Song of Red Pine Woods - Design and Study of Digital Picture Books for Preschool Children on iPad

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Abstract. The cultivation of children's early reading ability is of vital importance in their entire life. As preschool education attracts more and more attention, the primary challenge for many designers of children's books is how to better guide children to read with higher quality. This paper takes the design of *Song of Red Pine Woods* as an example, discusses the actual effects and realization way of interactive design in preschool children's picture books. Based on the author's experiment results in preschool, the paper proves that digital picture books have unique advantages compared to traditional paper picture books, and also proposes new ideas on how to improve children's reading interest and reading experience.

Keywords: Preschool children · Digital picture book · Cognitive features Interactive design

1 Introduction

The cultivation of early reading ability plays a very important role in preschool children's growth stage and will influence their lifelong learning and thinking ability. During preschool stage, children are experiencing rapid physical growth and gradually mature visual sense, auditory sense, smell sense and so on. Therefore, the design of preschool reading should meet children's special cognitive features and behavioral habits. At present, the quality of picture books in China is patchy. Those with relatively high quality and better popularity are mostly translated works from foreign countries [1].

With continuous development of computer and multi-media technology, the carrier of children's picture books has gradually transformed from traditional paper books into multi-media devices such as iPad. Children's reading mode also changes from manually leafing through the books to touching the screen, so does the route of information transmission which has changed from simple image-text forms into diverse and

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compound forms including image-text, videos, audios and so on [2]. The new forms of artistic expression have exceeded storybooks and traditional picture books, and developed into multi-media art that integrates words, images, music and audio [2]. Though there are still many controversies over the use of multi-media products such as iPad, it is undoubted that proper design and use of new interactive multi-media technologies will surely bring benefits for educating children and cultivating their reading ability. In recent years, quite a few excellent design schemes have broadened the way for designing digital picture books for preschool children.

The interactive picture book Little Star that won Apple Design Award 2012 has integrated sensing devices such as gravity sensor, gyroscope and microphone, with touch control and gesture recognition technology (see Fig. 1). Many interactive modes are designed during the reading process. For example, if you drag the sun, the red sun will bounce like a football; if you slide the meadow, the scene will also move; if you click the black-and-white photos, they will turn full colors; if you shake the screen, the small ball will bounce in the screen and the feather duster will also flap up and down. These different interactive modes have brought more surprises and fun to children.

Fig. 1. *Little Star* (Color figure online)

Good Night is a most popular bedtime story in Children Interaction of App Store in 2015 (see Fig. 2). In this picture book, the story is ingeniously integrated with interactive design. Through a repetitive interactive operation of clicking, children can turn off the lights for different animals and help them fall asleep in the scene. The background music creates a quiet and peaceful atmosphere, which also exposes children to the core content of the whole story, that is, it is late, and you should turn off the lights and go to sleep.

According to the cognition features of preschool children and current situation in relevant fields, this paper designs an interactive digital picture book for 3–6-year-old preschool children on iPad-*Song of Red Pine Woods*. Themed on popularization of forest ecology, it helps children know various interesting animals and plants as well as relevant ecological knowledge while reading the story on iPad by designing amusing interactive reading methods and beautiful graphic effects. More details about the interactive design, realization process of the system and experiment in preschool will be introduced in the following.

Fig. 2. *Good Night*

2 Interactive Design for *Song of Red Pine Woods*

2.1 Interactive Process Design

Interactive design is the core content of this digital picture book. Good interactive experience should be based on the cognitive and psychological features of preschool children and follow simple and vivid interactive principle so as to involve children in interactive reading, increase their reading interest and improve reading experience [3]. Relevant experiments will have to be conducted to test and evaluate whether children's reading experience has been improved.

Guided interactive reading method enables children to get involved in the story context of the picture book, increase their confidence and relieve their sense of failure [4]. The whole interactive process of *Song of Red Pine Woods* is realized through designing two task modules, namely, unlock module and reading module. In unlock module, the dynamic prompts on the screen guide children to unlock the role cards at the bottom. Every time when the children click a role correctly, the corresponding profile in the card will be enabled. There will be a pop-up message introducing the role with background dubbing. The role cards will roll out downward after all of them are unlocked, and meanwhile there will be 7 number buttons from 1 to 7. The prompt tone of victory indicates that the task is successfully completed and the play button in the bottom right indicator sign will be enabled.

In this task module, children have to discover prompt information through careful observation. The role introduction after the role cards are unlocked enables the children to know the forest in a more visualized way. The repetitive unlocking operation is designed according to the behavioural habits of children at this age group. Besides, the pictures and audio effects after the role cards are unlocked also bring visual and auditory excitement to children and also increase their sense of pleasure and accomplishment, thus improving their reading interest and encouraging them to acquire knowledge more actively [5].

Only after successfully completing the unlock tasks, users can enter reading module. In this way, children will get a glimpse of main forest species involved in the story before they start reading, which will help them better understand the story.

According to the story, *Song of Red Pine Woods* includes 7 chapters. In reading module, children have two reading modes to choose, including linear and non-linear reading modes. When children click the play button at the bottom right, the story will be played automatically from chapter 1 (linear reading). If children click one of the number buttons, the story will enter corresponding chapter (non-linear reading). The non-linear reading design enables children to choose reading order independently and get back to the home page at any time to choose another chapter (Fig. 3).

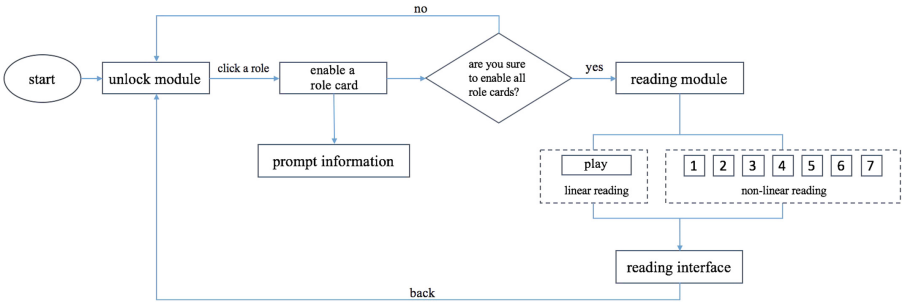

Fig. 3. Interactive process of *Song of Red Pine Woods*

2.2 Interactive Interface Design

Interface is the most direct platform to exchange information with users. Preschool children feature some typical psychological traits such as strong curiosity, unstable attention, active personality, imitation, expectation for recognition and emotional tendency [6]. The interface design of the unlock module adopts a forest style (see Fig. 4), which allows children to get immersive experience in the story once they enter the interface. The animals in the scenarios all adopt cute and cartoon appearance design with simple and smooth lines. The icon design features vines and wood grain elements, echoing the forest theme and satisfying children's curiosity in exploring a forest. In addition, the deep and light color contrast strengthens the yellow background effects and creates stronger visual shock to attract children's attention. The task cards are designed in wooden structure with a concave-convex feeling, matching with the story context. After locked, the roles cards will turn into colourful ones. The yellow stroke effectively distinguishes the locked cards from the unlocked ones to help children better complete the tasks.

In reading module, there are four interactive button icons at four corners of the screen (see Fig. 5). Users can click the top left audio button to turn on/off the story dubbing. The top right home button enables users to get back to the home page, review introduction information of each role or re-select a chapter to read. The bottom buttons can be used to turn the pages, such as backing to the former page or skipping to the next page.

Fig. 4. Interface design of unlock module in *Song of Red Pine Woods* (Color figure online)

Fig. 5. Reading interface Design of *Song of Red Pine Woods*

2.3 Interactive Plot Point Design

Amusement is a necessary element in digital picture books for children. By extracting the story plots from *Song of Red Pine Woods* and integrating human-machine interactions and story plots through ingeniously interactive technologies, the digital picture book allows children to get involved in interactions and enhance their reading interest and experience [7].

In reading module, every single page is a small scene. An array of interesting interaction operations are realized by adding many actions such as clicking, sliding, dragging and shaking the screen in different scenes. For example, in the 5th scene of chapter 1, a big black bear is holding a trunk. The background dubbing is "this big black bear is so impatient that he shake the trunk very violently to enjoy the food in advance". Children can click the bear according to the prompt information on the screen, then the big black bear will start shaking the trunk violently. In this way, an interactive course is completed. Also, at the beginning of chapter 2, there are some yellow leaves on the tree. The background dubbing is "Listen, the winter is coming". Children can shake the screen according to the sliding arrow in the screen, then the yellow leaves on the tree will gradually fall down. Moreover, children can also drag and control the pine cones, click a chipmunk to watch it eating pine cones or cut fruits from the trees by dragging the knives.

These deliberately designed interactive plot points have added more fun to children's reading process, allowing them to transform from merely listening to, reading

and watching stories into controlling what happened in the story. This has greatly enhanced children's participation degree and experience, which will dramatically stimulate their reading interest (Fig. 6).

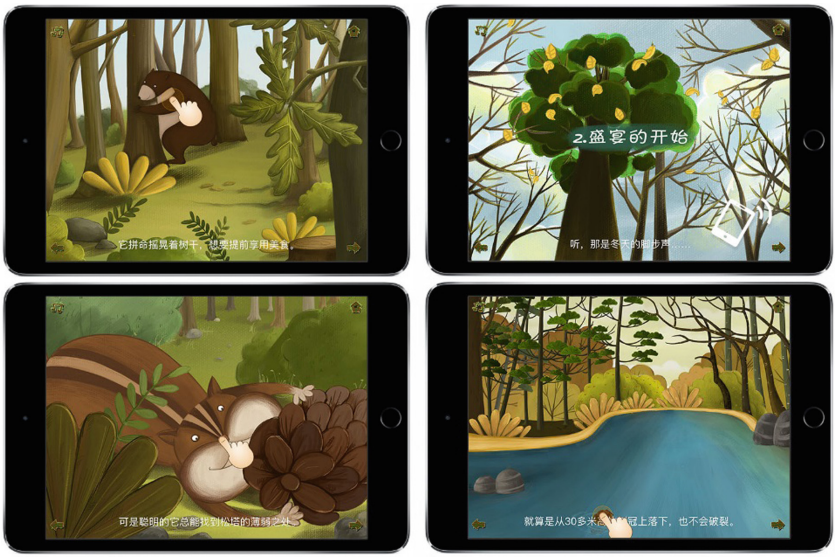

Fig. 6. Interactive interface of *Song of Red Pine Woods*

3 System Realization

During technological realization, many measures were taken at earlier stage to test the effects. Also, the test also used development kits like the three-dimensional game engine Unity. After several tests, Xcode, the official iOS App development kit was finally adopted.

Traditionally, Objective-C is used as the programming language for developing iOS apps. During the development process, we used Swift, issued by Apple in 2014, as the programming language. Swift also supports Functional Programming, Tuple data type and other features which can make the project code more simple and concise, better fit for the rapid iteration development mode and ensure good quality of software project.

This app mainly uses Sprite Kit as its animation engine. As a 2D animation and game engine of Apple, Sprite Kit support Sprite display, animation, audio player, particle effects, physical simulation and other features. Besides, Apple's official development kit Xcode has a built-in scene editor for Sprite Kit. Sprite Kit will greatly save development time and make for rapid iteration. For instance, the code for a series of actions is set for the scene's background as below:

```
  background?.runAction(SKAction.sequence([
SKAction.moveBy(CGVectorMake(50,  70),  duration:  4.5),
SKAction.moveBy(CGVectorMake(40,  0),  duration:  3.5),
SKAction.scaleBy(0.8,          duration:          3.5),
SKAction.moveBy(CGVectorMake(0, -100), duration: 6.0)]))
```

With Sprite Kit, an animation sequence such as move upper right, move right, scale down and move upward can be added to the story scenes in this way. It can be seen that the programming code of Sprite Kit is visualized, simple, flexible and convenient.

Through such development method, the subtitles can be added in a simple way and the intervals of each subtitle can also be controlled:

```
  let subtitle = SubtitleNode(textAndTime: [     ("We are
wrapped in the hard shell of pine cones,", 3.6),     ("It
won't  crash  even  if  falling  from  a  30-meter-high
tree.",4.5),     ("We won't be able to come up if we fail
to leave this shell.", 6.0)])
```

Therefore, by combining Swift programming language with Sprite Kit animation kit, we are able to realize more flexible interactive effects and guarantee the development efficiency and quality of software project.

4 Experimental Observation

4.1 Experimental Subject

The experiment was conducted in a preschool in Beijing. A total of 72 children were chosen from three levels of classes equally (24 children of P1, P2 and P3 classes of the preschool respectively) and they fell into three groups: Group A/B/C.

4.2 Experimental Method

Experiment 1. Observing the Popularity of Digital Picture Book on iPad and Traditional Paper Picture Book.

Experiment Content: In order to control the influence of irrelevant variable, the author designed a paper picture book of *Song of Red Pine Woods* with the same stories and pictures before the experiment. The teacher gave each child of three groups an iPad with digital picture book *Song of Red Pine Woods* and a paper one. Considering that these children were too young to answer the questionnaire independently, without disturbing children's choice, the teacher recorded their answers through subjective Q&A method.

Table 1. Children questionnaire

No.	Subjective questions	A iPad digital picture book	B Paper picture book
Q1	Which one is more convenient?	A	B
Q2	Which one do you prefer?	A	B

Experiment 2. Test Children's Reading Effects of Digital Picture Book on iPad and Traditional Paper Picture Book.

Experiment Content: 24 members of Group A was divided into Group A1 and Group A2. Each child of Group A1 was given an iPad with digital picture book for reading while each one of Group A2 was given a paper book for reading with the help of the teacher. Children were arranged for reading the story at the same given time. Then the teacher conducted a quantitative test according to the story to check their reading quality. The same experiment was conducted in Group B and Group C.

Table 2. Questionnaire of teacher's evaluation on children's reading quality

No.	Subjective questions	Degree				
Q1	Can you read independently?	1	2	3	4	5
Q2	Can you read without being distracted?	1	2	3	4	5
Q3	How much are you interested in the story?	1	2	3	4	5
Q4	Can you recognise the animals and plants in the story?	1	2	3	4	5
Q5	Can you retell the story?	1	2	3	4	5

*Tick a "√" under corresponding degree: 1 = poor 2 = not bad 3 = just so 4 = good 5 = very good

4.3 Discussion of Experiment Results

Experiment 1. According to the two subjective question in Table 1, the answers of 72 children are presented in pie chart as shown in Fig. 7

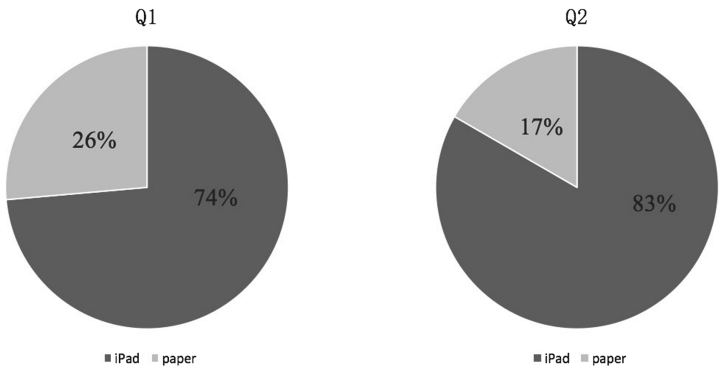

Fig. 7. Pie chart of children questionnaire results

Data analysis and comparison: According to Q1 results, over 70% of children favored that reading on iPad is more convenient. It indicated that digital picture book on iPad has fully considered children's behavioral and reading habits. And the indicative signs and dynamic animations in interface design also bring interesting human-machine interaction experience for children.

According to Q2 results, over 80% of children preferred reading on iPad, which showed children's preference for iPad. Due to strong curiosity and thirst for knowledge, children are inherently inclined to be attracted by interactive screens. Besides, with the popularity of multi-media devices, most children have contacted these interactive electronic devices from a young age.

Experiment 2. Table 2 compares three groups' reading quality of digital picture book on iPad and traditional paper picture book and collects the questionnaire data from Group A, B and C.

According to the experiment results shown in Fig. 8, children reading with iPad generally get higher scores than those reading paper picture books, which indicates that digital picture book on iPad can better improve children's reading quality. In particular, the highest Q3 score in Group A1, B1 and C1 is much higher than that in Group A2, B2 and C2. It can be concluded that iPad has played an effective role in boosting children's reading interest. Children reading with an iPad are more willing to read, which shows that iPad reading is more attractive for children. According to Q2 score in three experiments, it can be seen that children reading with an iPad show obviously better concentration than those reading paper picture books. It proves that interactive reading can immerse children in the story scenes and enhance their reading experience.

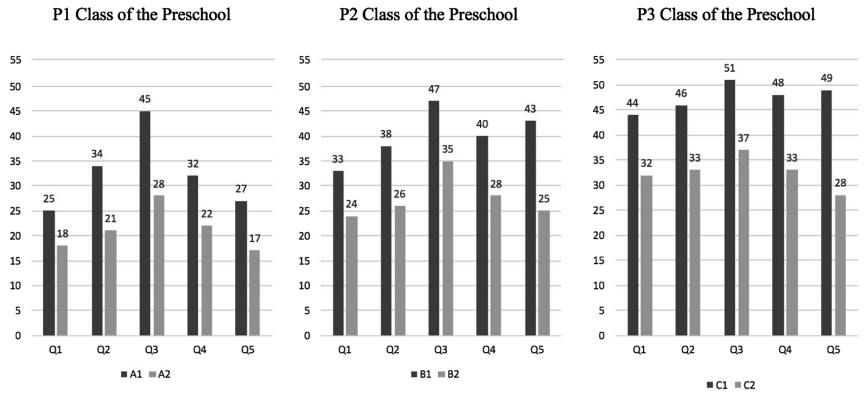

Fig. 8. Bar graph of children's reading quality analysis

Based on the experiment results of three groups, it can be concluded that children's reading quality is positively correlated with their ages. During the experiment, the author also found that children in P1 class (Group A) have some difficulties in reading on iPad because they were too young to figure out how to read the digital picture book

on iPad. Also, due to their poorer comprehensive ability and language competence, they are not good at retelling the story. Hence, the reading quality of children in Group A is obviously lower than that in Group B and Group C. During the experiment, children in Group B and C are familiar with reading on iPad. It can be seen from the results in Q4 and Q5 that children reading with an iPad acquire more knowledge than they do in paper picture books.

Based on the experiment results mentioned above, it can be concluded that reading with an iPad can improve children's reading quality. In order to further verify the experiment results, the author conducts a hypothesis test on 72 children's answer data.

Firstly a normal distribution test is conducted to check whether the data of iPad reading and traditional paper reading is of normal distribution. The null hypothesis supports normal distribution and the alternative hypothesis opposed. The test method is shapiro.test.

```
  shapiro.test(iPad)#   Normal   distribution   hypothesis
rejected
  Shapiro-Wilk normal distribution test
  data:  ipad
  W = 0.89579, p-value = 0.002623
  shapiro.test(paper)#   Normal   distribution   hypothesis
rejected
  Shapiro-Wilk normal distribution test
  data:  paper
  W = 0.79883, p-value = 1.544e-05
```

The p-value is lower than 0.05, so the null hypothesis is rejected.

As the experimental data is not of normal distribution, the author decides to use wilcoxon rank sum test to check the ranked data with no idea about the general distribution. The null hypothesis is that the two sampling scores have no difference. The alternative hypothesis is that the score of the groups reading with iPad higher than that of the groups reading with paper books.

```
  wilcox.test(iPad, paper, alternative="greater",exact=F)
  Wilcoxon rank sum test with continuity correction
   data:  iPad and paper
  W = 1106, p-value = 4.498e-08
  alternative hypothesis: true location shift is greater
than 0
  As the p-value is lower than 0.05, so the null
hypothesis is rejected and the alternative hypothesis is
accepted. That is, the score of the groups reading with
iPad higher than that of the groups reading with paper
books.
  Appendix: R code
  mydata=read.csv("C:/Users/Yiwei/Documents/Fanyiwei/data
.csv")
  head(mydata)
  ipad=mydata[,1]
  paper=mydata[,2]
  #Normal distribution test
  shapiro.test(ipad)#   Normal   distribution   hypothesis
rejected
  shapiro.test(paper)#   Normal   distribution   hypothesis
rejected
   #Ranked data of non-normal distribution, checked by
wilcoxon
```

5 Conclusion

The paper designs a digital picture book *Song of Red Pine Woods* for preschool children based on iPad device. Driven by children's cognitive features and aesthetic demands, the digital picture book enables children to get better reading experience during their interactions with iPad by setting guided reading signs and interesting interactive plot points. During the sampling experiment in a preschool, it can be concluded from the subjective Q&A and questionnaire results that digital picture books

are more advantageous than traditional paper picture books to attract children's reading interest and improve their reading quality. With the popularity of more and more multi-media mobile devices, this new reading method has offered a new outlet for improving children's reading ability.

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