were randomly assigned to the control condition (children listened to a story eight times), the dialogic-then-embodied condition (children engaged in dialogic reading for four readings and then embodied action was added), or the embodied-then-dialogic condition. The embodied action required the child to act out components of the story using toys. Adding embodied action increased story recall, vocabulary acquisition, and positive affect (with generally large effect sizes). Thus, embodied action in conjunction with dialogic reading provides an effective model for promoting early literacy skills. We discuss the possibility that all benefits of dialogic reading come about through embodied processes.

Keywords Dialogic reading · Embodied cognition · Vocabulary acquisition · Language comprehension · E-books · Literacy skills · Educational technology

Embodied Action Scaffolds Dialogic Reading

This study examines two methods for improving literacy skills during shared reading: dialogic reading strategies and using principles of embodied cognition. Because we use an e-book in this research, we begin with a brief review of the literature on e-book reading followed by reviews of dialogic reading and embodied cognition. We then present an experiment that demonstrates how modifying dialogic reading in light of principles of embodiment can greatly enhance the benefits of dialogic reading for story comprehension, vocabulary learning, and positive affect. Our discussion focuses on implications of these results for instructors, parents, and future research. In addition, we discuss the theoretical possibility that all benefits of dialogic reading come about through embodied processes.

✉ Arthur M. Glenberg
glenberg@asu.edu

[1] Department of Psychology, Arizona State University, Mail Code 1104, Tempe, AZ 85287, USA

[2] University of Wisconsin-Madison, Madison, USA

[3] INICO, University of Salamanca, Salamanca, Spain

Shared Reading of E-books

The use of educational technology is increasing in schools (Korat & Shamir, 2008), and many schools use technology to boost emergent literacy skills such as phonological awareness, alphabet knowledge, word recognition, and vocabulary, that is, the skills needed for developing independent reading (Justice et al., 2009; Korat & Shamir, 2008). When e-books are used appropriately, the activity supports vocabulary acquisition and other reading skills (Smeets & Bus, 2012; Walker et al., 2017a). For example, in Walker et al. (2017a) elementary-age students read and moved pictures on an iPad to simulate the meaning of texts. This activity was effective in enhancing comprehension. Nonetheless, not all components of e-books are effective. Takacs et al. (2015) report that hotspots, games, and even dictionaries can be distracting.

Although e-books are capable of promoting emergent literacy skills, most commercial e-books do not emphasize acquisition of those skills and instead focus on graphics and animations. For example, after analyzing approximately 43 e-books, Korat and Or (2010) found that only 28% highlighted the text as the story was read, 28% included games that could distract from the story, and only 4.3% made a dictionary available (Korat & Shamir, 2008). E-books that were considered educational did attempt to promote phonological awareness, word recognition, and other emergent skills (Korat et al., 2009). Children who used this type of e-book learned up to 18% more words (Smeets & Bus, 2012). Additionally, Verhallen and Bus (2011) found that children were more likely to focus on parts of a picture that are mentioned in the text, thus suggesting that pictures can be a source of information for children (Fallon et al., 2015).

We will be using an e-book in our research. Nonetheless, except when specifically noted, our statements about reading and reading comprehension are meant to apply to both e-books and traditional books.

Dialogic Reading

Korat and Or (2010) suggest parental shared reading prepares children for academic achievement. Furthermore, they report that the level of success was determined by both the quality of the e-book and the quality of the parent-child interaction (Korat & Or, 2010). One form of parent-child interaction is dialogic reading, a method that focuses on creating a collaborative dialog between the parent and child in relation to the story (e.g., Lever & Senechal, 2011). Specifically, dialogic reading methods use open-ended "wh-" questions (often beginning with an interrogative such as "who," "what," "where," and "why"), repeat the correct answers, and expand on the child's answer through additional discussion (Lever & Senechal, 2011).

Dialogic reading consists of three phases (Lonigan, 2012; Whitehurst et al., 1988; Zevenbergen et al., 2018; for related work see Hirsh-Pasek et al., 2018). In the first phase, parents question children about literal components of the story and any pictures. In the second phase, children are asked open-ended questions so that they can describe the events of the story themselves. The third phase connects the story to the child's own life (e.g., "Do you remember when we went to the zoo?"). Dialogic reading is effective in improving expressive vocabulary and story recall in kindergarteners especially when the story is emphasized during the dialogic reading guided conversations (Lever & Senechal, 2011). In addition, Troseth et al. (2019) demonstrated how an e-book can be used to teach dialogic reading strategies to parents and thereby improve the quality of parental prompts and interchanges. Importantly, however,

Troseth et al. (2019) did not find any improvement on measures of child vocabulary or story comprehension associated with change in parental talk. Furthermore, the benefits of dialogic reading may be smaller than initially reported. Noble et al. (2019) reported an extensive meta-analysis of shared book reading. Although the average effect size (g = .194) was significant, when they only considered data from research using random assignment to an active control condition, the benefits largely disappeared (g = .028). Thus, there is a need to consider both how to improve dialogic reading methods and theoretical reasons for the variability in effect sizes.

Our study uses materials and procedures first developed by Fallon et al. (2015). That study aimed to answer whether using dialogic reading methods with an e-book could increase a child's understanding of the story's vocabulary and his or her ability to recall the story itself. Using an iPad, children listened to a story called "The Dream" developed by Swipea Kids Apps (2012). Because the story relates magical events that take place in the Middle East, it has some vocabulary that is likely to be unfamiliar such as "bazaar" and "mysterious." Thus, there was a good opportunity for vocabulary learning. (It should be noted, however, that in Fallon et al. and the current research all of the language used in the story, including all vocabulary words, are standard English).

Children in the control group listened to the story four times (in four sessions distributed over 4 days) while the researcher sat with the child without interacting. Children in the dialogic reading intervention participated in story-focused conversation with the researcher as they went through each listening. Specifically, these children received four different listening experiences. The first session included scripted questions (see online Supplementary Information) within the context of the story. These were simple questions about the events that occurred, the pictures on the page, and vocabulary from the story. The second session included open-ended questions that prompted the child to describe the events on the page. The questions asked during the third session related parts of the story and the vocabulary to the child's own life. The final dialogic reading session was child-led; that is, the child drove the conversation. Pre-test and Post-test measures were included to test vocabulary acquisition and story recall.

Fallon et al. (2015) found that children in the dialogic reading condition scored significantly higher on Post-test measures of story recall than those in the control group. In regard to vocabulary, children in both groups improved, but there was not a significant difference between the conditions.

Embodied Cognition

Theories of embodied cognition suggest that sensory, motor, and emotional processes underlie all cognition, including language comprehension and reading (Glenberg, 2008; Glenberg & Gallese, 2012; Sadoski, 2018; for other approaches to embodied cognition see Barsalou, 2008; Chemero, 2009; Lakoff, 1987; Proffitt & Baer, 2020). Also, there are clear links between educational technology and embodied cognition as described in Agostinho et al. (2016), Johnson-Glenberg (2018), Lindgren and Johnson-Glenberg (2013), and Walker et al. (2017b).

According to Glenberg and Gallese (2012), reading comprehension is a simulation process. The reader uses the words to drive sensorimotor and emotional systems much as if the reader were literally experiencing the situations described by the text. For example, to understand a sentence such as, "He worked long and hard digging ditches in the desert soil," a reader might use his or her visual system to imagine what a desert looks like (e.g., Rueschemeyer et al.,

2010), the motor system is used to imagine the act of digging (e.g., Hauk et al., 2004), and the emotional system is used to simulate the feelings (e.g., Havas et al., 2010).

Although embodied cognition is a theoretical approach to cognition, it also suggests methods that enhance learning (see Sadoski, 2018, for a review of methods). For example, Glenberg et al. (2004) introduced a two-part intervention to teach children simulation while reading. In the physical manipulation (PM) stage, children manipulated toys to act out sentences, thus creating an external simulation. For example, when reading a story that takes place on a farm, the child might encounter, "The farmer drove the tractor to the barn." To apply PM, the child would literally move the toy farmer to the tractor and then move the tractor to the barn. Thus, PM helps the child to map the word "tractor" to the object (and thus the sensory information produced by perceiving the object) and map the syntax of the sentence (the who does what to whom) to her own actions. (See Pouw et al. (2014) for a review of the effectiveness of instructional manipulatives.) After success in the PM stage, the child is taught imagine manipulation (IM); that is, the child is asked to imagine moving the toys rather than literally moving them. Thus, IM teaches the child how to create internal simulations. PM and IM have been demonstrated to enhance reading comprehension (Glenberg et al., 2004; de Koning et al., 2017), and when the child has adequate decoding skill, IM generates transfer to new stories (Adams et al., 2019). Additionally, PM and IM are effective when the child manipulates computer graphics instead of physical toys (e.g., Glenberg et al., 2009; see also Hald et al., 2015), and Walker et al. (2017a) demonstrated the effectiveness of the procedure within an e-book context.

Both Vygotsky and Bruner presaged components of dialogic reading and embodied cognition. Vygotsky's (1962, 1978) sociocultural educational theory and the concept of the zone of proximal development stress the importance of the teacher and student communicating during learning opportunities, much like dialogic reading strategies place emphasis on creating a collaborative dialog. Furthermore, Vygotsky's theory suggests that teachers should assume an interactive role so that the student can then individually construct knowledge, placing emphasis on the active role of the student (Verenikina, 2008). Wells (1999) further identifies key components of Vygotsky's work suggesting that the co-constructed dialog must first support the student in a task they could not handle alone, assisting them to achieve independent competence and finally allow for demonstration of that competence. Wells explains this as an effective approach to scaffolding.

Wood et al. (1976) discuss scaffolding as a means of understanding Vygotsky's zone of proximal development. That is, through scaffolding, a child can learn concepts that would otherwise be unlearnable given the child's current knowledge. Bruner (1968) further suggests that children learn first through "enactive" representations, followed by "iconic," and finally "symbolic" representations. That is, the primary way children understand the environment is through action and through interacting with objects around them. In the iconic stage, children use images to represent the world, and in the symbolic stage children use language and symbols as a means of understanding (Bruner, 1968). (We would argue, however, that linguistic symbols need to be grounded in sensorimotor and emotional systems to be meaningful.)

Bruner's attention to the importance of action-based learning mirrors the importance of using embodied strategies in learning. Furthermore, looking back to Vygotsky (1962), he places emphasis on social interactions and culture as a means of learning, as in dialogic reading. In summary, from the perspective of Vygotsky and Bruner, the benefits of social interaction that come from dialogic reading ought to be enhanced by adding embodied action.

Research Questions

We now get to the heart of the issue and the questions guiding the current research. Dialogic reading can be effective, but it does not always improve a child's vocabulary and comprehension. Might adding an embodied component using PM and IM enhance dialogic reading so that it increases comprehension and vocabulary? Note that dialogic reading depends on the child having the appropriate experiences to engage in dialog. For example, one component of dialogic reading is to connect the story to the child's own life. However, when reading about, for example, a farm, if a child has never visited a farm, parents would not ask, "Do you remember our visit to the farm?" In contrast, when reading about a farm using PM and IM, those activities provide the sensorimotor experiences that the child can use even in the absence of a visit to a real farm.

Research Question 1 Does combining dialogic reading with PM and IM result in greater story comprehension than dialogic reading alone? (Specific planned comparisons are described in the "Results" section.)

Research Question 2 Does combining dialogic reading with PM and IM result in greater vocabulary acquisition than dialogic reading alone when the PM is used as part of the vocabulary learning?

Research Question 3 Does combining dialogic reading with PM and IM improve vocabulary acquisition even for those words encountered without PM and IM?

Research Question 4 Does combining dialogic reading with PM and IM enhance the child's affective engagement as measured by rated positive affect, attention, and engagement?

Methods

Participants

All procedures were approved by the Arizona State University IRB for STUDY00006326. The participants were enrolled in a laboratory preschool associated with a university in the southwestern region of the USA. The average age was 4 years and 9 months with the youngest being 3 years and 7 months and the oldest being 5 years and 6 months; there were five 3-year-olds, twelve 4-year-olds, and twelve 5-year-olds. Most of the children (22) were non-Hispanic White children with the remaining seven representing various ethnicities. Eight of the children had some facility with a second language, and one was a non-native English speaker who was learning English simultaneously with his native language. After data collection was completed, we learned that one child had a formal autism spectrum disorder diagnosis. We chose to keep this child's data because the child's receptive language skills were within the range of the other members of the triad (see below).

Children were recruited based on previously measured receptive vocabulary scores on the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 2007). Invitations to participate were extended to 36 children with comparable PPVT scores between the ages of 3 and 5 years.

Parents of 30 children provided consent to participate. Following the start of the study, one child completed only two of the sessions and therefore was excluded from the analyses. The final sample included 29 children (18 male), with 9 in the control group and 10 in each of the experimental groups. Following informed consent, we created triads based on the PPVT scores and age. One child in each triad was then randomly assigned to each of three conditions: control, dialogic-then-embodied, or embodied-then-dialogic.

Procedure

All children received nine individual sessions, and children were always tested individually. The first session included a Pre-test of vocabulary and story comprehension. The vocabulary words are in Table 1. Each word was read to the child, and then the child was asked, "What do you think_____means?" The comprehension questions are in Table 2[1]. For the Pre-test, the child was told, "I know we haven't read the story yet so these questions might be tough, but I want you to take your best guess." Immediately following the Pre-tests, the children heard the story for the first time. They heard the story three more times, once on each of the next three sessions. At the beginning of the fifth session, the Mid-tests (see Tables 1 and 2) were administered. The Mid-tests were followed by four additional shared readings (sessions 5–8). Finally, the Post-tests (see Tables 1 and 2) were administered at the ninth session. The child received a small gift at the end of each session. Time between each session was between 2 and 4 days. Thus, it took between 4 and 5 weeks for each child to complete the entire procedure. Children in the same triad were tested within the same week to control for any week-to-week variation. In addition, the same researcher worked with all the children in a triad to minimize any effect of differences among the researchers.

Control Condition

Children in the control condition simply listened to the story during the eight sessions.

Dialogic-then-Embodied Condition

Children in this condition received a researcher-led, dialogic reading–informed script based on Fallon et al. (2015) and reproduced in the online Supplementary Information. In the first session, the dialogic questions focused on the pictures visible on the iPad. For example, the experimenter would ask "Who is this?" while pointing to Ahmed or "What color is the house?" Whenever an emphasized (i.e., taught) vocabulary word was encountered, it was defined, and the child repeated the word. For example, the experimenter's half of the dialog for one word was, "What is Ahmad doing? He is digging in the *soil*. Soil is another word for dirt. Can you say soil? Great!" In the second session, the researcher asked open-ended questions such as "What is happening in this picture?" In the third session, the questions attempted to bring in the child's experiences, such as "What color is your house?" The fourth session was child-directed, meaning the child was able to move forward, ask questions, or make comments as the child saw necessary, and hence not scripted.

[1] Asking comprehension questions before the initial reading of the text serves two purposes. First, it provides a measure of baseline knowledge. Second, it allows us to demonstrate that correctly answering the questions requires information obtained from the text (see the Pre-test data in Table 3).

Table 1 Tested vocabulary words

Soil*	Departure*	Hesitation
Fortune*	Puniest	Curiosity
Mysterious	Inspected*	Mounted*
Startle*	Realized	Merchant*
Suddenness*	Tempered	Contented*
Puzzled*	Despair*	Swiftly
Trudging	Bazaar*	

Note: Words with asterisks were emphasized (explicitly taught) in the dialogic-then-embodied and embodied-then-dialogic conditions

Starting in the fifth session, these children received the embodied PM script (along with the toys illustrated in Fig. 1) combined with dialogic questions. The three sets of toys in Fig. 1 correspond to three scenes in the story: one that takes place around Ahmed's house, one that involves a dream, and one that takes place at a bazaar. Much like the dialogic reading sessions, the researcher led the first three of the embodied sessions; however, these sessions focused on PM and IM. There were four scripts, one used in each of the four sessions (see Supplementary Information). During the first two sessions, children physically manipulated the three-dimensional figures based on stated actions in the story. For example, in the first embodied session, the researcher asked the question, "Why does Ahmad wake up?" Interaction around this question included the researcher using PM to teach the vocabulary word "startled." The researcher instructed the child to make the Ahmad toy express being startled by making him jump up out of bed. In addition, when the story implied movement of characters or objects, the child literally moved the objects.

In the second embodied session, the child sets up the scene with the toys. The child was instructed "let's make the toys match the pictures on the page." As in the first embodied session, the child moved the characters and the objects to correspond to the story.

For the remaining two sessions, children were instructed to imagine the actions, that is, to use IM. In the third embodied session, the toys were present but pushed back so that the children could not touch them. The children were instructed that they could look at the toys to help them with their imagination. The fourth embodied session did not have a page-by-page script and the toys were not present. Instead, at the start of the session the researcher encouraged the child to use his or her imagination. In remainder of the session, any conversation (and IM) was child-led.

Table 2 Comprehension questions

Who is the story about?
What does Ahmad's house look like at the beginning of the story?*
Where does Ahmad go in the story?
Why does he go there?
Does Ahmad's family know why Ahmad left for Cairo?*
What animal does Ahmad take on his trip?
What did his dream tell him to do when he got to the Bazaar?*
Who does he talk to when he is in the bazaar?
How does the Merchant make Ahmad feel?*
What was the Merchant's dream?*
How long does he stay in the bazaar?
What does Ahmad find when he gets home?
What does Ahmad do to find his treasure?*
How does the camel feel after Ahmad finds his fortune?*

Note: Questions indicated with an asterisk were not asked at the Pre-test

Fig. 1 Toys used in embodied scripts. Near Ahmed's house (top); dream sequence (middle); bazaar (bottom)

Embodied-then-Dialogic Condition

The order of the scripts was changed for the children in this condition. That is, for the first four shared reading sessions, the children received the embodied scripts (and the toys depicted in Fig. 1); for the last four sessions, the children received the dialogic scripts (without the toys).

Incentives

All children participated in an incentive program to help keep their interest and engagement throughout the eight readings. That is, the attractiveness of the incentives increased across reading sessions. For each consecutive reading session, children were given one of four different sized prize boxes. The prize boxes were referred to as the first box, the new box,

the big box, and the biggest box. Children worked their way up to the biggest box during their first four reading sessions. The size of the toys in each of the boxes increased with the size of the boxes as well. The children chose a toy from the appropriate box at the completion of each session. Following the Mid-test, the children started with the first box with verbal reminders that the boxes would once again increase in size.

Measures

Receptive language measures were used in creating the matched triads. Two of the 10 triads were matched based on their raw scores on the tabletop version of the Peabody Picture Vocabulary Test Fourth Edition (PPVT-4; Dunn & Dunn, 2007). The remaining triads were paired based on the uncorrected standard score of the NIH Toolbox Picture Vocabulary Test for Early Childhood (see https://www.healthmeasures.net/explore-measurement-systems/nih-toolbox). Children were matched with others who were within 10 or fewer points of each other. The average difference between picture vocabulary scores was 3, and the largest difference was 8. Children were also matched by age, with each child in a triad being within 5 months of age of the other children in that triad. Creating these triads was intended to reduce error variability between the conditions.

Vocabulary The vocabulary measure of the Pre-test, Mid-test, and Post-test included the same 20 words. For each test, the children (tested individually) were shown each of the words on a piece of cardstock. The researcher read the word aloud and asked the child to define the word. The responses were recorded for later scoring. A score of 0 was given to a non-response, an "I don't know" response, or an unrelated incorrect response. For example, for the word "startled," an unrelated incorrect response would be an answer such as "when you start to do something." A score of 1 represented an emerging response, or a partially correct response, meaning the response showed a general understanding but did not fully demonstrate a full knowledge of the word. It also included an answer that used words in the definition correctly but did not define the word itself. For the word "startled," a child would receive a score of 1 if the child stated, "It means to wake up in a startle." This response was considered partially correct because within the context of the story, it is the behavior Ahmad demonstrated. Nonetheless, the child does not define the word. Additionally, a score of 1 was assigned to an answer that was correct but not within the context of the story, for example, if a child stated, "I was startled when I saw a spider one time." Whereas this answer is correct, it does not relate back to the story and therefore does not demonstrate learning from the context of the story. Scores of 2 and 3 represented a correct response; however, a 2 was an answer that required one prompt. Prompting was only given after a child initially gave "I don't know" as a response. If a child answered I don't know twice, the child then received a 0; however, the child could also earn a 1 or 2 depending on a second answer. A score of 3 was only given to a fully correct response without any prompting. A fully correct answer for the word startled would be "scared," or "If you jumped out of bed because you were scared."

To assess reliability, a second coder independently scored vocabulary using the same scoring method. The Pearson correlations between the two coders were .976 (Pre-test), .977 (Mid-test), and .980 (Post-test).

Story Comprehension A score of 0 was given to a non-response, an "I don't know" response, or an unrelated incorrect response. For example, one question was "What does Ahmad do to

find his treasure?" The correct answer is "dig under the carob tree." An incorrect answer is "Marry a princess!" A score of 1 was given to an emerging response or a partially correct response that showed a general, but not specific, understanding. A partially correct response was "go home." Although Ahmed did return home to dig for his treasure, this response does not show full understanding of the events of the story. A score of both 2 and 3 represented a correct response; however, a 2 is an answer that required one prompt. Prompting was only given after a child initially gave "I don't know" as a response. If a child answered I don't know twice, he or she then received a 0; however, he or she could also earn a 1 or 2 depending on the second answer. A 3 was only given to a fully correct response without any prompting, such as a response that mentioned digging. The Pre-test was scored out of 21; the following tests include additional questions (see Table 2) and were scored out of 42.

To assess reliability, a second coder independently scored story comprehension using the same scoring method. The Pearson correlations between the two coders were 1.000 (Pre-test), .997 (Mid-test), and .988 (Post-test). Coders based their scoring on a written transcript that included the child ID number but not the condition. Although the primary coder was aware of which child ID corresponded with which child (and thus potentially the condition), the secondary coder was completely blind to condition.

Positive Affect, Engagement, and Attention Coding To assess positive affect, engagement, and attention of each child during all 8 training sessions, video recordings were reviewed. For all three measures, a 5-point Likert scale was used. The positive affect measure was based on positive cues such as smiling, laughing, and remarks. A score of 1 indicated no displays of positive affect, while a score of 5 indicated at least three large, intense positive displays. The engagement measure assessed the child's level of participation in the activities. A score of 1 indicated that the child was not engaged with the task and required repeated directions. A score of 5 indicated that the child was very engaged with the task and that there was no need for repeated directions. The attention measure indicated the child's level of focus with a score of 1 meaning not attentive (requiring more than six prompts to refocus to the task) and a score of 5 meaning very attentive and demonstrating the ability to refocus themselves.

To assess reliability of the ratings, a second coder scored data from all eight sessions for 12 of the children. (Unfortunately, data were lost from one participant so that reliability is based on 95 of the 96 possible observations.) The values of the Pearson correlations were .74, .85, and .73 for the engagement, attention, and positive affect scores, respectively. When the two coders disagreed, the score from the primary coder was used.

Results

Research Question 1

Does combining dialogic reading with PM and IM result in greater story comprehension than dialogic reading alone? The data relevant to Research Question 1 are in Table 3.

We answer this question using a series of planned comparisons when we have clear predictions and a fuller, exploratory analysis when we do not. The predictions (and hence planned comparisons) are as follows.

Table 3 Mean percent story comprehension (standard deviation)

Condition	Pre-test	Mid-test	Post-test
Control	3.17 (6.30)	50.79 (15.88)	56.88 (14.21)
Dialogic-then-embodied	0.95 (2.01)	55.71 (22.57)	69.52 (23.08)
Embodied-then-dialogic	0.95 (3.01)	69.76 (22.70)	73.10 (22.48)

RQ1a There will be greater improvement from Pre-test to Mid-test for children in the embodied-then-dialogic condition (i.e., the children who used PM and IM before the Mid-test) than for children in the control condition. This prediction was verified, $F(1, 17) = 6.57$, $p = .02$, with a partial eta-squared effect size of .28 (i.e., a large effect). Although we did not make a specific prediction for the improvement from Pre-test to Mid-test for the children in the dialogic-then-embodied condition relative to the control condition, we note for completeness that this interaction was not significant, $F(1, 17) < 1$.

RQ1b There will be greater improvement from Pre-test to Mid-test for children in the embodied-then-dialogic condition than for children in the dialogic-then-embodied condition (children who have not yet used PM and IM). Although the means were clearly in the right direction (see Table 3), this effect was not confirmed statistically (probably because of low power), $F(1, 18) = 2.10$, $p = .17$.

RQ1c At the Mid-test, performance in the embodied-then-dialogic condition will exceed that for children in the control condition. This prediction was practically confirmed, $t(26) = 1.99$, $p = .058$, Cohen's $d = .96$ (a large effect, using the error term from an ANOVA with all three conditions and hence 26 degrees of freedom). The difference between the control condition and the dialogic-then-embodied condition was not significant $t(26) = 0.52$.

RQ1d At the Mid-test, performance in the embodied-then-dialogic condition will exceed that for children in the dialogic-then-embodied condition. Again, although the means were clearly in the right direction, this prediction was not confirmed, $t(26) = 1.52$, $p = .14$.

These results are consistent with Noble et al.'s (2019) meta-analysis showing small effects of dialogic reading when contrasted to an active control condition. Overall, the weight of the evidence (RQ1a, RQ1c, and the direction of means in RQ1b and RQ1d) indicate that combining dialogic reading with an embodied manipulation results in greater story comprehension than dialogic reading alone. These data are also consistent with reviews by Pouw et al. (2014) and Sadoski (2018), and with data presented in de Koning et al. (2017), although we tested children considerably younger than in most research looking at embodiment effects on language comprehension.

The exploratory analyses involved performance on the Post-test. At the Post-test, children in both the dialogic-then-embodied and embodied-then-dialogic conditions have read the book using dialogic questioning alone, and when dialogic question has been combined with PM and IM. Consequently, the question is whether having initial interaction with the text of one kind or another makes a difference. For example, having the embodied experience first may prepare the children for better learning when only dialogic questioning is used. However, it might also be the case that embodied interaction (or listening to the story eight times) results in near-ceiling learning. Thus, for analyses of the Post-test story comprehension, we did not use

planned comparisons. There were no significant effects when analyzing the Post-test data alone.

Research Question 2

Does combining dialogic reading with PM and IM result in greater vocabulary acquisition than dialogic reading alone when PM is used as part of the vocabulary learning? Data relevant to this question are in Table 4.

The analysis strategy for Research Question 2 directly parallels that for Research Question 1.

RQ2a There will be greater improvement from Pre-test to Mid-test for children in the embodied-then-dialogic condition (i.e., the children who used PM and IM before the Mid-test) than for children in the control condition. Although the means were in the predicted direction (see Table 4), this prediction was not verified statistically, $F(1, 17) = 2.38$, $p = .14$. Although we did not make a specific prediction for the improvement from Pre-test to Mid-test for the children in the dialogic-then-embodied condition relative to the control condition, we note for completeness that this interaction was not significant, $F(1, 17) = 1.38$, $p = .26$. Note also that the interaction effect is in the wrong direction. That is, numerically there was a greater improvement from the Pre-test to the Mid-test for the control condition (3.7% to 9.6%) than for the dialogic-then-embodied condition (4.4% to 6.7%).

RQ2b There will be greater improvement from Pre-test to Mid-test for children in the embodied-then-dialogic condition than for children in the dialogic-then-embodied condition (children who have not yet used PM and IM). This prediction was confirmed by a significant interaction (see Table 4), $F(1, 18) = 5.16$, $p = .04$, with a partial eta-squared effect size of .22 (a large effect).

RQ2c At the Mid-test, performance in the embodied-then-dialogic condition will exceed that for children in the control condition. This prediction was not confirmed, $t(26) = 1.39$, $p = .18$. The difference between the control condition and the dialogic-then-embodied condition was also not significant $t(26) = 0.64$.

RQ2d At the Mid-test, performance in the embodied-then-dialogic condition will exceed that for children in the dialogic-then-embodied condition. This prediction was confirmed, $t(26) = 2.09$, $p = .05$, $d = .84$ (a large effect). Again, these results are consistent with Noble et al.'s (2019) meta-analysis showing small effects of dialogic reading when contrasted to an active control condition. Overall, the weight of the evidence (RQ2b, RQ2d, and the direction of means in RQ2a and RQ2c) indicates that combining dialogic reading with an embodied manipulation results in greater taught vocabulary acquisition than dialogic reading alone.

Table 4 Mean percent taught vocabulary acquisition (standard deviation)

Condition	Pre-test	Mid-test	Post-test
Control	3.70 (3.11)	9.57 (05.91)	7.10 (5.74)
Dialogic-then-embodied	4.44 (4.93)	6.67 (8.51)	21.11 (14.12)
Embodied-then-dialogic	2.50 (4.43)	15.83 (13.23)	22.22 (19.99)

Again, the exploratory analyses involved performance on the Post-test. The main effect of condition was not quite significant, $F(2, 26) = 3.04$, $p = .07$. None of the pairwise comparisons were significant after a Bonferroni correction.

Research Question 3

Does combining dialogic reading with PM and IM improve vocabulary acquisition even for those words not taught with PM and IM? We had no strong predictions for this dependent variable. In fact, children did quite poorly on the tests of the non-taught vocabulary, with condition means between 3 and 5% and means of 4%, 3%, and 4% for the Pre-test, Mid-test, and Post-test, respectively. One factorial ANOVA compared performance on the Pre-test to the Mid-test crossed with the three conditions. No effects were significant, all Fs < 1. A second factorial ANOVA compared performance on the Mid-test to the Post-test crossed with the three conditions. Again, no effects were significant, all Fs < 1.

Research Question 4

Does combining dialogic reading with PM and IM enhance the child's affective engagement as measured by rated positive affect, attention, and engagement? To better correspond to the analyses of story comprehension and vocabulary, we averaged the ratings for the first four readings (corresponding to the Mid-test) and the second four readings (corresponding to the Post-test). Nonetheless, these analyses are not completely comparable to earlier analyses because there are no Pre-test data. That is, we do not have ratings before shared reading began. Data for positive affect, attention, and engagement are in Table 5.

RQ4a At the Mid-test, children who read using PM and IM in the previous four readings (i.e., children in the embodied-then-dialogic condition) will show greater positive affect than children in the control condition. This prediction was confirmed, $t(26) = 4.37$, $p < .01$, $d = 2.10$ (a large effect). Although we did not make a specific prediction for the dialogic-then-embodied condition relative to the control condition, we note for completeness that there was no significant difference between the control condition and the dialogic-then-embodied condition, $t(26) = 1.80$, $p = .08$.

Table 5 Rated positive affect, attention, and engagement with standard deviations in parentheses

Condition	Positive affect		Attention		Engagement	
	Mid-test (sessions 1–4)	Post-test (sessions 5–8)	Mid-test (sessions 1–4)	Post-test (sessions 5–8)	Mid-test (sessions 1–4)	Post-test (sessions 5–8)
Control	1.08 (0.25)	1.39 (1.17)	4.08 (0.56)	4.04 (0.76)	4.36 (0.60)	4.25 (1.07)
Dialogic-then-embodied	1.80 (0.93)	3.08 (1.12)	4.05 (0.79)	3.65 (0.70)	4.22 (0.49)	4.40 (0.39)
Embodied-then-dialogic	2.83 (1.12)	1.85 (0.71)	3.75 (0.63)	4.02 (0.88)	4.10 (0.56)	4.38 (0.44)

RQ4b At the Mid-test, children who read using PM and IM (i.e., children in condition embodied-then-dialogic) will show greater positive affect than children in the dialogic-then-embodied condition. This prediction was confirmed, $t(26) = 2.64$, $p = .01$, $d = 1.00$ (a large effect).

RQ4c At the Post-test, children who read using PM and IM in the previous four readings (now, children in the dialogic-then-embodied condition) will show greater positive affect than children in the Control condition. This prediction was confirmed, $t(26) = 3.63$, $p < .01$, $d = 1.48$ (a large effect). There was no significant difference between the control condition and the embodied-then-dialogic condition (children who had used dialogic reading alone in the previous four readings), $t(26) = 0.99$, $p = .33$.

RQ4d At the Post-test, children who read using PM and IM in the previous four readings (now, children in the dialogic-then-embodied condition) will show greater positive affect than children in the embodied-then-dialogic condition. This prediction was confirmed, $t(26) = 2.70$, $p = .01$, $d = 1.34$ (a large effect).

The data from these four comparisons are consistent with de Koning et al. (2017). They found that embodied training greatly enhanced reading motivation for 9-year-old children.

We had a parallel set of predictions for the attention and engagement measures as for positive affect. However, none of the analyses of attention and engagement produced significant effects (see Table 5).

Discussion

Embodied action scaffolds dialogic reading. That is, the weight of the evidence is that PM and IM produce the cognitive activities that make dialogic questioning effective in significantly increasing both vocabulary learning and story comprehension. (Note that dialogic reading by itself, compared to the control condition, did not significantly improve story comprehension (Table 3) or taught vocabulary (Table 4) at the Mid-test, although admittedly, power is low.) Why should this be? One possibility is that the combination of embodied activities and dialogic reading results in more dialogic interaction and helps to focus the child's attention. This alternative seems unlikely given the absence of effects for our attention and engagement measures. Consideration of the literature on embodied cognition and reading comprehension also suggests that this alternative is, at best, incomplete. For example, Glenberg et al. (2004) controlled for time on task and attention to important information but still observed benefits of embodied action. Second, irrelevant action produces no benefits; only actions that result in a simulation of the text are beneficial. Third, Glenberg et al. (2019) showed that the benefits of PM and IM on listening comprehension were strongly correlated with activity in sensorimotor cortex while listening; this correlation would not be expected if the mechanism behind PM and IM were attention to the task.

A second possibility for explaining the benefits of embodied activities is that it is more fun. Indeed, the data in Table 5 clearly demonstrate that when engaged in PM and IM, the children were displaying greater positive affect than with dialogic reading alone (and see de Koning et al., 2017). Positive affect alone, however, cannot be the whole reason for the improved

comprehension and vocabulary. Data in Table 4 show that PM and IM (in the embodied conditions) increase the learning of targeted vocabulary. However, PM and IM had no effect on learning the words that were not targeted. That is, just because the children were having more fun in the embodied-then-dialogic condition, they did not learn everything (i.e., the non-targeted words) better than in the control condition or the dialogic-then-embodied condition. Action congruent with the information that needs to be learned (as in the targeted vocabulary) appears to be necessary.

If not attention and not motivation, how can we explain the benefits of the embodied manipulation over the dialogic manipulation? Theories of embodied cognition provide an answer. Namely, language comprehension requires simulation in sensorimotor and emotional cortices (e.g., Glenberg & Gallese, 2012; Hald et al. (2015); de Koning, 2017; Pouw et al., 2014; Sadoski, 2018). On this account, listening to words, and even the ability to recall words verbatim, does not guarantee comprehension. Instead, comprehension is an imaginative process of using words and phrases to drive the sensorimotor cortex into states homologous to those during literal experience with the situation the language describes. PM teaches children how to construct these imaginative simulations by externalizing the process. IM teaches children how to internalize the process.

As an example, consider again how the vocabulary word "startled" was taught. In the first session of the dialogic-then-embodied condition, the researcher interacts with the child by saying, "Why does Ahmad wake up? That's right, (repeat child's answer). He was startled. That means to feel frightened or scared. Can you say startled?" Although the child is provided with a definition of "startled," there is no guarantee that the child understands this definition. That is, the child might simply be processing the word forms, not their meanings. In contrast, in the first session of the embodied-then-dialogic condition, the researcher says, "Why does Ahmad wake up? That's right, (repeat the child's answer). He was startled. That means to feel frightened or scared. Because he's startled he jumps out of bed. Make him jump. Let's make him startled (hand over Ahmad and make him shake). Can you say startled?" That is, the PM actions (jumping and shaking) directly embodies the meaning of "startle" for the child.

Our conclusion is generally consistent with a decades-long research record indicating improved comprehension when using a mental imagery strategy similar to IM (e.g., Sadoski & Paivio, 2013). However, it should be noted that most of the previous literature has involved older participants than the 3- to 5-year-old children in our research.

Although we have focused our embodied explanation on overt hand and arm actions, it is certainly the case that more was involved. For example, the pronunciation of "startled" is inflected both in the dialogic and embodied activities, but that inflection is accompanied by action when PM was used, thereby making it more noticeable. Similarly, the research assistants may have used greater facial expression such as eye-widening during PM. We see these components as part of embodied activity that helps to induce appropriate emotional responses that are part of the meaning of a word such as "startled" (e.g., Ponari et al., 2020).

Our results raise the possibility that dialogic reading works by providing the opportunity for embodied simulation. That is, it is not the mere fact of asking questions, or engaging in dialog, that is beneficial. Instead, many parents and teachers will direct dialog in a direction that will allow the child to engage in simulation[2]. For example, when reading about activities on a farm,

[2] Not all parents and cultures naturally engage in question-asking. Mesa and Restrepo (2019) report that Latino parents with primary or secondary educations rarely ask questions during shared reading. Similarly, Gómez et al. (in press) document that college-educated Latino immigrant parents (in the USA) rarely ask questions.

but knowing that the child had recently been to a zoo, the parent might ask, "When we went to the zoo, what were the animals that we saw?" Asking this question allows the child to access her sensorimotor experiences (e.g., what she did and saw at the zoo) to both understand the question and generate an answer that continues the dialog. Of course, this sort of interaction has added benefits of social interaction, potentially extending the child's vocabulary and syntax, and generating positive affect. But these added benefits arise by taking advantage of embodied processes. Going back to the Noble et al. (2019) meta-analysis, it may well be the case that when dialogic questions tap into the child's embodied experiences (or provide those experiences during the question asking using something like PM), that dialogic reading outperforms control conditions. However, if the questions remain on a verbal level, they may produce only modest gains.

Our results have implications in several domains. First, they document the effectiveness of a shared reading technique that can be incorporated into classroom or at-home activities. An added bonus is that the activities increase positive affect as well as learning.

Although we have demonstrated how PM and IM can scaffold dialogic reading, it may appear impractical. That is, we went through considerable effort to construct the elaborate materials depicted in Fig. 1. However, several research projects suggest that benefits of embodied interaction can be achieved with far less effort. As one example, Macedonia (2014) used gesture, without any literal objects, to facilitate vocabulary acquisition in a second language. In addition, Gómez et al. (2019) had children read a text about Newton's laws of motion to learn vocabulary such as "force" and "acceleration." In one condition, children moved pictures on the screen of an iPad to simulate sentences such as "When you pull the boat by the rope, the pulling force starts the boat moving." In another condition, the children used whole-body actions to act out the sentence without any objects. Both of these conditions resulted in significant gains in vocabulary acquisition relative to control conditions, and there was no difference between the two embodied conditions. That is, the benefits of embodied interaction can be achieved without elaborate props. Both of these projects were conducted with participants considerably older than the preschool children used in the current project. Nonetheless, we see no reason why whole-body actions would be ineffective with young children.

A second implication of our results relates to e-book reading. Simply listening to an e-book (e.g., our control condition) does not result in much vocabulary learning. Adding interaction such as PM and IM (see, for example, Walker et al., 2017a) will significantly increase the learning. But, can an e-book further increase learning by adding dialogic questions? We think that this possibility is unlikely. The e-book is unlikely to be able to take the place of a parent or teacher who is familiar enough with the child to ask questions related to the child's sensorimotor experiences. Nonetheless, this is an open empirical question.

Third, our results have implications for future research. Of course, there are limitations on our research (see below) that need to be addressed. But, the research also suggests a new interpretation of dialogic reading that needs to be directly tested. If, indeed, dialogic reading is only effective when it promotes embodied processing, then there is an opportunity for creating more effective teaching techniques as well as a better understanding of human cognitive development.

Several limitations of our research should be considered. The first limitation concerns the sample. Only 29 children participated in the study. Not only is the sample small, but also all

children were selected from one preschool. Thus, caution is needed to generalize the findings beyond the current sample. However, the benefits of PM and IM have been demonstrated for diverse samples (e.g., Glenberg, 2011; Hald et al., 2015; de Koning, 2017; Pouw et al., 2014; Sadoski, 2018; Walker et al., 2017b).

Second, constraints of experimental design limited full application of dialogic reading. For example, the structure of the e-book limited the opportunities for discussion, and the e-book disrupted the flow of conversation. This structure impacted both dialogic reading and embodied action procedures. Furthermore, the ability to physically manipulate the objects in the story was limited to the items in Fig. 1. Although the research on embodied cognition supports both e-book manipulation of pictures and three-dimensional manipulation, the presence of the manipulatives possibly produced distraction because the researchers had to prepare the scenes while the child listened to the story presented by the iPad. Many children observed the researcher rather than the e-book itself.

Third, the story itself limits generalization. The selected book was set in a different country with a different cultural background than that of many of the participants. As a result, parts of the story and plot included concepts that were foreign to the participants and could be considered difficult to understand.

Even with these limitations, we think that it is a safe bet to encourage physical, embodied action along with dialogic reading. The technique is clearly valuable for some populations; that is, it enhances story comprehension and vocabulary acquisition. Furthermore, because embodied actions engender positive affect, we believe that they are likely to motivate both parents and children to use dialogic reading. Thus, as Vygotsky and Bruner would have predicted, embodied action supercharges the benefits of dialogic reading.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10648-021-09617-6.

Acknowledgements Many thanks to the children, parents, and staff of Arizona State University's Child Study Laboratory. Additional thanks to Ashlie Woodburn whose senior honors project inspired this research and who developed the dialogic script and to the publishers of Swipea Kids for the permission to use images. Arthur Glenberg was partially supported by grants 1324807 and 1917636 from the National Science Foundation. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Availability of Data and Materials All data are available from the corresponding author.

Author Contribution DW contributed to conceptualization, data collection, data analysis, and writing. SF contributed to conceptualization. AK contributed to conceptualization. AMG contributed data analysis and writing.

Funding Arthur Glenberg was partially supported by grants 1324807 and 1917636 from the National Science Foundation.

Declarations

Ethics Approval All procedures were approved by the Arizona State University IRB for STUDY00006326.

Competing Interests The authors declare no competing interests.

References

Adams, A. M., Glenberg, A. M., & Restrepo, M. A. (2019). Embodied reading in a transparent orthography. *Learning and Instruction, 62*, 27–36.

Barsalou, L. (2008). Grounded cognition. *Annual Review of Psychology*, 59.

Bruner, J. S. (1968). *Toward a theory of instruction*. W.W. Norton.

Chemero, A. P. (2009). *Radical embodied cognitive science*. The MIT Press.

Dunn, L. M., & Dunn, D. M. (2007). *PPVT-4: Peabody picture vocabulary test*. Pearson Assessments.

Fallon, A., Truong, Q., Serrano, L., & Kupfer, A. (2015). *Examining the effects of dialogic reading methods on early literacy skills of typically developing children [poster presentation] Four Corners ABA*. Santa Fe.

Glenberg, A. M. (2008). Embodiment for education. In P. Calvo & A. Gomila (Eds.), *Handbook of cognitive science: An embodied approach* (pp. 355–372). Amsterdam.

Glenberg, A. M., & Gallese, V. (2012). Action-based language: A theory of language acquisition, comprehension, and production. *Cortex, 48*(7), 905–922. https://doi.org/10.1016/j.cortex.2011.04.010.

Glenberg, A. M., Goldberg, A. B., & Zhu, X. (2009). Improving early reading comprehension using embodied CAI. *Instructional Science, 39*, 27–39.

Glenberg, A. M., Gutierrez, T., Levin, J. R., Japuntich, S., & Kaschak, M. P. (2004). Activity and imagined activity can enhance young children's reading comprehension. *Journal of Educational Psychology, 96*(3), 424–436.

Glenberg, A. M., Marji, M. L., Schwartz, C., Kupfer, A., Nguyen, T., & Blais, C. (December, 2019). *Learning to listen*, *Poster presentation*. Annual ASU/UA Cognitive Science Conclave.

Gómez, L. E., Glenberg, A. M., Badilla, M., Restrepo, M. L., & Walker, E. (December, 2019). *Action, not technology enhances comprehension*. Annual ASU/UA Cognitive Science Conclave.

Gómez, L. E., Restrepo, M., Glenberg, A. M., & Walker, E. (in press). Enhancing question-asking during shared reading in immigrant Latino families. *Journal of Latinos and Education.*

Hald, L. A., van den Hurk, M., & Bekkering, H. (2015). Learning verbs more effectively through meaning congruent action animations. *Learning and Instruction, 39*, 107–122. https://doi.org/10.1016/j.learninstruc.2015.05.010.

Havas, D. A., Glenberg, A. M., Gutowski, K. A., Lucarelli, M. J., & Davidson, R. J. (2010). Cosmetic use of botulinum toxin-a affects processing of emotional language. *Psychological Science, 21*(7), 895–900. https://doi.org/10.1177/0956797610374742.

Hauk, O., Johnsrude, I., & Pulvermüller, F. (2004). Somatotopic representation of action words in human motor and premotor cortex. *Neuron, 41*(2), 301–307.

Hirsh-Pasek, K., Alper, R. M., & Golinkoff, R. M. (2018). Living in Pasteur's quadrant: How conversational duets spark language at home and in the community. *Discourse Processes, 55*(4), 338–345. https://doi.org/10.1080/0163853X.2018.1442114.

Johnson-Glenberg, M. C. (2018). Immersive VR and education: Embodied design principles that include gesture and hand controls. *Frontiers in Robotics and AI., 5*. https://doi.org/10.3389/frobt.2018.00081.

Justice, L. M., Kaderavek, J. N., Xitao, F., Sofka, A., & Hunt, A. (2009). Accelerating preschoolers' early literacy development through classroom-based teacher-child storybook reading and explicit print referencing. *Language, Speech, and Hearing Services in Schools, 40*(1), 67–85.

de Koning, B. B., Bos, L. T., Wassenburg, S. I., & van der Schoot, M. (2017). Effects of a reading strategy training aimed at improving mental simulation in primary school children. *Educational Psychology Review, 2017*(29), 869–889. https://doi.org/10.1007/s10648-016-9380-4.

Korat, O., Segal-Drori, O., & Klien, P. (2009). Electronic and printed books with and without adult support as sustaining emergent literacy. *Journal of Educational Computing Research, 41*(4), 453–475.

Korat, O., & Or, T. (2010). How new technology influences parent-child interaction: The case of e-book reading. *First Language, 30*(2), 139–154.

Korat, O., & Shamir, A. (2008). The educational electronic book as a tool for supporting children's emergent literacy in low versus middle SES groups. *Computers & Education, 50*(1), 110–124.

Lakoff, G. (1987). *Women, fire, and dangerous things: What categories reveal about the mind*. University of Chicago Press.

Lever, R., & Senechal, M. (2011). Discussing stories: On how a dialogic reading intervention improves kindergarteners' oral narrative construction. *Journal of Experimental Child Psychology, 108*(1), 1–24.

Lindgren, R., & Johnson-Glenberg, M. (2013). Emboldened by embodiment: Six percepts for research on embodied learning and mixed reality. *Educational Researcher, 42*(8), 445–452. https://doi.org/10.3102/0013189X13511661.

Lonigan, C. (2012). *CONNECT Video 6.4: Dr. Christopher Lonigan: Using CROWD prompts.* [Video File] http://community.fpg.unc.edu/connec4t-modules/resources/ videos/video-6-4

Macedonia, M. (2014). Bringing back the body into the mind: Gestures enhance word learning in foreign language. *Frontiers in Psychology, 5*. https://doi.org/10.3389/fpsyg.2014.01467.
Mesa, C., & Restrepo, M. A. (2019). Effects of a family literacy program for Latino parents: Evidence from a single-subject design. *Language, Speech, and Hearing Services in Schools, 50*(3), 356–372.
Noble, C., Sala, G., Peter, M., Lingwood, J., Rowland, C., Gobet, F., & Pine, J. (2019). The impact of shared book reading on children's language skills: A meta-analysis. *Educational Research Review, 28*, 28. https://doi.org/10.1016/j.edurev.2019.100290.
Ponari, M., Norbury, C. F., & Vigliocco, G. (2020). The role of emotional valence in learning novel abstract concepts. *Developmental Psychology, 56*(10), 1855–1865.
Pouw, W. T. J. L., van Gog, T., & Pass, F. (2014). An embedded and embodied cognition review of instructional manipulatives. *Educational Psychology Review, 26*(1), 51–72. https://doi.org/10.1007/s10648-014-9255-5.
Proffitt, D., & Baer, D. (2020). *Perception: How our bodies shape our minds*. St. Martin's Press.
Rueschemeyer, S.-A., Glenberg, A. M., Kaschak, M. P., Mueller, K., & Friederici, A. D. (2010). Top-down and bottom-up contributions to understanding sentences describing objects in motion. *Frontiers in Psychology, 1*. https://doi.org/10.3389/fpsyg.2010.00183.
Sadoski, M. (2018). Reading comprehension is embodied: Theoretical and practical considerations. *Educational Psychology Review, 30*(2), 331–349. https://doi.org/10.1007/s10648-017-9412-8.
Sadoski, M., & Paivio, A. (2013). *Imagery and text: A dual coding theory of reading and writing*. Routledge.
Smeets, D. J. H., & Bus, A. G. (2012). Interactive electronic storybooks for kindergarteners to promote vocabulary growth. *Journal of Experimental Child Psychology, 112*(1), 36–55.
Swipea Kids App. (2012). The dream, read along to me & storytime for kids (Version 3.3.6) [Mobile application software]. https://apps.apple.com
Takacs, Z. K., Swart, E. K., & Bus, A. G. (2015). Benefits and pitfalls of multimedia and interactive features in technology-enhanced storybooks: A meta-analysis. *Review of Educational Research, 85*(4), 698–739. https://doi.org/10.3102/0034654314566989.
Troseth, G. L., Strouse, G. A., Flores, I., Stuckelman, Z. D., & Johnson, C. R. (2019). An enhanced ebook facilitates parent-child talk during shared reading by families of low socioeconomic status. *Early Childhood Research Quarterly, 50*, 45–58.
Verenikina, I. (2008). Scaffolding and learning: Its role in nurturing new learners. In P. Kell, W. Vialle, D. Konza, & G. Vogl (Eds.), *Learning and the learner: Exploring learning for new times* (pp. 161–180). University of Wollongong, Australia https://ro.uow.edu.au/edupapers/43.
Verhallen, M. J. A. J., & Bus, A. G. (2011). Young second language learners' visual attention to illustrations in storybooks. *Journal of Early Childhood Literacy, 11*(4), 480–500.
Vygotsky, L. S. (1962). *Thought and Language*. MIT Press.
Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.) Cambridge, MA: Harvard University Press
Walker, E., Adams, A., Restrepo, M. A., Fialko, S., & Glenberg, A. M. (2017a). When (and how) interacting with technology-enhanced storybooks helps dual language learners. *Translational Issues in Psychological Science, 3*(1), 66–79. https://doi.org/10.1037/tps0000100.
Walker E., Wong A., Fialko S., Restrepo M.A., & Glenberg A.M. (2017b). EMBRACE: Applying cognitive tutor principles to reading comprehension. In: André E., Baker R., Hu X., Rodrigo M., du Boulay B. (eds) *Artificial Intelligence in Education*. AIED 2017. Lecture Notes in Computer Science, vol 10331. Springer, .
Wells, G. (1999). *Dialogic inquiry: Towards a sociocultural practice and theory of education*. Cambridge University Press.
Whitehurst, G. J., Falco, F. L., Lonigan, C. J., Fischel, J. E., Debaryshe, B. D., Valdez-Menchaca, M. C., & Caufield, M. (1988). Accelerating language development through picture book reading. *Developmental Psychology, 24*(4), 552–559. https://doi.org/10.1037/0012-1649.24.4.552.
Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*(2), 89–100.
Zevenbergen, A. A., Worth, S., Dretto, D., & Travers, K. (2018). Parents' experiences in a home-based dialogic reading programme. *Early Child Development and Care, 188*(6), 862–874. https://doi.org/10.1080/03004430.2016.1241775.