

1 The effects on children's literacy skills of reading e-books with different features: Are 'bells  
2 and whistles' over-rated?

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**Abstract:** Children’s literacy skills in schools and at home are widely supported by technologies designed to advance their development. Surprisingly, the unique effects of specific interface features are widely disputed and inconsistent research findings make it challenging to generalise across different technologies. It is difficult to make an informed choice about which types of e-books, and which specific features, are most effective. This small-scale, experimental study examines the effects of specific interface features and compares them to a Flat e-book. In a pre- and post-test comparison design, we investigated the effects of three different e-book conditions 1) ‘Flat’ e-book, 2) ‘E-friend’, and 3) ‘Dictionary’. Ninety typically developing Year-1 readers were selected from nine primary schools in England and then randomly assigned to one of the experimental groups. Results showed that children in the ‘Dictionary’ group increased more in Word Recognition of target words compared to the children in the ‘E-friend’ group. However, children in the ‘E-friend’ group made significantly greater gains in Reading Comprehension than children in the ‘Dictionary’ group. Children in the ‘Flat e-book’ performed as well on all measures as children in the enhanced features groups. We suggest new directions for research on features that might be superior to Flat e-books.

**Keywords:** e-book; intervention; young readers; digital features; literacy development.

## 1. Introduction

Children's literacy and language skills in schools and at home are widely supported by technological devices such as electronic books (e-books). Indeed, a number of research studies have reported that well-designed e-books can support children above and beyond traditional books and are able to enhance children's phonological decoding skills, vocabulary and comprehension [1–7]. The enhancements in e-books make the reading experience qualitatively different from that of traditional paper books [8].

When children read or listen to e-books, they can choose to read a story themselves, listen to the story, and/or engage with interactive features [9]. E-books include features like animated pictures, hotspots, sounds and activities. They often incorporate oral reading and print that changes colour as it is being narrated, which helps the child follow the text [4]. Previous literature demonstrates that the 'highlighting' of written words when read out by a narrator exposes children to grammatical forms of written language and draws attention to individual words [4,10–13]. In addition, activities might expand children's knowledge of the story's events beyond the original text.

E-books can provide children with 'personalised' reading support, enabling them to read independently and assume greater control over their own learning [14]. They have the potential to support, encourage and motivate children [15], possibly because of the digital enrichments that traditional books do not have [8]. They can make books fun through lively animations and expose children to print and pictures in an enjoyable manner. In contrast, when children read traditional books, they can set their own pace but might struggle with decoding unfamiliar words or understanding passages without the help of an accomplished reader [16].

The literature on adult support during traditional book reading shows clear benefits for children. A meta-analysis on the added value of parent-child interactions during shared book reading demonstrated that it is not just exposure to storybooks that fosters children's literacy

development but that parent-child dialogue is equally important [17]. Parents' participation strengthens the effects of book reading and boosts story comprehension and language development by, for example, asking specific questions and expanding on the text [17].

E-books and the like contain increasingly more enhanced features that resemble adult support. Hotspots, which are intended to provide additional information to the reader [18] are inserted to activate questions about the story and highlight the pronunciation of words, mimicking a parent-child interactive reading session. However, too many embedded features may distract children from the narration. Only when narration and non-verbal information are congruent with one another, are e-books able to promote story and text comprehension [8]. Embedded dictionaries, which provide synonyms or definitions of difficult words, may be similar to parents' explanations when children do not know a word. Similarly, highlighting and narrating of text may be similar to adults pointing to words when a child reads traditional print books. Interestingly, however, a recent study has shown that the attention of young (pre-school aged) children was not always on the word being pointed at by the adult [19].

One major drawback in a rapidly changing technological world is that many e-books are untested and potentially not of educational benefit [20–22]. Bus et al. [8] warn about cognitive overload and the fact that young children find it difficult to divide their attention between story comprehension and on-demand features like dictionaries and pronunciations. The authors suggest that multitasking requires complex executive functions, and that many young children are not yet able to control their attention skills effectively and switch between story text and embedded features.

Another major criticism of research on e-book features is that studies are heterogeneous [9] and research findings inconsistent [11]. Findings depend on the nature of the specific e-books used and do not readily generalise to other products, making it difficult to draw firm conclusions about what advantages children gain from e-books and other devices [23,24].

1 Unique effects of specific interface features are disputed and unclear [21,22]. The  
2 effectiveness of a particular e-book depends on several factors, including the quality and  
3 purpose of the e-book, the specific reading skills promoted, accompanying activities, the  
4 child's age, their initial knowledge, and how they use the e-book [11,24]. For example,  
5 highlighting of text in e-books has been found to have limited effects on the print-specific  
6 skills of children under 5 [25], whereas it has been found to be effective for older children  
7 [11,26,27]. Furthermore, the impact on children's recall skills is still in question [9]. A study  
8 by de Jong & Bus [4] demonstrated that children who read e-books with numerous hotspots  
9 were able to recall as much from the story as from stories read to them by adults. Another  
10 study by Ricci and Beal [28] found that children who read enhanced e-books with hotspots  
11 (unrelated to the story) had improved recall. However, another study showed that children  
12 who read 'enhanced' e-books recalled significantly fewer narrative details than children who  
13 read the print version of the same story [29].

14 A recent meta-analysis (43 studies) on the effects of technology-enhanced stories on young  
15 children's literacy development by Takacs et al. [9], found a small but significant additional  
16 benefit of technology for story comprehension ( $g=+.17$ ) and expressive vocabulary ( $g=+.20$ ).  
17 The authors conclude that technology could enhance the effects of storybooks on young  
18 children's literacy development. However, it was suggested that a wide variety of technology-  
19 enhanced stories and measures were used in the studies and effects were heterogeneous. The  
20 authors underscore the "importance of investigating the effects of different technological  
21 features on literacy development" (p. 30) [9]. Bus et al. [8] also call for well-controlled studies  
22 that examine the effects of new e-book and app formats on emerging literacy skills. They  
23 emphasise that researchers are obliged to examine key components of effective digitised  
24 books, so that technology might reduce the disparity in academic performance between groups  
25 of students.

1 In sum, inconsistent findings limit generalising across different software products, making  
2 it difficult to make an informed choice about which incorporated features are most effective.

3 What features support children's literacy and language skills? Does the combination of certain  
4 features result in additional support for reading?

5 The current study attempts to tease apart some of the common interface features found in  
6 e-books and investigates which features are effective in supporting specific literacy skills.

7 Three e-book conditions were compared. The first was a 'Flat' e-book, to act as a 'control'  
8 condition. This was simply a book in PDF format which included flat illustrations and text.

9 The other two separated certain features in order to study their effects independently. The 'E-  
10 friend' e-book was designed to support general reading of the text as well as understanding of  
11 the story. It involved a character who would ask questions and offer highlighting and audio  
12 cues. The 'Dictionary' e-book was also designed to offer enhanced reading support, although  
13 its main feature, inbuilt dictionary definitions and pronunciations of individual words, focused  
14 on certain key words.

15  
16 Based on the literature, the following hypotheses were tested:

- 17 1. Children in the E-friend and Dictionary groups will have higher scores on target *word*  
18 *reading* when compared with the Flat e-book group.
- 19 2. Children in the E-friend condition will demonstrate higher scores on story *comprehension*  
20 compared with the other groups.
- 21 3. Children in the E-friend and Dictionary groups will show higher scores on *recalling* the  
22 story than the Flat e-book condition.
- 23 4. Children in the Dictionary group will demonstrate higher scores than children in the other  
24 conditions to describe the *meaning of target words*.

## 2. Method

### 2.1. Design

The effects of three e-book conditions were examined in a randomised control trial with three experimental conditions:

- *'Flat e-book'* (N=30): Children independently read an e-book with flat illustrations and text on a computer. This e-book included no additional features, audio, highlighting or animations. It was identical to a paperbook, but presented on a computer screen, with pages being advanced by the child clicking the mouse, and thus can be seen as the 'control' group.
- *'E-friend'* (N=32): Children independently read the E-friend e-book. Pressing the "E-friend" button opened a separate window in which the E-friend asked a question about the story. The E-friend did not have audio; children had to read the question themselves. Children also had access to visual highlighting and an audio cue via the "Speaker" button. It should be noted that children were only able to hear the full sentence read aloud to them in a 'story-telling' voice but could not click on separate words for pronunciations (as in the Dictionary e-book).
- *'Dictionary'* (N=28): Children independently read the Dictionary e-book and could access pronunciations of each individual word but not the full sentence (as in the E-friend version). When children clicked on a word they received the pronunciation in a computer voice. The e-book also included inbuilt dictionary definitions taken from a well-known children's dictionary. When children clicked on the "Dictionary" button challenging words were highlighted. If the child clicked on a highlighted word, the pronunciation and definition was given by a human voice in a separate window.

### 2.2. Participants

A total of 90 typically developing Year-1 readers (34 boys) from diverse socioeconomic status (SES) families were selected from 9 primary schools in Oxfordshire. Children's ages ranged between 68 and 84 months ( $M=74.64$  months,  $SD=3.71$ ). Children who speak English as an additional language (EAL) were represented in the sample ( $N=27$ ). Informed parental consent was obtained in line with the British Psychological Society (BPS) guidelines. Children's assent was also obtained informally. The number of participants per school varied from 2 to 15. Eligible children were randomly assigned to one of three conditions, stratified for school.

### 2.3. Intervention Material

The book 'The Parachute' [30] was selected, which was available in all three e-book formats. The book presents a simple story around an event with two children and an alien. The book included detailed illustrations but not detailed enough to enable the child to understand the story without narration. The length of the story text was 214 words. Participants in the three conditions read the story once, either as a 'Flat', 'E-friend' or 'Dictionary' e-book. Before reading the E-friend and Dictionary e-book, a small 'feature demo' introduced children to the e-book functionality.

### 2.4. Apparatus

Children performed the e-book activities individually on a laptop computer with attached mouse. All assessments were given orally and the experimenter recorded the responses on a standardised form.

### 2.5. Pre- and Post-test Assessments

The following standardised assessments were administered to children at pre-test:



- 1 • *British Ability Scale (BAS) Naming Vocabulary subscale* [31] measures expressive  
2 vocabulary.
- 3 • *Wechsler Abbreviated Scale of Intelligence (WASI) Matrix Reasoning Subscale* [32]  
4 measures non-verbal reasoning and working memory, which are associated with reading  
5 and recall skills [33]. Unstandardised adjusted raw scores were used, as 19 children were  
6 not old enough to register a standard score.

7

8 The following tests were developed for this study. Prior to testing, the authors compiled a  
9 scoring manual for the Comprehension, Recall and Word Definitions questions, that included  
10 ‘legitimate’ correct answers and exemplar ‘incorrect’ answers. The manual was strictly  
11 adhered to during scoring, although very occasionally the authors added incorrect responses  
12 to the manual after discussion.

- 13 • *Target Word Reading*: test to assess word recognition (decoding) of printed words from  
14 the ‘Parachute’ book (scored 0/1 for incorrect/correct responses; maximum: 21). Each  
15 child was asked to read aloud 21 target words individually presented in a random order.  
16 Test items generally occurred no more than twice throughout the book, although  
17 ‘parachute’ had 10 occurrences. The split-half internal reliability (Spearman–Brown  
18 coefficient) for this measure was .80.

- 19 • *Target Definitions* (post-test only): test to assess children’s knowledge of the meaning of  
20 21 target words in the e-books that had ‘definitions’ in the Dictionary format. (Scored 0/1  
21 for incorrect/correct responses following scoring manual procedure; maximum: 21.) The  
22 internal reliability was .80.

- 23 • *Story Comprehension* (post-test only): task that included 6 open-ended questions about the  
24 story events (1 inferential question, 1 complex phrase question and 4 factual questions).

(Scored 0/1/2 for incorrect/partially correct/fully correct responses; maximum: 12.) The internal reliability was .70.

- *Recall* (post-test only): measure to assess children's recall of the e-book story. Children had to recall the story without the aid of the book. (Scored 0/1 for omission/inclusion; maximum: 13.) The internal reliability was .64.

- *Enjoyment questionnaire* (post-test only): this measure was included for descriptive purposes. A Likert scale measure was used to capture children's enjoyment of e-books.

## 2.6. Procedure

Primary school teachers were asked to select children who were able to read at the Oxford University Press level 5-8. Struggling readers (level <5) and very good readers (level >8) were not included. Children were randomly assigned to 3 groups (Flat, E-friend and Dictionary), stratifying for school. A member of the research team conducted the randomisation by using a random digit generator in Microsoft Excel. The procedure was not blinded, owing to limitations associated with the small scale of the study.

The intervention and assessments took place in the school in a quiet area free from distraction. The pre-assessments were conducted in one session and intervention/post-tests in another. Children worked individually through an e-book during the intervention session and were post-tested immediately afterwards. Due to the exploratory, small-scale nature of the study the tester was not blind to the particular e-book the children had read.

Children were asked to read an e-book story at their own pace. They used the computer mouse to activate a new page, go back, select a feature, etc. None of the children had problems manipulating the mouse. During the e-book reading, a researcher was always present, but did not interfere in the child's activities. Anecdotal records indicated that few children used the Dictionary feature.

### 3. Results

#### 3.1. Exploratory Data Analyses

Preliminary screening for normality revealed that one variable (WASI) showed a significant skew. An appropriate standard data transformation (square root transformation for modest positive skew) was undertaken on this variable prior to further analysis [34]. Transformation improved the distribution substantially. No significant differences between the three conditions were found at pre-test. The children demonstrated above average verbal skills (BAS scores: Flat 116.97, E-friend 118.56, and Dictionary 119.59) in comparison to the norming sample (100), the possible implications of which are considered in the discussion.

Inter-correlations across the measures are presented in Table 1, followed by the means and standard deviations for the three groups in Table 2. Table 1 shows weak ( $r = .20$  to  $.33$ ) to moderate ( $r = .40$  to  $.59$ ) correlations among the measures. As expected, the correlations between Target Word Reading pre- and post-test ( $r = .70$ ) and Target Word Reading post-test and Definitions ( $r = .81$ ) were strong. The WASI only weakly correlated with Word Reading (pre and post) and Definitions, whereas the BAS correlated with all dependent variables (weak to moderate). We report partial eta squared ( $\eta^2_p$ ) as an indicator of effect size, which is provided by the statistical software package (SPSS 21).

*<Insert Table 1 and 2 about here>*

#### 3.2. Analysis strategy

An analysis of covariance (ANCOVA) and a multivariate analysis of covariance (MANCOVA) were carried out to test the hypotheses presented in this study. Target Word

1 Reading was the only dependent measure administered at pre- and post-test; therefore an  
2 ANCOVA was conducted with e-book condition as between factor (Flat, E-friend,  
3 Dictionary).

4 A MANCOVA was carried out on the Comprehension, Recall and Definitions scores,  
5 with condition as between factor. The MANCOVA was chosen to account for multiple testing  
6 and for inter-correlation between the dependent variables to reduce the chance of a Type 1  
7 error. Both analyses included as covariates children's age (in months) because the dependent  
8 variables were not age-adjusted, and the WASI to control for non-verbal reasoning. As the  
9 randomisation was stratified by school, school was also included as a covariate. Pre-test  
10 Target Word Reading was used as a covariate for the ANCOVA, to ensure that any post-test  
11 difference truly results from the treatment and to account for variation in where the children  
12 started [35]. Since pre-test measures were not available for the three dependent measures used  
13 in the MANCOVA, the BAS Naming Vocabulary was used to control for children's language  
14 skills.

### 16 3.3. Target Word Reading

17 Assumptions of ANCOVA were met [34]. An ANCOVA was run to determine the effect  
18 of e-book group on post-intervention Target Word Reading after controlling for school,  
19 WASI, pre-test, and age (months). A statistically significant difference in post-intervention  
20 Target Word Reading was found between the intervention groups,  $F(2, 75) = 3.597, p < .05$ ,  
21 partial  $\eta^2_p = .09$ . Post-hoc analysis was performed with a Bonferroni adjustment. Post-test  
22 Target Word Reading scores were significantly greater in the Dictionary group versus E-friend  
23 group, mean difference of 1.357 (95% CI, 0.063 to 2.652),  $p < .05$ . No significant differences  
24 were found between the Flat versus E-friend group, mean difference of .946 (95% CI, -.336 to

2.227),  $p > .05$  and Flat versus Dictionary group, mean difference of  $-.412$  (95% CI,  $-1.786$  to  $.963$ ),  $p > .05$ .

### 3.4. Comprehension, Recall and Definitions

Tests of normality and sphericity showed no violations of assumptions. A multivariate analysis of covariance (MANCOVA) was run to determine the effect of e-book type (Flat, E-friend and Dictionary) on children's reading performance. The measures assessed were Comprehension, Recall and Definitions; covariates were school, WASI and BAS scores, and children's age. The differences between the groups on the combined dependent variables was statistically significant:  $F(6, 142) = 2.459$ ,  $p = .027$ ; Wilks'  $\Lambda = .810$ ; partial  $\eta^2_P = .094$ .

Follow-up univariate ANCOVAs showed that children's Comprehension scores differed significantly between the groups:  $F(2, 73) = 3.248$ ,  $p = .045$ ; partial  $\eta^2_P = .082$ . Bonferroni post-hoc tests showed that children from the E-friend group had significantly higher mean Comprehension scores than children from the Dictionary group ( $p < .05$ ), but no significant differences were found between the E-friend and Flat e-book group ( $p > .05$ ) or the Dictionary and Flat e-book group ( $p > .05$ ). Lastly, ANCOVAs for Recall and Definitions did not show significant effects:  $F(2, 73) = 2.826$ ,  $p > .05$ ; partial  $\eta^2_P = .072$  and  $F(2, 73) = 1.827$ ,  $p > .05$ ; partial  $\eta^2_P = .048$  respectively.

### 3.5. Enjoyment

Results showed little variation in scores: the majority of children enjoyed reading e-books, and children in all groups reported equally that they (really) liked using the computer for reading and preferred reading e-books over paper books.

## 4. Discussion

1 This study examined the effects on literacy skills of three e-book types. A small-scale pre-  
2 and post-test experiment aimed to identify the specific reading skills supported by a flat e-  
3 book or one with specific feature enhancements. For *Word Reading* the Dictionary  
4 outperformed E-friend but not the Flat e-book; for *Comprehension* E-friend outperformed  
5 Dictionary but not the Flat e-book; for *Recall* and *Definitions* there were no differences  
6 between e-book types.

#### 8 4.1. Target Word Reading

9 The literature reports positive effects on word learning for e-books that include extra-  
10 textual explanations, such as dictionary options that ‘speak’ and define words [3,12]. The oral  
11 word meanings for difficult words in the Dictionary e-book might have focused children’s  
12 attention on the words and supported word recognition. Moreover, clicking on each individual  
13 (unfamiliar) word for its pronunciation might have further strengthened the connection  
14 between the auditory and visual forms of the words, i.e. reinforced orthography to phonology  
15 mappings [36]. This might have facilitated word learning by reducing the effort required for  
16 decoding [37].

17 The finding that the Dictionary group significantly outperformed the E-friend group was  
18 surprising, however. We expected both conditions, with their additional features, to support  
19 children’s word reading more than the Flat e-book. Previous literature has shown that visual  
20 highlighting and audio cues – included in the E-friend e-book – expose children to  
21 grammatical forms of written language and draws attention to individual words, similar to  
22 adults pointing to words as text is read [11,12,38].

23 So, why did the E-friend e-book fail to support children’s word recognition as much as the  
24 Dictionary e-book? A plausible explanation might be that whilst in the E-friend e-book the  
25 whole sentence was read aloud (and highlighted), children were not able to click on individual

1 words for pronunciations. The ‘reading aloud of the whole sentence’ might have encouraged  
2 children to ‘listen’ instead of ‘read’ and decode the sentences themselves. It is possible that the  
3 automatic read feature might prove detrimental for word reading, if readers repeatedly ask for  
4 text to be read aloud without attempting to develop their own abilities.

5 Prior studies, for example using eye-gaze methodology to monitor visual attention during  
6 picture storybook reading, have shown that children – unless they can read the text themselves  
7 – fixate on illustrations while a storybook is read to them [39–41]. Even older children and  
8 those able to read, during shared book reading remained fixated on the illustrations for 50% of  
9 the viewing time [41] and half or more of the actual fixations on print were a mismatch with  
10 the words being read [19]. Consequently, the Dictionary feature might have emphasised  
11 children’s matched fixations (i.e. looking at words in concert with the narration) more than the  
12 E-friend and prevented mismatches with the words being read. Furthermore, children’s  
13 ‘listening to text’ in the E-friend e-book might have resulted in children not focusing on print  
14 and might explain why children in this condition showed less progress in word recognition  
15 compared to the children in the Dictionary condition. However, despite its hypothesised  
16 strengths, the Dictionary did not support word reading any better than the Flat e-book, which  
17 will be discussed later.

#### 18 19 4.2. Comprehension Measure

20 A significant difference between conditions was found with children in the E-friend  
21 group answering more comprehension questions than children in the Dictionary group, while  
22 no significant difference was found between the other conditions (i.e. E-friend and Dictionary  
23 versus Flat e-book). This positive E-friend finding was expected, although not the non-  
24 significant difference compared with the Flat e-book. Firstly, the ‘E-friend’ asked questions  
25 about the story, which may have supported children to think about the narrative and aid

comprehension. E-friend ‘mimicked’ questions that adults often ask during adult–child reading, which are effective in encouraging children to be more engaged in extracting meaning [42]. Similarly, Smeets and Bus [6] attributed their findings to the higher cognitive interaction required by answering questions and thinking about a story as opposed to passively hearing definitions or pronunciations of separate words (as in the Dictionary group). Next, the children could use the visual highlighting and audio cues as often as needed to read/listen to the story. In being read the story, children's comprehension may have been supported. They did not expend mental energy deciphering words, nor did they have to struggle with decoding unfamiliar words. Therefore, theoretically, more time and cognitive energy were left to focus on the story plot and comprehension [43]. Surprisingly, the hypothesis that the E-friend would support children’s comprehension skills significantly more than the Flat e-book was not confirmed. A sensible explanation might be that the Flat e-book contained flat illustrations and text (like a normal book) and no additional features, pronunciations, highlighting or animations. The children had to independently decode the words (familiar and unfamiliar) themselves without any support of an adult or computer. The absence of ‘supporting features’ might have resulted in children putting more effort into processing the text.

#### 4.3. Recall

No significant differences between e-book conditions were found and our finding fails to support the third hypothesis. Interestingly, a trend (non-statistically significant) in this small sample showed that children in the Flat e-book condition scored higher than children in the Dictionary and E-friend condition.

#### 4.4. Definitions Task



No significant difference between groups was found on the Definitions task, when children were asked to explain the meaning of 21 target words. This finding fails to support our hypothesis that the Dictionary e-book, with explicit meanings of target words, would support children's ability to provide better definitions than the Flat and E-friend e-books. The dictionary produced oral definitions for difficult words, mimicking parents' explanations and feedback when children do not know a word, and was expected to be an important vehicle for supporting children's understanding of words. However, anecdotal observations showed that few children accessed this feature, which may explain the null result.

#### 4.5. Enjoyment

The enjoyment questions showed little variation; children in all groups enjoyed reading on a computer and there were no significant differences in scores. This is consistent with McKenna [16], who suggested that e-books promote a positive attitude towards reading. Despite numerous positive comments about the features in the two enhanced e-books, they appeared to add little to the children's skill at words or text over and above the flat e-book.

#### 4.6. The Power of the Flat e-book

It was expected to establish the positive effects of specific features over and above the effect of reading a story on screen. This small-scale study failed to demonstrate this, and found instead that the Flat e-book supported a variety of literacy skills just as well as the other conditions. Why did the Flat e-book group do as well as the other conditions? Firstly, children in the Flat e-book group read the story with no interruptions, as they would with a normal printed book. The absence of 'supporting features' might have resulted in children putting more effort into processing the text. Furthermore, the features in the E-friend and Dictionary e-books might have prolonged the reading event, causing fatigue and loss of focus.

1 Previous studies found that some interface features in e-books had adverse effects, as  
2 they can distract the reader's attention from the main storyline and interfere with recall. For  
3 example, Trushell, Maitland and Burrell [29] argued that e-book readers might experience  
4 cognitive overload and become disengaged from the plot or become increasingly involved  
5 with superficial animations, thus compromising the essential meaning of the story. They  
6 found that children recalled story event structures better when an e-book allowed linear  
7 progression through the text, screen-by-screen, compared to an e-book which encouraged  
8 linear progression but permitted linear regression and screen selection.

#### 10 4.7. Limitations, Conclusions and Future Research

11 This study showed that Year-1 children benefit from e-books even after a short  
12 intervention of one story reading. Children gained on word recognition and story  
13 comprehension without adults creating a supportive context and providing higher-level  
14 assistance. In addition, the study demonstrated that independent e-book reading was an  
15 enjoyable and fun activity across all conditions.

16 Caution should be exercised when interpreting the findings. Firstly, the sample size  
17 (N=90) is very small and is underpowered. The sample also comprised children of slightly  
18 above average verbal ability. Replications with a range of e-book stories and a bigger sample  
19 should be carried out to explore features further, as our conclusions are based on an  
20 intervention with only one e-book story. Moreover, when considering the results, it is difficult  
21 to completely unravel which interface features of the Dictionary and E-friend e-books explain  
22 the effects. As previously mentioned, anecdotal records indicated that few children used the  
23 Dictionary feature. Children saw the highlighted word but did not often click on the word to  
24 hear the meaning. Furthermore, the design combining E-friend with visual highlighting and  
25 audio cue make it impossible to disentangle the effects of these two features. Comparing a

1 condition with visual highlighting and audio cue with a condition containing an ‘E-friend’  
2 that asks questions will shed more light on this matter. Also, it is expected that the  
3 combination of visual highlighting and audio cue of the whole sentence, followed by the  
4 opportunity to click on separate words for pronunciations, might support children’s word  
5 recognition even more than merely highlighting and narrating the sentence (as in the E-friend  
6 e-book). Another important issue is to look carefully at whether, and for how long, children’s  
7 progress on literacy skills lasts after the intervention by administering a delayed post-test.

8 To conclude, different e-book features enhanced different skills. E-books with ‘Flat’,  
9 ‘Dictionary’ and ‘E-friend’ features appear to have the capacity to increase children’s early  
10 literacy skills. Providing children with a dictionary containing multimedia meanings and  
11 audio cues of challenging words supported word recognition skills, whereas providing  
12 children with highlighted text together with synchronised narration and an ‘E-friend’  
13 supported comprehension. Interestingly, the Flat e-book fared just as well as those conditions  
14 with interactive features. None of the children in the Dictionary or E-friend conditions were  
15 actually performing better than children in the Flat e-book group.

16 Future studies should be designed to better understand reading processes while using  
17 different e-books. A series of experimental studies is needed that directly examine the focus  
18 of children’s attention to interface features, illustrations and displays of text, and the effects  
19 on various areas of literacy development. By using eye-gaze tracking systems it will be  
20 possible to test where (e.g. in illustrations or text) and for how long children fixate while they  
21 listen to/read the story text. For example, when language is ambiguous and children  
22 misinterpret the meaning of a sentence, eye movements include fixations on incorrect  
23 representations, thus making misunderstandings visible [44]. This knowledge will lead to a  
24 new understanding of the characteristics of high quality e-books, and more explicitly, what

the unique effects are of specific interface features. It will also deepen our understanding of how to improve children's literacy outcomes through cost-effective interactive e-books.

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1 Table 1. *Inter-correlations of variables*

	1	2	3	4	5	6	7
1. Target Word Reading Pre	-	.70**	.54**	.22*	.31**	.32**	.32**
2. Target Word Reading Post		-	.81**	.29**	.40**	.33**	.43**
3. Definitions			-	.46**	.45**	.25**	.57**
4. Comprehension				-	.59**	.05	.48**
5. Recall					-	.12	.28**
6. WASI						-	.10
7. BAS							-

2 \* p < .05; \*\* p < .01.

1 *Table 2. Mean scores (and standard deviations), statistical tests and effect sizes on all*  
2 *measures, for each e-book condition along with post-hoc comparisons.*

Variable	Flat	E-friend	Dictionary	Statistical	Effect
	(N = 30)	(N = 32)	(N = 28)	Test	size
	Mean (SD)	Mean (SD)	Mean (SD)	F	$\eta^2_p$
Gender (M/F)	12/18	15/17	7/21		
Schools (n)	8	9	9		
Age (months)	75.43 (3.60)	74.47 (4.16)	74.00 (3.23)		
EAL status (NS/EAL)	21/9	24/8	18/10		
BAS (pre-test)	116.97 (15.55)	118.56 (12.92)	119.59 (11.14)		
WASI (pre-test)	3.15 (.35)	3.07 (.39)	3.07 (.35)		
Target Word Reading (pre-test)	17.20 (2.64)	16.13 (2.87)	15.37 (3.77)		
Target Word Reading (post-test)	18.83 (2.48)	17.19 (3.71)	17.93 (2.46)	3.597*	.09
<i>Post-hoc Analysis</i>	ns	D > E	D > E		
Comprehension (post-test)	9.03 (2.59)	9.90 (1.94)	8.41 (2.87)	3.248*	.08
<i>Post-hoc Analysis</i>	ns	E > D	E > D		
Recall (post-test)	6.20 (2.40)	5.75 (2.21)	4.81 (2.30)	2.826	.07
Definitions (post-test)	15.30 (3.91)	13.53 (4.02)	14.36 (3.83)	1.827	.05

3 *Note: BAS means are standardised scores; WASI scores are unstandardised adjusted raw scores; and Target Word Reading*  
4 *scores, Comprehension, Recall and Definitions are absolute scores.*

5 EAL = English as an additional language; NS = Native Speaker

6 Effect size partial eta squared ( $\eta^2_p$ ): .01 = small effect; .06 = medium effect; .14 large effect [45].

7 E = E-friend; D = Dictionary. Ns = Not significant.

8 \* p < .05.