A Pen-Based Teaching System for Children and Its Usability Evaluation

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Abstract. The computer has become more and more important in children' life and learning. Various issues exist in the application of multimedia edutainment software and courseware. Therefore, we analyze the current situation and requirement of preschool education software, and present the development of pen-based teaching system for children. Lecturing courseware, annotation, adding contents have been provided, which make targeted classroom teaching convenient, and children interactive courseware function has also been provided to arouse their learning initiative and enthusiasm. After analyzing the feedback, we design and develop the improved version of the system, and evaluate the two versions through experiments. Finally, we propose some suggestions for its modification.

Keywords: pen-based interaction, children, teaching system, usability.

1 Introduction

With the development and popularization of computer, children have opportunities to access to computers. They use computer to learn knowledge, play games. The computer is changing the way of children' living and studying [1]. Early childhood is the enlightenment stage of their lifetime, children's education in this period will influence the development of their life, and therefore, preschool education is a very important work. There are 1.6 billion preschool children in China, more than 110,000 kindergartens, and 2000 million children in the kindergartens. But now our childhood education still adopts the traditional teaching mode basically, which mainly rely on teachers' dictation with the instructional aids, pictures, audio and video playing to lecture the teaching contents.

In recent years, the investment in the education information both at home and abroad is very considerable, however mainly in the infrastructure construction, network environment construction, and development of multimedia learning software, there are rarely special tools for the classroom teaching [2]. Analyzing relevant teaching software both at home and aboard, the main problems are software which belongs to tool type lacks of target, the efficiency of making courseware is low. A series of teaching courseware cannot be modified and improved in accordance with children and

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teachers' need. Some software for Intelligence and skill development lacks of systematic, and not suitable for realizing whole classroom teaching.

In addition, most of software is using the keyboard and mouse operation basically. Lecture activities need frequent outline, so the keyboard and mouse operation is less free and easy to operate than pen, and against children's participation in classroom activities. In recent years, pen-based interactive technology has been widely used. Pen-based interaction has great advantage in teaching: the operation is free and simple in keeping with cognitive and operation habit. It will provide an effective means of interaction in teaching activities; In addition, Pen-based interaction is an effective tool to solve the input problem of Chinese characters computers. It is convenient to writing for teachers and helpful to learn Chinese writing for children [3].

According to the current situation of preschool education software and requirement of preschool education, combining with advanced teaching theory, we analyze the characteristics of children, and propose an pen-based teaching system and realize a teaching environment where teachers can fully play a leading role, while children can play more initiative and active, and participate in the teaching in order to promote the teaching effect. Through using the software in kindergarten, software functions and performance have been improved continuously according to the users' feedback, and moreover based on the earlier version (version 1), a new version(version 2) has been designed and developed. These two versions have been evaluated in usability. We will analyze the evaluation process and results in detail and give the system improvement comments and suggestions.

2 Related Works

2.1 Pen-Based Interaction Technology

Natural interaction and human interface is the development trend of human-computer interaction. Pen-based user interface develops with the emergence of pen-based interaction devices like the handwritten pen, the touch screen and so on. The earliest pen-based interaction devices appeared before mouse and graphical user interface, which appeared in the system of Sketchpad in 1963[4]. With the progress of computer software and hardware technology, pen-based computing environment with features of pen-based interaction is rapidly developing. One of the obvious characteristic in pen-based interaction is easy to control, effective to use, natural to outline [5]. Both text and graphics can be naturally outlined and displayed on the screen; therefore, applying pen-based interaction to education has become a new hotspot. It not only makes the full use of natural pen and paper way of working, but also make up for the limit of estimating the position of mouse click on and contents input from keyboard, simply teachers' operation, reduce controlling difficulties [3].

2.2 Educational Software for Children

Computer technology is affecting the education and learning, especially network and multimedia technology, which is very suitable for helping learning. Computer technology has enough potential to improve students' score. Multimedia electronic

courseware combined with text, video, and images has completely changed the traditional teaching and learning mode. The multimedia teaching process can be regarded as the process in which teachers make use of multimedia technology to present study materials and let students to obtain information/knowledge. In the learning process by using multimedia, multimedia is not only an information transmission tool, but also means of helping students understand knowledge [6]. Multimedia technology which combines various media such as text, images, audio, video, animation and so on, can attract children's attention, arouse their interest, create the scene atmosphere, arouse their emotional development, enhance the teaching effect through the organic combination of teaching information, promote children's multisensory development through improvement of interpersonal interaction [7].

Currently, many researchers perform in-depth studies in children's education software, and have developed some education software. Britain's Sussex University studied the learning environment that supports children's learning of biological concepts [8]. Carrie Heeter et al. studied software suitable for girls to learn animals [9]. Several large software companies also marketed multimedia course development tools, e.g. Microsoft's PowerPoint allows users to conveniently produce texts, graphs, adding images, audio, motion pictures, video, etc. It also allows design of presentation effects based on needs. Macromedia's Authorware is an editing platform based on icons and lines, multimedia production software for developing Internet and on-line learning applications [10]. Software such as Action, Flash provides tools for producing course materials. However, the cost of learning this kind of software is high, the operation is complex, and special training is necessary. Therefore it will take ordinary teachers long time to make courseware, the efficiency is very low. Software are not satisfied with the requirement for preschool education, because of not considering the characteristics of preschool teachers and the situation of children education, therefore, they cannot be used for most preschool teachers. In addition, there are some series of courseware, such as WaWaYaYa etc. [11], which are made according to some teaching materials. Coursewares provide abundant content of courses and multimedia display effect. However, this kind of software does not allow teachers to modify the content of courses and reuse courseware materials, which constraints teachers' activities.

Therefore, developing the teaching system for children is proposed in the paper. It is suitable for Chinese children, convenient to teaching activities for teachers. Simultaneously, allow children to participate in teaching activities, improve their learning enthusiasm and initiative.

3 Design and Realization Pen-Based Interaction System

3.1 Platform Architecture

Based on above analysis, we developed a pen-based children teaching system, the framework of which is shown in figure 1. The top layer is pen-based user interface; the middle layer is data processing layer; the lowest layer is system database, primarily comprised of courseware base, resource base, constrain base, gesture base and text base. Users can communicate with system through pen-based user interface. Input

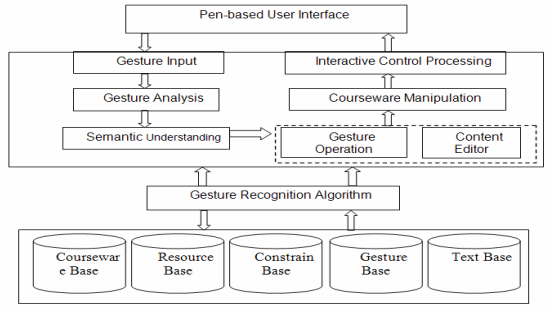

Fig. 1. Architecture of System

gestures are transmitted into system. The system first analyzes and comprehends the input. Through the support of recognition algorithms, the system obtains the input intents of the user, and performs the corresponding operations. Then the system's responding results are output to the user interface.

3.2 System Function

The function of the system is shown in figure 2. It is divided into four modules: basic operation module, media interaction operation module, handwriting operation module and auxiliary operation module. Among them, the media interaction operation includes pictures interaction, text interaction, audio, Gif animation control, and track-based animation control, all of which have their own interaction properties (such as: click to show, click to hide etc.), and allow users to interact freely.

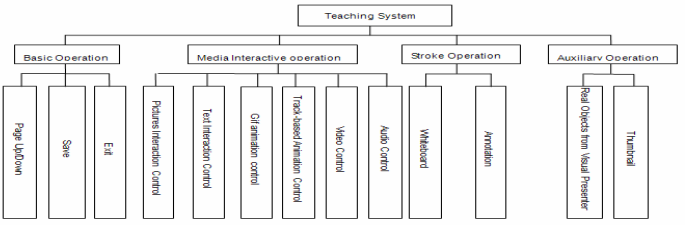

Fig. 2. System Function

3.3 System Realization

The teaching system was developed in VC++ 6 based on our lab existing pen-based software development platform. This platform provides basic pen-based interface and gesture lib. Users go through pen to interact with the system. The system first analyzes and comprehends the input, carry on the according processing and operation, then the system's responding results are output to the user interface. The system interface of Version 1 is showed in figure 3-4. This system has been provided for more than kindergartens to try out. Analyzing the users' feedback, we propose an improved version (Version 2), which is showed in figure 5-6.

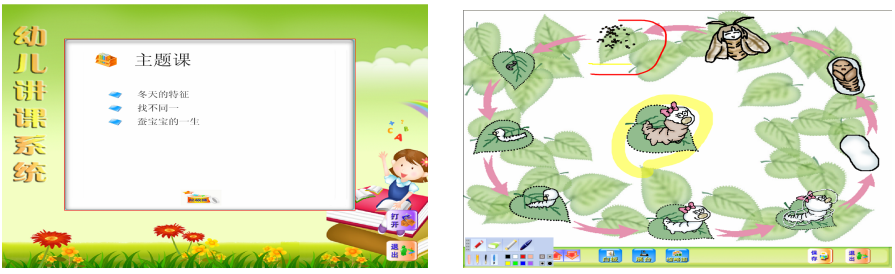

Fig. 3-4. Interface of Teaching System (Version 1)

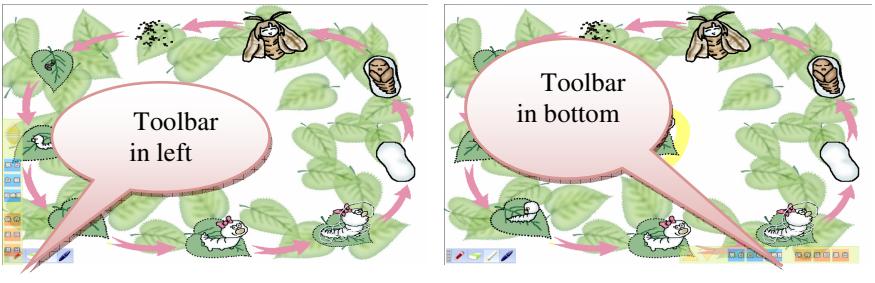

Fig. 5-6. New Interface of Teaching System (Version 2)

4 Usability Evaluation of the Teaching System

4.1 The Evaluation Method

Among all of the evaluation methods, user testing and questionnaire are selected to evaluate the teaching system. The tester first finishes a group of tasks according to the requirements, then he or she answers the questions. In order to let the tester learn the teaching software quickly, the training scheme and testing tasks were devised using interface scenarios, and this method has been proven to efficiently improve learning rate of the user and finishing rate of the tasks.

4.2 Evaluation Process

Participants and Software

The users of our system are mainly teachers who teach students by the teaching system. Therefore, we choose 6 testers three male and three female. All of them are 20 to 30 years old. In addition, some of the testers were ever teachers. The evaluation software is the teaching system developed earlier (to be called version 1□indicated with V1 later), another is the new teaching system in this article (called version 2, indicated with V2 later). The differences between two versions are that we add a dragged function toolbar in the version 2. The purpose of this evaluation is to understand what kind of interface testers like more and test various availability indicators of the teaching system. In this evaluation we adopts contrast experiments for two versions, we will also carry on the contrastive analysis for two versions' test data.

Evaluation training
The staff member first introduced the purpose and arrangement of this experiment, then explained the usage of the software with a scenario-based method, and offered a demo. Then, the testers had 10 minutes exercise. At last, the instructor introduced the testing requirements and tasks.

Testing and questionnaire
After the exercise, the testers began to test according to the task requirements. The staff members recorded the errors and other problems during testing. All the errors and problems did not be prompted. After testing, the testers filled out the questionnaires.

4.3 Result Analysis

We mainly analyze the test result from two aspects. One is objective aspect, analyze data recorded during the test procedure, such as wrong number, time of finishing tasks and so on; The other is subjective aspect, testers' questionnaire survey results.

Objective data
- Integrity

Table 1 shows the integrity which the testers finished each task in, and the data is analyzed using statistical method, and the average integrity and deviation of finishing every task were obtained.

Table 1. Integrity of finishing tasks (the highest is 1)

Task	Mean	s.d.
V1 : Lesson preparation	1	0
V1 : class begin	0.98	0.03
V2 : Lesson preparation	1	0
V2 : class begin	0.98	0.03

From table 1, we can see the achievement of testers in two versions is the same. According to task completion rate, the whole task can be basely finished. In version II, we have joined the dragged toolbar, however from the objective data, it is not difficult for testers to understand and operate. Integrity of the task doesn't reduce. Therefore, the data shows that testers feel tasks difficult to understand or to implement during the test, and the tasks and operations are within their cognitive workload and operation scope.

- The errors

During the whole evaluation process, when tester operates, problems may occur. The reason may be the habit of the testers, or the operation error, or it may be that the system produced the errors. The statistical results of the errors are: during the process of finishing tasks for two versions, the numbers of system errors are both 0. It shows that our systems are running stable relatively. The error frequency of operation is also low overall. The number of errors in version 1 is more than that in version 2, such as that the pen attributes Toolbar in version 1 has hidden page turning buttons, thus results in wrong operations. The data is shown in the Table 2.

Table 2. The statistics of the errors

Version	Group	Error number
V1	System error	0
	Operation error	2
V2	System error	0
	Operation error	1

The occurrence rate of both in version 1 and version 2, errors are very low. Testers used the teaching system very fluently. It implies that the software has high reliability and naturalness. However, since errors occurred, there were some aspects should be improved in the system. We will focus on these errors, and get the clue of the further perfection.

The results of questionnaire

For the design questionnaire, the teaching system includes three parts: the first one is the overall evaluation of the teaching system, the second is evaluation of version 1, and the last one is the evaluation of version 2.

In the 8 questions of part 1, the 1st, 3rd, 5th and 7th questions are proposed to version 1, the others are proposed to version 2. The average score of version 1 is 2.71, and 3.79 for version 2. Therefore, the synthetic evaluations for version 2 are higher than version 1. Testers prefer to use version 2 which has the dragged function toolbar.

The questionnaire is consisted of 18 questions, adopting 5 degree evaluation table. It provides the overall evaluation of our teaching software version 1, including easy-learning, easy use, reliability, naturalness, interaction and satisfaction. The results are shown in Table 3. The usability evaluation score of version 1 shows in figure 7.

Table 3. Usability evaluation for version 1

V1 : questionnaire result	Mean	s.d.
Easy-learning	4.17	0.71
Easy-use	4.33	0.52
Reliability	4.00	0.93
Naturalness	4.33	0.52
Interaction	4.28	0.57
Satisfaction	4.33	0.50
Overall Score	4.24	0.62

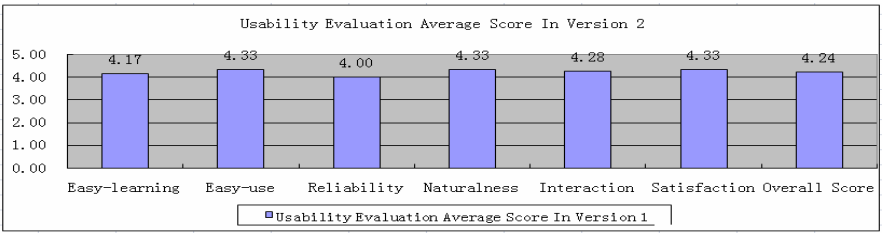

Fig. 7. Usability evaluation score of version 1

Similarly, we also evaluate version 2 on easy-learning, easy-use, reliability, naturalness, interaction and satisfaction. The results are shown in Table 4. The usability evaluation score of version 1 shows in figure 8.

Table 4. Usability evaluation for version 2

V1 : questionnaire result	Mean	s.d.
Easy-learning	4.17	0.64
Easy-use	4.43	0.51
Reliability	4.00	0.54
Naturalness	4.50	0.52
Interaction	4.31	0.59
Satisfaction	4.33	0.56
Overall Score	4.29	0.56

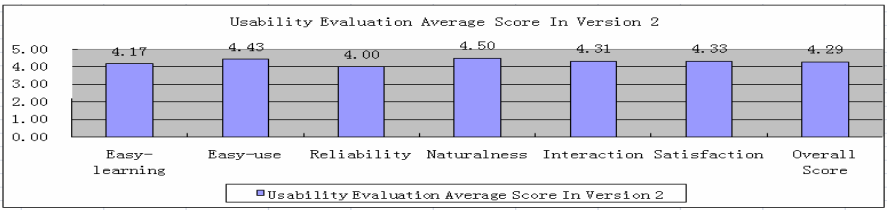

Fig. 8. Usability evaluation score of version 2

From above data, the average scores of each availability indicator in both versions are more than 4, which are high scores. The standard deviations are also in the normal scope. It shows that the evaluation result of the teaching system is satisfied. Especially in terms of Naturalness, the system has been given higher scores. It is mainly because we fully taken into account the users' habits during the process of design and realization.

Synthesized comparison between two versions is shown in Table 5 and in Finger 9. The scores of two versions are not very different, synthetical score in version 2 is higher. It shows that as a whole, synthesized evaluation for version 2 is higher than version 1. And in easy-learning, easy-use, reliability and satisfaction, the evaluation score in two versions is closed. It shows that joining the dragged toolbar doesn't make users feel more difficulties. However, the evaluation of version 2 is higher than that of version 1 in two aspects of naturalness and interaction. It shows the dragged function toolbar makes users more convenient when using the teaching system, while in version 1, users cannot drag the toolbar at will. If the position of teachers is distant from the function buttons like page up or page down buttons, then the teacher may have to go to distant locations to find those function buttons, causing a certain amount of inconvenience. The introduction of the dragged function toolbar strengthens interface interaction of the entire system. According to testing situation and questionnaire survey, users authorize this interactive approach of the dragged toolbar.

Table 5. Synthesized comparison between two versions

	V1: synthesized average score	V2: Synthesized average score
Easy-learning	4.17	4.17
Easy-use	4.33	4.43
Reliability	4.00	4.00
Naturalness	4.33	4.50
Interaction	4.28	4.31
Satisfaction	4.33	4.33
Overall Score	4.24	4.29

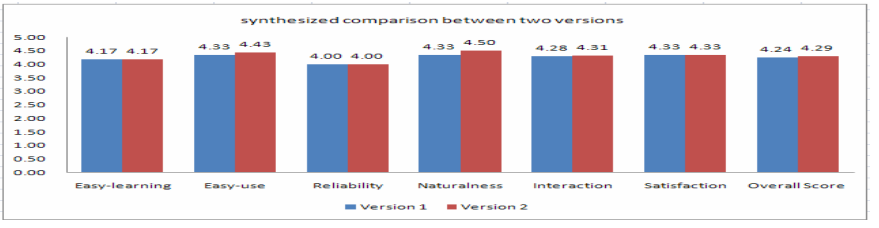

Fig. 9. Synthesized comparison between two versions

4.4 Overall Evaluation

For both version 1 and version 2, the integrity of finishing task is very high. Simultaneously the error rate is also quite low. The testers basically can complete the testing tasks well. Looking from questionnaire survey, testers have given good evaluations in both version 1 and version 2. The improvement that is the dragged function toolbar in version 2 has been approved.

In addition to evaluation questionnaires, we have gotten some testers' ideas from their feedback for the system, such as their favorite functions, improvement points. Testers feel that adding animation in the course of teaching has enhanced the effectiveness of teaching. Whiteboard function is also very appropriate for the system design; teachers can open "white board" for writing at any time.

However, through the evaluation process, we have found the shortage of the software design. For instance, the dragged function toolbar can sometimes hide other buttons, or when the dragged toolbar moves to upper boundary, it cannot automatically close the border in accordance with the placing of the border, as well as some users want to operate more naturally and so on. We will improve it and do further research on how to make teachers interact with the teaching system more smooth and natural.

5 Conclusion

This paper, focused on the issues in multimedia teaching and the needs of children's education software, presented the development of a pen-based children courseware system. The platform provided for the teachers a convenient environment for lecturing

courseware to facilitate multimedia teaching for the teachers, as well as for the children an interactive and interactive environment, where children can be allowed to participate in multimedia courseware explanation to deepen their understanding and memorization of the knowledge, so as to improve their learning results. This paper combined pen-based interface technology and the design of natural user interface to provide for the teacher and the children an easy-to-learn, easy-to-use teaching system. Through the use of system and feedback, we have modified the design of the system and obtain the new software version. Through comparing the new version with the old one, we present some comments and suggestions for improvement.

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