Computers & Education 100 (2016) 56–70

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

The effects of high/low interactive electronic storybooks on elementary school students' reading motivation, story comprehension and chromatics concepts

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ARTICLE INFO

Article history:
Received 15 September 2015
Received in revised form 27 April 2016
Accepted 29 April 2016
Available online 2 May 2016

Keywords:
Elementary education
Evaluation of CAL systems
Improving classroom teaching
Media in education
Teaching/learning strategies

ABSTRACT

Providing e-books does not automatically increase readers' comprehension. E-books must be designed to facilitate students' learning effects. We designed two versions (high/low interactive) of the electronic picture book titled "Color Monster's Adventure," which has a fantasy storyline and appealing art design, and embedded basic concepts of chromatology and color psychology. The low interactive e-book version contains only simple interactive buttons with narration, and the high interactive e-book version features the following three advanced functions: guidance, prompt and feedback. We conducted an experiment in a northern Taiwan elementary school with a total of 40 fourth-grade students. The results showed that the students in the high interaction group performed significantly better in reading motivation, story comprehension and chromatics concepts than their low interaction counterparts. We concluded by proposing a high interactive e-book model and providing suggestions regarding integrating proper scaffolding into designing the e-book content to improve students' reading performance.

1. Introduction

Reading is a unique cognitive activity through which we comprehend various concepts and gain different knowledge and messages (Franceschini, Gori, Ruffino, Pedrolli, & Facoetti, 2012). Reading is viewed as the key to learning (Boekhorst, 2003; Gabrieli & Norton, 2012) and has a considerable impact on children's academic success and future cognitive development (Snow, Burns, & Griffin, 1998). Boekhorst (2003) indicated that an individual's knowledge could be expanded through reading; one's mind could be enriched and skills in different fields could be developed. Additionally, problem solving skills and critical thinking could be cultivated through reading (Ediger, 2002; Volentine & Tenopir, 2013).

However, for elementary school students, a large number of unfamiliar words could present a barrier to reading comprehension and lead to a lack of interest in the reading activity. To eliminate these learning barriers, many elementary school teachers have been using story books and incorporating reading strategies to enhance reading comprehension and reading motivation (Grimshaw, Dungworth, McKnight, & Morris, 2007; Lewin, 2000; Shamir, Korat, & Barbi, 2008). In the

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http://dx.doi.org/10.1016/j.compedu.2016.04.013
0360-1315/

children's world, story and picture books play an important role. Many scholars have indicated that the story can not only cultivate creative thinking but also improve reading pleasure and interest (de Jong & Bus, 2003; Korat, 2010). Therefore, teachers could navigate students through the world of reading by integrating the children's favorite stories and pictures into learning materials, providing new learning strategies and applying various media in their classroom activities.

In today's digital world, spreading knowledge is no longer limited to the medium of paper. Increases in digital content and electronic books have initiated a wave of reading revolution, overturning the traditional reading experience. Take electronic storybooks, for example; the multimedia effects of electronic storybooks could effectively attract children's attention and reduce the heavy cognitive load of the large amount of printed text for children. The students might understand the content of the storybook easier and their reading motivation might be increased (de Jong & Bus, 2004; Doty, Popplewell, & Byers, 2001; Grimshaw et al., 2007; Lefever-Davis & Pearman, 2005; Pearman, 2008; Underwood & Underwood, 1998). To effectively enhance the effects of reading electronic storybooks for children, Graesser, Jeon, and Dufty (2008) and Mayer (2005) indicated that instruction designers should provide more assistance and guidance for young learners. Moreno and Mayer (2005) also indicated that multimedia-assisted teaching should include the following four interactive functions: reflection, guidance, feedback and interactivity. These techniques help to decrease the young learners' feelings of disorientation and frustration in learning and lead to improvement in reading performance.

Thus, if we could design a high interactive electronic storybook that guides students to observe details through related cues, provides appropriate questions for students to reflect on, and initiates instant explanatory feedback after the students have made their choices, these assisted functions should help the learners grasp the primary ideas and improve their reading performance. Therefore, we developed an interactive electronic storybook, "Color Monster's Adventure," which has a fantasy storyline and appealing art design, to introduce chromatics-related concepts to the students. The main plot tells a story about a mysteriously colored forest at the other end of the rainbow. The forest is the origin of colors, and color monsters that control various colors live in the forest. Different color monsters have their own powers and tasks. We aimed to learn (1) whether our electronic storybook could support students' reading motivation, story comprehension and chromatics concepts of learning and (2) whether this support differs for students with high or low interactive functions. The findings of the present study would provide empirical evidence to understand how different interactive designs of electronic storybooks might impact reading motivation and performance.

2. Review of the literature

2.1. Electronic storybooks

Electronic storybooks assist learners to construct messages and connect information by presenting a reading environment and process that extend beyond what is offered in traditional storybooks (Ertem, 2010). In particular, electronic storybooks provide a customized learning environment for the learners to explore at their own pace (Adam & Wild, 1997; Verhallen, Bus, & de Jong, 2006). With the development of technology and the popularity of multimedia, electronic storybooks provide animation and sound effects beyond that which is available in traditional storybooks and may support better reading motivation (Chen, Ferdig, & Wood, 2003; Ciampa, 2012b; Grimshaw et al., 2007; Korat, 2010; Morgan, 2013). Moreover, electronic storybooks that incorporate oral reading, sound effects, dynamic images, highlighted text, and interactions can improve an individual's reading comprehension by decreasing cognitive overload, burden of decoding words or grammar, and usage of working memory (Ciampa, 2014; de Jong & Bus, 2003; Pearman & Chang, 2010; Ricci & Beal, 2002; Schugar, Smith, & Schugar, 2013; Takacs, Swart, & Bus, 2015). It is urgent to develop appropriate learning aids for children to improve their reading comprehension and reading motivation by using this type of media.

Various issues related to electronic storybooks were studied in the past, such as reading comprehension (Grimshaw et al., 2007), reading proficiency (Evans & Gibbons, 2007; Moreno & Mayer, 2005, 2007), reading motivation (Ciampa, 2012a; Miranda, Johnson, & Rossi-Williams, 2012), reading literacy (Shamir et al., 2008), and word recognition (Lewin, 2000); the evidence suggested the positive effects of electronic storybooks. However, learners might feel disoriented and distracted by the abundant multimedia effects in electronic storybooks. The overuse of supplemental features, such as automatic reading of text, sound effects with graphic animations, and hotspots, might not only permit the children to ignore their learning goals but also decrease their reading comprehension (Ciampa, 2014; Pearman & Chang, 2010; Ricci & Beal, 2002; Schugar et al., 2013). Thus, educators should be cautious in incorporating reading skills/strategies in their instruction and interactivity into electronic storybooks to moderate over-reliance on these features to avoid cognitive overload and boost reading performance.

2.2. Interactivity

The interactivity features in multimedia learning environments are responsive to the users' actions and behaviors during reading (Moreno & Mayer, 2007). Several researchers have suggested that interactive elements, such as games and hotspots, were not beneficial to understanding the story content because the visual information would distract students from the verbal texts (de Jong & Bus, 2002, 2003; Rolandelli, 1989; Schugar et al., 2013; Takacs et al., 2015). However, several empirical studies have emphasized that the congruence between the interactive elements and the story line can simultaneously facilitate the processing of visual and verbal information and thus promote the

learning process (Bus, Takacs, & Kegel, 2014; Korat, 2010; Labbo & Kuhn, 2000; Mayer, 2005; Zucker, Moody, & McKenna, 2009).

Interactive features that connect to the story content have potential advantages. One advantage is that the extra textual vocabulary instructions contained in interactive e-books (e.g., dictionary options that explain word meanings automatically; Korat, Levin, Atishkin, & Turgeman, 2014; Korat & Shamir, 2008; Shamir & Korat, 2009; Shamir, Korat, & Shlafer, 2011; Smeets & Bus, 2014) can promote word learning and vocabulary acquisition. For example, Smeets and Bus (2014) observed that pupils increased their vocabulary after reading interactive animated e-books, although there was no significant progress in story comprehension. One approach is to incorporate interactive features that are related to the story into educational e-books (e.g., provide a hotspot with a question that is congruent with the story); in this way, the learner's literacy could be enhanced (Shamir, Korat, & Fellah, 2012; Smeets & Bus, 2014) as well as their story comprehension ability (Bus et al., 2014; Doty et al., 2001; Korat, 2010; Labbo & Kuhn, 2000; Roskos, Brueck, & Widman, 2009; Zucker et al., 2009). Moreno and Mayer (2005) suggested that instructional concepts should be implemented to reduce the learners' frustration and improve their reading effectiveness in multimedia environments. In other words, users should be allowed to explore the reading content using the interactive features that are related to instructional principles. The above-mentioned studies indicated that the interactive features in e-books should be not only congruent with the text (Korat, 2010; Korat & Shamir, 2007, 2008) but should also refer to the design factors and educational goals from the perspective of multimedia learning (Moreno & Mayer, 2005, 2007) to improve the children's reading comprehension ability.

Interactivity in e-books can be generally categorized into low and high interactive modes. The low interactive electronic storybooks contain only limited interactivity for users. For instance, users can utilize the control button (e.g., play or stop) to adjust their reading pace or enable the narrator to carefully follow the written words, phrases, or passages that are being read to them (Chaudhry, 2014; Ertem, 2010; Gonzalez, 2014; Grimshaw et al., 2007; Lewin, 2000; Shamir et al., 2008). Shamir et al. (2008) found positive impacts of the control button and narrator on kindergarteners' emergent literacy skills. Additionally, one common feature in the low interactive mode is the "dictionary," which is used to explain difficult words in the form of hotspots (Gonzalez, 2014; Korat & Shamir, 2008; Korat, 2010; Shamir & Korat, 2009; Shamir et al., 2011). The high interactive electronic storybooks have several features that respond to readers' actions during reading (e.g., feedback), thereby fostering and enhancing learning for the learners. To design an effective multimedia learning environment, several theoretical studies have indicated that high interactive features coupled with instructional concepts should be implemented, such as reflection, feedback, and guidance (Moreno & Mayer, 2005, 2007; Wetzel, Radtke, & Stern, 1994). Additionally, several empirical studies have emphasized the importance of providing appropriate feedback for learners to promote deep learning (Moreno & Valdez, 2005) or adopting embedded comprehension questions to engage readers in the process of reading (Ciampa, 2012a). Summarizing the above-mentioned features, this study adopted "guidance," "prompt," and "feedback" to create a high interactive e-book that has not been designed before.

2.3. Reading motivation

Guthrie and Wigfield (2000) suggested that not only cognitive abilities but also motivation should be essential components in reading comprehension. Many studies have indicated that students' reading motivation has a considerable impact on their reading behaviors (Guthrie, Schafer, Wang, & Afflerbach, 1995; Pakulski & Kaderavek, 2012; Wigfield & Guthrie, 1995, 1997; Wigfield, Guthrie, & McGough, 1996) and reading competence (Guthrie & Wigfield, 2000; Guthrie et al., 2007; McKenna, Conradi, Lawrence, Jang, & Meyer, 2012; Morgan & Fuchs, 2007; Park, 2011; Unrau & Schlackman, 2006). Reading motivation is not only domain-dependent but there are multiple facets. Reading motivation affects the individual's processing of reading materials and the amount of reading time (Wigfield & Guthrie, 1997). The study by Guthrie et al. (2007) demonstrated that several aspects of reading motivation (e.g., interest, choice, and engagement) can predict reading comprehension significantly after the pre-test scores of reading comprehension were controlled, that is, promoting the students' reading motivation can improve their performance on reading comprehension; similarly, the increase of reading motivation may have a positive effect on students' story comprehension skills. Keller (1983) developed a motivation model, ARCS (Attention, Relevance, Confidence, Satisfaction), to enhance the motivational appeal of instruction. The ARCS model can systematically strengthen the teaching design and inspire learners to involve and interact with others. According to these four components, teachers can adjust their teaching materials and methods to improve students' reading motivation, making them enjoy reading. Based on the ARCS model, we designed our electronic storybook content. We used interactive design and active participation to grab learners' "attention"; we detailed the "relevance" between the learning content and the learner's daily experience; we established appropriate guidance to help learners build "confidence" in success; and we aimed to achieve "satisfaction" in learners by providing a fantasy storyline and feedback.

2.4. Story comprehension

To achieve success in school and daily activities, the comprehension of various materials, such as narratives or text, is essential. To comprehend, people must form coherent representations of language that goes beyond sentences and across modalities (e.g., movies, informational text, and picture books) (Strasser & del Río, 2013). As one of the primary modalities in

people's daily lives, reading comprehension is an interactive process in which readers activate their prior knowledge while reading and then construct meaning derived from the text (Anderson & Pearson, 1984; Doty et al., 2001). Among a considerable amount of reading materials, storybook reading is regarded to be an important activity that supports young children's literacy development (Bus, van IJzendoorn, & Pellegrini, 1995; Mol & Bus, 2011).

Several studies have indicated that e-book stories can enhance children's story comprehension in this highly technological era (Salmon, 2014; Zucker et al., 2009). Visualizing story events, e-books present multimedia effects that offer nonverbal information that can support the comprehension of verbal information (Sharp et al., 1995; Takacs et al., 2015; Verhallen et al., 2006). However, the various multimedia features, which are incongruent with the text and the story-line, might be likely distractors for children and might interfere with their comprehension of the stories (Korat, 2010; Labbo & Kuhn, 2000; Underwood & Underwood, 1998). Guernsey, Levine, Chiong, and Severns (2012) collected 137 of the most popular American e-books for young children and found that 75% of the books embedded hotspots; however, only approximately 20% of the features were related to the story. Thus, the primary guideline is that the multimedia features should be congruent with the story to support reading comprehension (Bus et al., 2014; Korat, 2010; Roskos et al., 2009; Zucker et al., 2009). For example, Korat used hotspots that are congruent with the story to facilitate understanding of the children's story-line. Therefore, it is essential to improve students' story comprehension by embedding features (e.g., hotspot, prompt, feedback, and guidance) that are closely connected to the storyline in the storybooks.

Researchers have previously suggested various components and levels for measuring reading comprehension (Gagn'e, 1985; Gagn'e, Yekovich, & Yekovich, 1993; Lapp & Flood, 1986; OECD, 2006), from the simple level of answering easy questions (yes/no or true/false) to the demanding level of creating stories (Carlisle & Rice, 2002). Lapp and Flood (1986) stated that there are three levels of comprehension: 1) literal comprehension (reading on the lines), 2) inferential comprehension (reading between the lines), and 3) critical comprehension (reading beyond the lines). Ertem (2010) used oral retelling to assess students' reading comprehension performance in a storybook. Six evaluators independently analyzed the structural elements (setting, theme, plot episodes, and resolution) of the same story retellings. Then, Korat (2010) suggested the following two levels for examining individuals' story comprehension: the factual information of the story and referential questions regarding the characters' actions and motivations.

Generally speaking, the levels proposed by Lapp and Flood (1986) explained reading comprehension from simple to demanding levels. At the literal level of comprehension, readers must identify the core information of the text; at the inferential level, readers must integrate meanings and draw conclusions or inferences; and at the critical level, readers must use current information to find likely new information or insights. Accordingly, the comprehension levels of Lapp and Flood (1986) provided appropriate and accessible standards for us to examine children's reading comprehension from the literal to inferential levels and subsequently critical aspects in a continuously developing process.

2.5. The current study

Summarizing the above-mentioned literature survey, we believe that e-books should be designed with interactive features that are not only congruent with the story (Korat, 2010; Korat & Shamir, 2007, 2008) but are also based on instructional design principles from the perspective of multimedia learning (Moreno & Mayer, 2005, 2007). In particular, we adopted "guidance," "prompt," and "feedback" functions that have not been used before to create a high interactive e-book. By offering students more opportunities to interact with the content, high interactive e-books provide greater potential for enhancing students' reading motivation or performance. This study aims to investigate the effects of the different levels of interactivity in electronic storybooks on elementary school students' reading motivation, story comprehension and chromatics concepts.

We posed the following research questions:

1. What is the difference in reading motivation between students who read high interactive electronic storybooks and students who read low interactive electronic storybooks?
2. What is the difference in story comprehension between students who read high interactive electronic storybooks and students who read low interactive electronic storybooks?
3. What is the difference in conceptual understanding on chromatics between students who read high interactive electronic storybooks and students who read low interactive electronic storybooks?
4. What is the relationship between students' reading motivation and story comprehension in reading e-books?
5. What is the relationship between students' reading motivation and the benefits of chromatics concepts in reading e-books?

3. Research design

The present research focused on the interactive assisted functions of an electronic storybook. We chose chromatology as the learning subject and designed two electronic storybooks with the same content but with different levels of interactivity. We adopted a quasi-experimental design to investigate the effects of the different levels of interactivity in electronic storybooks on elementary school students' reading motivation, story comprehension and chromatics concepts.

To understand the learners' change in reading performance, both groups were tested using the chromatics concept test and the story comprehension test after completing two different levels of interactive electronic storybooks.

3.1. Participants

The participants were 40 fourth-grade elementary school students from two classes in northern Taiwan. Each group had 20 students and was assigned to a high interaction group or a low interaction group based on their classes. The school had long been using mobile device to accompany the Chinese stroke practice learning in Chinese textbook (including using iPad, Asus, Acer Pad). Thus, all of the students from the two classes were experienced in using mobile devices. The instructor only needed to remind the students about the user interface and usage. All of the participants had taken chromatology in their liberal arts class in the third and fourth grades. Therefore, they all had similar basic knowledge regarding the concept of chromatology.

3.2. Procedure

The students were expected to finish a chromatics concept test with an approximate ten-minute duration as the pre-test in the first stage. The second stage consisted of reading the low/high interactive electronic storybook activity. Before the activity, the researcher demonstrated how to use electronic storybooks and helped the students set up their iPads. The students started the reading activity in pairs. During the 30-min reading period, the researcher and the teacher did not interrupt the students and allowed them to independently operate the storybooks. In the final stage, the students were requested to complete the Reading Motivation Questionnaire for e-book, the Story Comprehension Test and the Chromatics Concept Test as post-tests (see Sections 3.4, 3.5, 3.6). This stage lasted for approximately thirty minutes. It should be noted here that the participants were required to read the interactive electronic storybook "Color Monster's Adventure" first, before they could answer the questions in the reading motivation and the story comprehension tests. Therefore, for these two measurements, only post-tests were performed. During the pre- and post-tests, the students were forbidden to discuss the materials (Fig. 1).

3.3. Interactive electronic storybooks

We designed two versions (low/high levels) of the interactive electronic storybooks using Flash CS5.5 and Illustrator CS5. The primary teaching content is based on the basic concepts of chromatology and color psychology. Both levels of storybooks have almost the same content and narration. The hints to the answers of the story comprehension test and chromatics

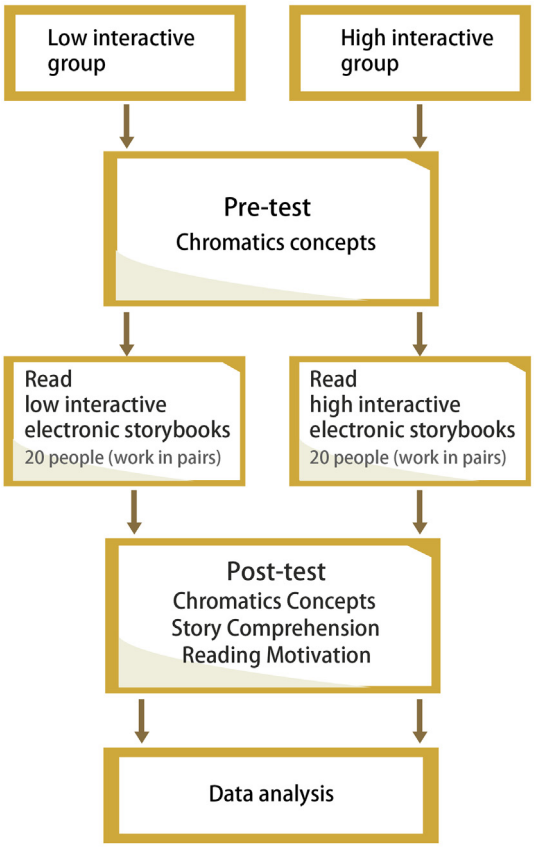

Fig. 1. Research process.

concept test are all covered in both versions of the e-storybooks. The only difference is in the design of their interactive functions and the ways in which the hints are provided.

The low interactive electronic storybook only includes narration and simple interactive buttons, such as previous page, next page and content menu. Moreover, the hints or answers in the low interactive storybook are provided as direct descriptions. For example, information on saturation is given as "The saturation of a color is decreased when white or black is added." On the other hand, the high interactive electronic storybook includes the functions of the low interactive electronic storybook as well as the three major functions (guidance, prompt and feedback) to engage the readers. "Guidance" does not provide a direct answer but it does provide the students with hints to let them think about the content and relatedness. "Prompt" means that the system will provide students with a task or question to think about and answer to enhance their thinking of the reading content. "Feedback" provides different explanations according to the answers after the students respond to the question.

3.3.1. *Story and content of the electronic storybook "Color Monster's Adventure"*

> "Look up into the sky. The sky today is especially clear and bright. After raining, the sky is just like a piece of blank paper, clear and clean, and as pure as a canvas waiting for painters to spread colors. Look! The rainbow is now showing red, orange, yellow, green, blue, indigo and violet! …"
>
> "Color Forest," the origin of colors. Here you can see colorful woods and shimmering flowers and grass. Ah? Something is hiding in the forest … with a pair of sharp horns, a fat short tail, a pair of innocent cute eyes and foolish looks, such dinosaur-like creatures are the guardians of Color Forest! They have a cute name called "Color Monsters"!

The main plot in the storybook concerns a mysterious color forest at the other end of the rainbow. The forest is the origin of colors, and the color monsters that control colors live there. Different color monsters have different powers and tasks. The teaching content integrated in the story is basic chromatology and color psychology. The basic chromatology focuses on the three dimensions of color (hue, value/brightness and chroma/saturation). It is designed to enable students to understand that there is not only pure color but also different colors because of different dimensions. Additionally, it introduces the concept of complementary color and analogous color. It also uses the concept of Itten's 12-hue color circle to enable students to understand how the three pure colors become thousands of different colors. The theme of color psychology focuses on how the colors can affect various internal feelings that result from the concepts of color and size, color and weight, color and emotions, and so on. For example, when there are two objects of the same size, the one with the lower value/brightness would appear to be heavier.

In the electronic storybook, the researcher followed what Lapp and Flood (1986) proposed as the three principles of reading comprehension to design the content of the story. In "literal comprehension," the content helps students comprehend the information in the story. For example, the story describes the horn-shaped flower as a precious plant in the green tribe. Thus, students understand that the horn-shaped flower lives in the green tribe. In "inferential comprehension," the content assists students to comprehend the context of the story, including information, cause and effect. For example, a picture in the story shows that the color forest is in darkness tonight. Students can infer from the information provided in the story and ascertain which color monster has not finished its task yet. In "critical comprehension," students use their prior experience and knowledge to formulate a judgment and application. For example, as the story comes to an end, students can reflect on the previous story content with respect to their personal experience. They can clearly explain why the color on the horn color monster turns brighter after seeing the horn-shaped flower.

Fig. 2. Features of the low interactive electronic storybook.

Fig. 3. High interactive electronic storybook (guidance).

3.3.2. Low interactive storybook

The low interactive storybook is presented in the format of animation. It provides narration while playing simple interactive buttons. In addition to the previous page and next page buttons, there is also the table of contents button to enable students to move directly to a specific page so that they can control their own reading process and phase (see Fig. 2).

3.3.3. High interactive storybook

In addition to providing interactive buttons by which students can control their own reading process and phase, the high interactive electronic storybook designed in this study also provides three interactive functions, that is, guidance, prompt and feedback.

For the "guidance" function, the system will provide related information instead of direct answers. This type of metacognitive hints allows students to think about the content of the storybook on their own. For example (Fig. 3), "guidance" only states "Observe the forest carefully. Could you tell the colors' differences between the farther and the closer trees?" By providing guidance instead of direct answers, students can pay more attention to the pictures and observe the color difference of the closer trees and further trees to figure out the facts and concepts involved.

For the "prompt" function, after each page finishes playing, the system will provide students with a task or question to enhance their thinking and impression of the reading content. The questions are primarily presented in multiple choice format based on the previous story content or chromatics concept that has been conveyed. For example (Fig. 4), the "prompt" would raise questions, such as "Yellow represents bright and optimistic, and orange represents warm and trusty. Do you remember what the color red (horn color monster) represents?" In addition to asking students the questions, the "prompt" also reminds students of what they have learned. Through this type of design, students can recall and comprehend the storybook content after reading the storybook.

For the "feedback" function, when the system asks a question, the student will choose an answer. After the answer has been chosen, the system will provide different explanations based on the answer that is given by the student. The explanation will tell the student the reason why the answer is right or wrong and provide correct information and knowledge (Figs. 5 and 6). For example, the "feedback" would first raise questions such as, "When white is added to yellow, is the saturation of yellow increased or decreased?" and would then give explanations based on the answers. Through this feature, the student learns the reason why the answer is right or wrong without re-answering the question.

3.4. Reading motivation questionnaire for an e-book: Electronic Storybook Motivation Scale

To investigate the impact of low/high interactive electronic storybooks on elementary school students' reading motivation, we adapted the Instructional Materials Motivation Scale (IMMS) from Keller (1991) to understand students' attitudes and preferences towards these two different versions of storybooks. The questionnaire uses the five-point Likert scale. Based on students' reading experience, they chose suitable choices ranging from "strongly agree," " agree," " neutral," "disagree," and "strongly disagree," with corresponding scores ranging from 5 to 1. A higher score indicates a higher level of reading motivation, and vice versa. The original IMMS consisted of 36 questions and was divided into four dimensions (attention, relevance, confidence, and satisfaction). The Cronbach's α of the overall questionnaire is 0.96 and the Cronbach's α for each of the sub-dimensions ranges between 0.81 and 0.92, demonstrating that this questionnaire has good reliability.

We adapted IMMS as our Electronic Storybook Motivation Scale (ESMS). The original 36 questions were reduced to 35 questions with the consideration of validity and reliability. Cronbach's α of the overall questionnaire is 0.94, and Cronbach's α for each of the sub-dimensions is between 0.88 and 0.93, demonstrating that the Electronic Storybook Motivation Scale had good reliability. The first dimension is "attention" (12 items), which decides whether the material can attract the students'

Fig. 4. High interactive electronic storybook (prompt).

attention and stimulate the students' curiosity. A sample question is as follows: "The content of the electronic storybook was interesting from the beginning, and thus attracted my attention." The second dimension is "relevance" (9 items), which is used to understand whether the teaching content can build its relevance with the students' prior experience to help the learners develop a positive learning attitude. For example, a sample question is as follows: "I can connect what I learned in the electronic storybook to the things I learned in the past." The third dimension is "confidence" (9 items), which attempts to determine whether the design of the material can build students' confidence, to avoid the material that is too difficult or easy and to help students develop a positive expectation for successful learning. A sample question is as follows: "I have confidence in learning chromatology because of the way by which the content of the storybook is presented." The last dimension is "satisfaction" (5 items), which measures whether the teaching material can provide context to satisfy learning needs and provide suitable encouragement for students so that they feel happy and develop a sense of achievement in learning. For example, a sample question is as follows: "When I answer the question correctly in the electronic story book, I feel a sense of achievement."

3.5. The story comprehension test

To understand the effect of using a low/high interactive electronic storybook on students' story comprehension, we adapted the reading comprehension test from Zhou (2006), which is based on the three levels of story comprehension proposed by Lapp and Flood (1986), as the story comprehension test used in the present study. This test is divided into the following three levels: literal comprehension, inferential comprehension, and critical comprehension. Literal comprehension (6 items) primarily tests whether students could understand the information revealed in the story. A sample question is as follows: "Is the blue tribe a tribe snowing all year?" Inferential comprehension (6 items) is designed to understand whether students could understand the implied information within the context and determine the relationship between cause and effect. For example, a sample question is as follows: "The color forest has turned into black and white. What happened?" Critical comprehension (6 items) is designed to understand whether students could use their prior knowledge and experience to make judgments and additional application. For example, a sample question is: "Would the forest color monster choose the fruit that seems lighter or heavier?"

The test format includes true/false, multiple choice, and essay questions for a total of 18 questions. Each correct answer receives a score of 1; the total score ranged from 0 to 18. Higher scores indicate that students have a better understanding of the story, and vice versa. After we finished designing the test, two 4th grade homeroom teachers were invited to adjust the wording and content of the questions to ensure that they were appropriate for the literacy level of elementary students. Using the Kuder-Richardson formula 20 for dichotomous responses, the reliability of the responses from the overall questionnaire is 0.50. There are several factors that could affect the reliability of a test, including test length and item difficulty (Mehrens & Lehmann, 1991). To prevent the questionnaire from being too long for our young participants, the researchers limited the number of items, which thus might yield a low reliability score.

3.6. The chromatics concept test

To understand students' level of chromatics concept before and after reading the electronic storybook, we developed a chromatics concept test. The content includes knowledge, such as knowledge of the three dimensions of color, complementary color and color psychology. The test format contains true/false and multiple choice questions comprising a total of 12 questions. Each correct answer receives a score of 1; the total score ranges from 0 to 12. Students who achieve higher scores

Fig. 5. High interactive electronic storybook (feedback for correct answer).

have a better comprehension of the chromatics concept, and vice versa. One of our researchers has five years of experience in graphic design and understands chromatology. Additionally, to ensure the validity of the test, we discussed the test with a 4th grade liberal arts teacher and asked her to make an adjustment to match the literacy level of elementary students. The teacher has seven years of teaching experience in liberal arts and is familiar with the material and instruction in chromatology. The Kuder-Richardson reliability coefficient for the chromatics concept test was 0.63, demonstrating that this questionnaire has acceptable reliability.

4. Results and discussions

4.1. Effects of high and low interactive electronic storybooks on reading motivation

An independent sample *t*-test was performed to examine whether the different interactive levels of electronic storybooks had various effects on the learners' reading motivation. Table 1 shows that the high interaction group's reading motivation was significantly higher than that of the low interaction group ($t = -4.14$, $p < 0.001$, $d = 1.34$), with a large effect size. Many researchers adopted Cohen's standards that small, medium and large effects are defined for d values of 0.20, 0.50 and 0.80, respectively (Cohen, 1988, 1992). This finding indicated that the reading motivation of children in the high interaction group could be improved through the functions of guidance, prompt, and feedback. As for the subscales of reading motivation, several independent sample *t*-tests were performed (Table 1). The high interaction group's reading motivation was significantly higher than the low interaction group in "relevance" ($t = -2.75$, $p < 0.01$, $d = 0.89$), "confidence" ($t = -4.28$, $p < 0.001$, $d = 1.39$), and "satisfaction" ($t = -4.69$, $p < 0.001$, $d = 1.52$), with all showing a large effect size. However, there was no significant difference between the two groups in terms of the attention" ($t = -1.16$, $p > 0.05$).

According to the results, the children in the high interaction group performed higher reading motivation, especially in the subscales of "relevance," "confidence," and "satisfaction." First, the functions of guidance, prompt, and feedback in the high interactive electronic storybook might help learners connect acquired knowledge and their life experiences and help learners to establish relevance between learning content and their interests/needs. Second, those functions made the content easier to understand; therefore, learners were confident in their ability to understand the story. Finally, the high interactive designs enabled learners to read in a pleasant reading atmosphere and satisfied learners' need to understand the content and feeling of accomplishment. In other words, without appropriate high interactive designs, students' level of confidence and satisfaction were not fully supported and the relevance between the learning content and students' prior experience could not be established in an effective approach.

In the subscale of "attention," an independent sample *t*-test did not reveal a significant difference between the two groups. It was likely that the two versions of the interactive electronic storybooks both invoked students' attention and curiosity with our fantasy storyline and the delicate art design because they both showed a high mean score (Low: $M = 4.39$; High: $M = 4.57$; score range: 1–5). Therefore, providing advanced high interactive features or simple functions only (e.g., control button and narrator) did not result in a significant difference in "attention" between the two groups.

4.2. Effects of high and low interactive electronic storybooks on story comprehension

An independent sample *t*-test was performed to examine whether the different interactive levels of electronic storybooks had various effects on learners' story comprehension. Table 2 indicates that the high interaction group's story comprehension was significantly higher than the low interaction group ($t = -3.77$, $p < 0.01$, $d = 1.22$), with a large effect size. The finding

Fig. 6. High interactive electronic storybook (feedback for incorrect answer).

Table 1
T-test results for reading motivation.

Variable	Group	N	Mean	SD	*t*
Attention	Low	20	4.39	0.59	−1.16
(items: 12)	High	20	4.57	0.37	
Relevance	Low	20	3.96	0.80	−2.75**
(items: 9)	High	20	4.52	0.42	
Confidence	Low	20	3.26	0.96	−4.28***
(items: 9)	High	20	4.29	0.51	
Satisfaction	Low	20	3.81	0.77	−4.69***
(items: 5)	High	20	4.71	0.39	
Total	Low	20	3.90	0.56	−4.14***
(items: 35)	High	20	4.50	0.33	

**$p < 0.01$, ***$p < 0.001$.

indicated that the high interactive electronic storybook could improve learners' story comprehension with the functions of guidance, prompt, and feedback. For the subscales of story comprehension, several independent sample *t*-tests were performed (Table 2). The high interaction group's story comprehension was significantly higher than the low interaction group in "literal" ($t = -3.49$, $p < 0.01$, $d = 1.13$) and "critical" ($t = -2.97$, $p < 0.001$, $d = 0.96$), with all showing a large effect size. Nevertheless, there was no significant difference between the two groups in terms of the "inferential" ($t = -1.32$, $p > 0.05$).

The results in general showed that the children in the high interaction group performed better than the children in the low interaction group in story comprehension. In this study, the low interactive electronic storybook only provided simple interactive buttons with no special design to facilitate learning. Without the high-level interactivity that was congruent with the story-line, the multimedia effect in low interactive electronic storybooks might not increase or even decrease the reading performance of learners by taking their focus away from the learning materials (Pearman & Chang, 2010; Ricci & Beal, 2002).

In the subscales of story comprehension, the high interaction group performed better than the low interaction group in "literal" and "critical," but not in "inferential." The functions (guidance, prompt, and feedback) in the high interactive electronic storybook could effectively improve learners' literal comprehension by guiding students to observe key information. Additionally, those functions enabled learners to think of reflective questions and determine the clues in the storybook in a more active manner. It not only engaged learners in the story but also made them think of the cause and effect and story context, leading to their improvement in critical comprehension. Regarding the subscale "inferential," there was no significant difference between both groups. One likely reason was that the two versions of interactive electronic storybooks both facilitated students' inferential ability because they both showed a high mean score (Low: M = 4.1; High: M = 4.6; score range: 0–6). Lapp and Flood's (1986) three levels of reading comprehension were used to design the content of the story. The quality of the story might therefore also have an impact on both groups of students' performance. The high interactive features might not achieve full potential to benefit students' inferential thinking process. Freeland, Skinner, Jackson, McDaniel, and Smith (2000) used repeated readings as a comprehension intervention and found that the technique improved the factual but not the inferential dimension in reading comprehension. Schmitt, Hale, McCallum, and Mauck (2011) indicated that the inferential comprehension ability might be hardly improved in a short period of time. Additional considerations should be applied in designing appropriate interactive features to better benefit students' inferential comprehension.

Table 2
T-test results for story comprehension.

Variable	Group	N	Mean	SD	*t*
Literal	Low	20	4.00	1.03	−3.49**
(range: 0–6)	High	20	5.10	0.97	
Inferential	Low	20	4.10	1.21	−1.32
(range: 0–6)	High	20	4.60	1.19	
Critical	Low	20	3.65	1.09	−2.97**
(range: 0–6)	High	20	4.65	1.04	
Total	Low	20	3.92	0.77	−3.77**
(range: 0–18)	High	20	4.82	0.74	

**$p < 0.01$.

Table 3
ANCOVA results for chromatics concept scores by the interactive condition.

Group	N	Adj. M	S. Err.	F value	η^2
(1) Low interaction	20	7.71	0.28	15.51***	0.29
(2) High interaction	20	9.29	0.28		

***$p < 0.001$.

4.3. Effects of high and low interactive electronic storybooks on the chromatics concepts

To examine the effects of high and low interactive electronic storybooks on the chromatics concepts, ANCOVA was performed. The post-test scores of the chromatics concepts were used as the dependent variable, and the pre-test scores of the chromatics concepts were used as the covariate. The group of high/low interactive electronic storybooks was used as an independent variable in the ANCOVA model. There was no interaction between the two groups in the post-test of the chromatics concepts ($F = 0.769$, $p > 0.05$), indicating that the assumption of homogeneity of the regression slope was met. As shown in Table 3, the ANCOVA results showed that there was a significant difference ($F = 15.51$, $p < 0.001$) with regard to the chromatics concepts, with a large effect size (η^2) of more than 0.14 (Cohen, 1988). The participants in the high interaction group (*Adj. M* = 9.29) scored significantly higher on their chromatics concepts than those in the low interaction group (*Adj. M* = 7.71).

The ANCOVA result showed that the learners in the high interaction group performed significantly better on the chromatics concept than the learners in the low interaction group. This finding was consistent with previous studies that demonstrated that learners could concentrate on understanding important concepts and perform better through the interactive features of the system (Korat, 2010; Mayer, 2004; Moreno & Mayer, 2005, 2007; Unsworth, 2003).

4.4. Correlation between reading motivation, story comprehension and the gains of chromatics concepts for learners in different interaction groups

To understand the correlation between reading motivation, story comprehension and the gain scores of chromatics concepts, Pearson's correlation analyses were performed, and the results are shown in Tables 4 and 5. The effect sizes for the correlation coefficient were classified into none ($r < 0.1$), small ($r < 0.3$), medium ($r < 0.5$) and large ($r \geqq 0.5$) (Cohen, 1988). All of the correlations were expressed using Pearson correlation coefficient.

In the high interaction group, the "satisfaction" of reading motivation significantly correlated with "literal" ($r = 0.45$, $p < 0.05$; medium effect size), "critical" ($r = 0.47$, $p < 0.05$; medium effect size), and the total scores ($r = 0.60$, $p < 0.01$; large effect size) of story comprehension. Additionally, the "critical" of story comprehension significantly correlated with "attention" ($r = 0.49$, $p < 0.05$; medium effect size) and the total score ($r = 0.46$, $p < 0.05$; medium effect size) of reading motivation. The results suggested that if the high interaction group paid more attention on or had higher satisfaction regarding the reading content, they would achieve better performance on understanding and judging the story. In the low interaction group, the "confidence" of reading motivation significantly correlated with "critical" ($r = 0.46$, $p < 0.05$; medium effect size) of story comprehension, indicating that the more confidence in reading the low interaction group had, the better critical comprehension ability they would achieve. In general, the results showed that with the improvement of reading motivation, learners had a better opportunity to integrate and internalize substantial information to critically comprehend the story content.

Furthermore, in the high interaction group, the "attention" of reading motivation significantly correlated with the gain scores of the chromatics concepts ($r = 0.48$, $p < 0.05$; medium effect size), indicating that the more attention the high interaction group could concentrate on the electronic storybook, the better gain scores they would have in the chromatics concepts. In comparison, there was no significant correlation between reading motivation and the gain scores of the chromatics concepts in the low interaction group. The results suggested that the higher the reading material invoked students' attention and curiosity, the better they would perform on the gain scores of chromatics concepts. These results corresponded

Table 4
Pearson's correlation analysis between reading motivation and story comprehension.

		Reading Motivation				Total
		Confidence	Attention	Satisfaction	Relevance	
High interaction group (N = 20)	Literal	0.10	0.32	0.45*	0.02	0.25
	Inferential	0.05	0.12	0.33	−0.14	0.07
	Critical	0.34	0.49*	0.47*	0.17	0.46*
	Total	0.12	0.44	0.60**	0.05	0.34
Low interaction group (N = 20)	Literal	−0.13	−0.19	0.04	−0.31	−0.23
	Inferential	0.03	−0.06	−0.09	−0.15	−0.08
	Critical	0.46*	0.09	0.10	0.00	0.26
	Total	0.18	−0.08	0.02	−0.22	−0.03

*$p < 0.05$, **$p < 0.01$.

Table 5
Pearson's correlation analysis between reading motivation and the gain scores of chromatics concepts.

		Reading Motivation				Total
		Confidence	Attention	Satisfaction	Relevance	
Gain scores of chromatics concepts	High interaction group (N = 20)	−0.07	0.48*	0.41	0.02	0.23
	Low interaction group (N = 20)	−0.05	−0.32	−0.07	−0.29	−0.25

*$p < 0.05$.

to several studies that also showed that reading motivation was significantly correlated to learners' reading comprehension (Anmarkrud & Bråten, 2009; Guthrie & Wigfield, 2000; Guthrie et al., 2004, 2007).

5. Conclusions

Delicate illustrations, vivid narrations and animations in e-books contributed to higher levels of motivation and engagement in readers (Ciampa, 2012a; Grant, 2004; Lewin, 2000). However, the interactive features that were not congruent with the storyline may cause extraneous burden that distracted learners from the text, thereby impeding reading comprehension (de Jong & Bus, 2002, 2003; Korat, 2010; Labbo & Kuhn, 2000; Mayer & Moreno, 2003; Rolandelli, 1989; Schugar et al., 2013; Takacs et al., 2015; Underwood & Underwood, 1998). This study designed a high interactive e-book by incorporating three features (guidance, prompt, and feedback) that were closely connected to the storyline to facilitate the learning effects in terms of reading motivation, story comprehension and chromatics concepts (Fig. 7). Through "guidance," the e-book triggered students' curiosity and encouraged them to carefully observe details with different cue information. Through a "prompt," students were requested to think of questions to fully comprehend the reading content. Through "feedback," students could receive instant information and explanations to better comprehend the reading material or correct their misunderstanding. These three interactive functions kept setting new learning goals for students so that their curiosity was aroused and their motivation was maintained.

This study showed that the students in the high interaction group perceived higher reading motivation, chromatics concepts and story comprehension. Ciampa (2012a) also indicated that an e-book that incorporated high interactive design (e.g., comprehension questions) could effectively improve early primary grade (K-2) students' reading motivation and comprehension on a collection of nonfiction and fiction e-books. As for reading motivation, the results indicated that the high interactive functions of an e-book could better improve students' performance on relevance, confidence and satisfaction than

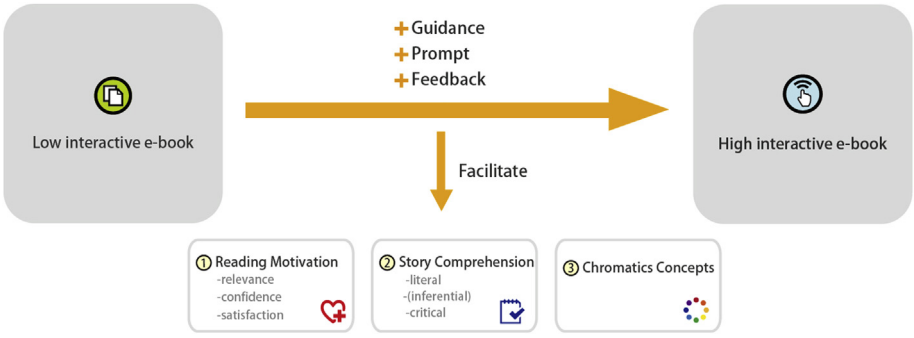

Fig. 7. A high interactive e-book model to facilitate reading effects.

their counterpart. As for story comprehension, the high interaction group performed significantly better than the low interaction group on literal and critical comprehension, but not on inferential comprehension. As for the concept of chromatology, excluding the influence of pretest scores, the high interaction group received significantly higher scores in the posttest than the low interaction group. Additionally, students' overall reading motivation, story comprehension and chromatics concepts were, in part, correlated at a significant level, especially for the students in the high interaction group. One concern is that the reading period only lasted for 30 min, suggesting that a novelty effect might be involved. As we have described in Section 3, both the low and high levels of the interactive electronic storybooks had almost the same content and narration, except for the design of their interactive functions. Both groups of participants employed iPads to read the e-books with a fantasy storyline and appealing art design; the novelty effects for both groups should thus be the same. In the future, the reading time may be extended to further minimize this possible issue.

Providing e-books cannot automatically increase understanding. Educators should take responsibility for designing or opting for e-books with effective multimedia and interactive features that are not only congruent with the story (Korat, 2010; Korat & Shamir, 2007, 2008) but are also based on instructional design principles (Moreno & Mayer, 2005, 2007). By offering students more opportunities to interact with the content, interactive e-books provide a better potential for enhancing students' reading motivation or performance. For teachers in practice fields, we suggested that they could use available e-books and incorporate the three high interactive functions (guidance, prompt, and feedback) proposed in our model (Fig. 7) into the reading content or reading activities. For teachers whose information technology skills are sufficient, they could design their own electronic story books for specific teaching domains. In addition to the multimedia feature, teachers should consider readers' background and blend obscure knowledge into interesting stories to arouse readers' interest and motivation.

Most importantly, achieving proper design of high interactive functions is the trend in multimedia learning. The process of multimedia-assisted learning changed from a traditional one-way mode to a two-way mode. Learners not only read or listen to the multimedia content but they also have more flexibility to explore and learn with the interactive content. In the future, with the popularity of information technology (e.g., augmented reality or virtual reality), providing more dynamic and instant two-way interactive design would help learners become immersed in the reading world. By enlarging the interactive flexibility and space between learners and e-book content, learners' reading performance could be optimally achieved.

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