Measuring Usability of the Mobile Mathematics Curriculum-Based Measurement Application with Children

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Abstract. In this paper, we present the application software on mobile tablet device called mathematics curriculum-based measurement (iCBM). The iCBM was developed by various mobile technologies. Thirty-four fifth-grade elementary students participated in the study. The findings demonstrated that students had positive attitudes toward the iCBM system as well as taking math tests through mobile tablet devices. The observations of usability test on iCBM system indicated that children can use iCBM successfully. Suggestions are made about the interface design for children while using iCBM to solve math problems.

1 Introduction

As mobile devices become increasingly prominent in the lives of children, many educators are enthusiastic about the use of mobile devices for teaching and learning purposes. Children can use their fingers to surf the websites, type emails, write texts, read books, swipe photos, and switch between various applications (Apps). The mobile learning applications for children should be designed and developed in accord with their technological skills and learning capabilities.

The mobile tablet devices provide a more flexible environment for computer-based assessment than paper-and-pencil assessment. However, computer-based assessment comes in mathematics with challenges of its own because of the very nature of mathematical notations. It is not easy for children to use mathematical representatives by the keyboard. Moreover, most of the computer-based assessments in mathematics are based on the objective tests and closed-type items, like true-false and multiple choices. These assessment systems can't match the trend in mathematics education which emphasizes various dimensional aspects of students' math abilities [4]. The curriculum-based measurement (CBM) is a data-based and problem-solving model for indexing students' academic competence and progress through ongoing assessment [2][6]. This study argues that a mobile tablet environment can provide better user interface, where students can naturally write mathematical symbols for online mathematics assessment. The aim of this paper describes the design of mobile mathematic curriculum-based measurement application (iCBM) in mobile tablet device for elementary students. The initial usability measurement of iCBM was also conducted.

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2 The Curriculum-Based Measurement

Curriculum-based measurement is premised on several salient characteristics such as its focus on direct and repeated measurements of student performance in the curriculum [6]. The assessment and decision making of CBM are directly linked with local curriculum [2]. That is, a student's performance on a test should indicate the student's level of competence in the local school curriculum. In our pervious study, we have developed ECBM system to perform the mathematics CBM tests in elementary schools in Taiwan [7]. The ECBM system had the mathematics CBM item bank which included all questions on two versions of mathematics textbooks in Taiwan.

Another important characteristic of CBM is the concept of repeated measurements. The ECBM system provided each teacher with his/her own privilege to dynamically generate CBM probes through randomized-selected module. Therefore, teachers can frequently administer CBM tests in regular classrooms. The CBM probes generated from the ECBM comprised the mixed-type math questions. Each mixed-type math CBM probe included five concepts, three computations and two application questions.

The use of ECBM system helps teachers implement CBM not only by saving substantial time in collecting data, but also by analyzing ongoing assessment information in an effective way. The positive findings suggested that applying class-wide dynamic-growth modeling as well as the assessment of integrated mathematics competency in the instructional processes facilitated students' mathematics learning. However, there are two major issues need to be improved for implementing CBM tests. First, CBM probes generated from ECBM were administered in the paper-and-pencil settings. Second, teachers indicated that the digital scoring process was time consuming. Given the characteristic of mobile devices, especially their pervasive and ubiquitous nature, the unique interaction modalities (e.g., touch screens, stylus, fingers) are very suitable for children to input the mathematics notations. Therefore, in this study, we put great efforts to develop the iCBM application on a mobile tablet device for assessing children's math proficiency. In addition, we intend to measure the usability of iCBM in terms of appropriateness for children to manipulate CBM test.

3 The Usability of Mobile Tablet Device for Children

Different platforms require different user interface designs. What works for mouse-driven desktop design is not the same as for gesture-driven touch screen design. Badiu and Nielson [1] measured the usability of iPad apps and indicated that usability guidelines have to be studied about users' experience using touch screen apps. The results of the study showed that usability problems with iPad were threefold: the content was large enough to read but too small to tap, the touchable areas were too small, and the users disliked typing.

Moreover, the measurement of the usability of technology-supported learning systems is needed in order to know what the intended students think about the system. Isabwe [3] investigated the usability of a formative assessment system of mathematics

on iPad. The study showed that using iPad in mathematics learning had added value. It enabled students to write using pens stylus-like to solve math problems. However, the usability measurement of mobile tablet devices for children remains scarce. As the mobile tablet devices such as iPad and EeePad become popular in children's daily lives, research focusing on children's needs is important.

4 Method

4.1 The iCBM System

The iCBM was developed by Adobe Air and C# technology on the Android mobile platform. The EeePad mobile device was used to implement iCBM tests for elementary students. The iCBM system architecture was composed of the following two main modules:

1. The Online Measurement Module

Figure 1 presented the iCBM online testing interface. On the top of the screen were the math questions. On the left of the screen was the question number marked as written or not written. The blue background was the canvas area where students can write math expressions on the touch screen by hand. On the bottom screen of iCBM interface was the math keypad. Students can drag the math keypad to any spot on the screen. There were two math keypads provided by the iCBM. The basic math keypad included numbers (0-9), equation symbols (+,-,x,÷) , and deleting function. The dynamic keypad was shown according to the definitions in each question in the itembank, such as km, gram, degree, square centimeters, and Chinese numerical characters.

The interface designs for various math question-types were developed according to the specific rules defined in the itembank of ECBM system. There were nine question-types developed in the iCBM system.

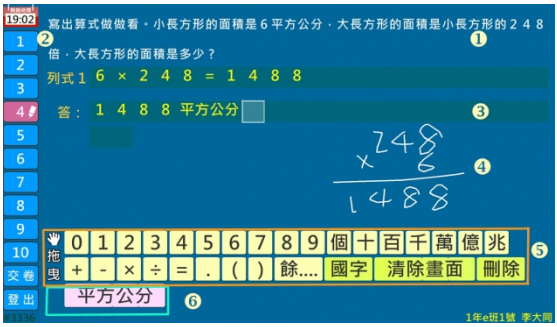

Fig. 1. The interface of iCBM (1) question area (2) question number (3) math sentences (4) drawing area (5) basic keypad (6) dynamic keypad

2. The Automated Digital Scoring Module

The scoring module of the iCBM system was developed according to the digital scoring rules of CBM model. For each question, we aggregated the correct digits of each part of a math question. For the question presented in the figure 2, students have to give answers in two parts. One is 10920 in the parentheses (5 digits), and the other is the multiplication in the records (17 digits). Then, students can get 22 digits for correct answers. For this question, the answer field defined in the itembank was [10920][##280, ###39, #2520, #840#, 10920]. The brackets were used to separate different part of answers and the "#" was defined as blank space.

Fig. 2. The interface for question-type: Rewriting number sentences as records

4.2 Participants and Procedures

Thirty-four fifth-grade students (14 boys, 20 girls) in an elementary school in Taipei, Taiwan participated. First, they followed the researcher's instructions to complete the iCBM sample test. Then, all participants were required to take one iCBM test individually. After one week, they took another iCBM test.

For usability testing, twelve students were randomly selected for video recording on screen while they were performing the iCBM tests. The researcher made observation on how they manipulated the iCBM system.

All of the students were asked to complete a questionnaire concerning the extent of perceived usefulness and users' ease.

5 Results

5.1 Students' Performance on the iCBM Tests

The average time that students completed an iCBM test was 9.48 minutes (SD=2.12). Comparing to the previous study, the average time for completing paper-pencil CBM test was 7.5 minutes. Due to the online test on the touch screen, students took longer time to input their answers in the corresponding answer areas.

The average digital scores of students' performance on iCBM tests were 52.15 (maximum digital score=65, SD=11.37) and 57.55 (maximum digital score=70, SD=10.06). Apparently, the iCBM automatic scoring module performed correctly.

5.2 Students' Attitude toward Using the iCBM Application on EeePad

In terms of students' attitudes toward using iCBM application on EeePad, a questionnaire was implemented after the second week of iCBM test. Based on 1-5 point Likert scale, ranging from 1 ("Strongly disagree") to 5 ("Strongly agree"), the results of the survey indicated that students showed a positive attitude toward using iCBM system on math tests (M = 4.46, SD = 0.46) (Table1).

The system and interface design were easily for children to use (M=4.41,SD=0.51). They like to use iCBM system to take math tests (M=4.71,SD=0.39). They agreed with the efficacy of taking math tests by using mobile tablet devices (M=4.35, SD=0.56). The interesting finding was that children showed a conservative attitude about the effectiveness of using mobile tablet device and their math performance (question 14).

There was no gender differences on the perceptions about using iCBM system (t = -7.7, p = 0.46).

Table 1. Mean scores for the students' attitude toward using iCBM application on EeePad

	M	SD
Easy to use on iCBM	4.41	.51
Using iCBM for math test	4.71	.39
Efficacy of using EeePad on math learning	4.35	.56

5.3 Results of Usability Testing of iCBM System

It was observed that most participants took math tests on mobile devices successfully. We adopted five criteria for analyzing the videos of usability testing on the second iCBM test: the number of times that children login successfully, the number of times that children choose the test number correctly, the number of incorrect answer formats of math questions, the number of times that children drag the math keypad, and the number of times that children compute on the drawing area. The third to fifth demotions were analyzed by each question on iCBM test. The results of analysis were presented on the Table 2.

We used the numerical characters as the username and password for children to login the iCBM. The results indicated that all of students could login to iCBM successfully. Two of observed children could not choose the iCBM test correctly. The observation showed that these children forgot to choose the test number after login the system. Therefore, it was suggested that the interface design for choosing the iCBM test number has to be revised as the one-step task instead of two-step tasks.

Table 2. The usability measure of students' performance on the iCBM test (N=12)

Measures	Count
The number of times that children login successfully	12
The number of times that children choose the test number correctly	10
The number of incorrect answer formats of math questions	7
The number of times that children drag the math keypad	24
The number of time that children compute on the drawing area	54

All students indicated that the operations on iCBM system was easy to remember while taking math tests. Some of the students still needed help to change the numerical keypads to Chinese numerical characters on the math keypad. According to the results, most errors occurring during the manipulation on iCBM were to input answers in the wrong formats for specific math questions. We found that there were two math question-types deserving more attention. First, the interface of the question, "multiplication: computing 90x80 in rewriting number sentences as records", has three rows to be answered. However, some students ignored the rows for 0 multiplications. They wrote the answer directly on the bottom row (Fig. 3). Second, the inputted answers in the wrong formats occurred in the word-problem type questions. Figure 4 represented the question: "List one math sentence for the following question: Chi bought two pencils. Each costs 35 dollars. She paid 100 dollars. How much could she get back?" The interface presented one math sentence area for students to input answers. However, some students still use two sentences in one row. To avoid this problem, the interface should prevent children from using equal sign twice in one math sentence.

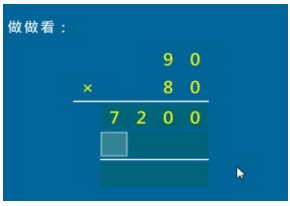

Fig. 3. The screenshot for input answers in the wrong formats for the multiplication question

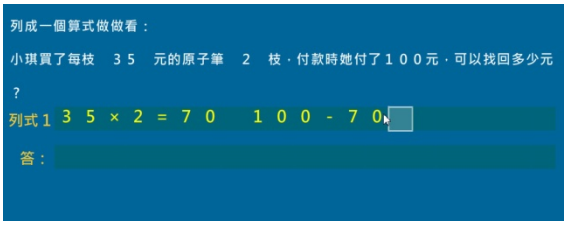

Fig. 4. The screenshot for input answers in the wrong formats for the word problem

The results of observation indicated children drag the math keypad very often while manipulating iCBM tests. Due to limited space on mobile tablet screen, students need to drag the math keypad to the upper area to get more space for hand writing computing, especially for the word-problem questions. The other situation that children will drag the math keypad occurred when the figure underneath of the math keypad. They usually drag the math keypad to the upper place of the screen.

It was observed that children used hand-writing computation on the drawing area very often (n=54). We observed that low-achieving students used more hand-writing computation than high-achieving students did. This feature was very helpful for children while taking math assessment on mobile tablet device, especially for low-achieving students.

Based on these results, we will add the "hide/show" function to the math keypad for improving drawing area for hand-writing computation.

6 Conclusion and Future Work

Our results indicated students showed the positive attitudes toward using iCBM system. They also showed the positive attitudes toward using mobile tablet devices for math tests. In terms of interface design, most of children can perform iCBM system successfully. We found that every task performed on the iCBM has to be revised to the single-step manipulation, e. g. choosing the test number. To improve interface about inputting answer format for math questions, the interface design of two question-types were needed to be revised in the future study. We also found that the math keypad and drawing area were very essential features for mathematics assessment on the mobile tablet devices, especially for low-achieving students. A mobile tablet device assess to mathematics assessment could be another promising approach for future work in this domain.

References

1. Badiu, R., Nielson, J.: Usability of iPad Apps and Websites, 2nd edn. Nielson Normal Group. CA, http://www.nngroup.com/reports/mobile/ipad/
2. Deno, S.L.: Curriculum-based Measurement: The Emerging Alternative. Exceptional Children 52, 219–232 (1985)
3. Isabwe, G.M.N.: Investigating the Usability of iPad Mobile Tablet in Formative Assessment of a Mathematics Course. In: Proceedings of the International Conference on Information Society, pp. 39–44. IEEE (2012)
4. National Council of Teachers of Mathematics Principles and Standards for School Mathematics. Author, Reston, VA (2000)
5. Nielsen, J.: Usability Engineering. Morgan Kaufmann, San Francisco (1993)
6. Shinn, M.: Curriculum-based Measurement: Assessing Special Children. Guilford Press, New York (1996)
7. Tsuei, M.: A Web-based Curriculum-Based Measurement System for Class-wide Ongoing Assessment. Journal of Computer Assisted Learning 24, 47–60 (1998)