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A Personalized Mobile Mathematics Tutoring System for Primary Education

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Abstract

During elementary education, mathematics study is important for young people. Learners need extensive practice to reinforce knowledge. This paper introduces a Mobile Mathematics Tutoring (MoMT) system, which provides mathematics tutoring, exercises, and discussion for students to improve their mathematical knowledge and skills. Based on the features of mobile devices and the needs and preferences of learners, MoMT provides a personalized tutor and/or exercises for mobile learners anytime and anywhere. MoMT also allows learners to participate in collaborative discussion or share ideas in text, image, audio or video, which are sent by using the email client on the mobile device. Through MoMT, the efficiency of and interest in learning may be improved.

Introduction

Mathematics is a fundamental human activity, a way of making sense of the world. Children possess a natural curiosity and interest in mathematics, and come to school with an understanding of mathematical concepts and problem-solving strategies that they have discovered through explorations of the world around them. According to the research of Johnson (2000), the Expert Panel on Mathematics (2004) and Ginsburg (2002), primary education is an important time of transitional growth in students' mathematical thinking. In order to become more accurate in their work, both in reading problems and in working out solutions, p rimary students need more practice to reinforce what they are learning, a process which usually takes place on paper.

However, when students encounter questions or difficulties while they are solving problems in whatever medium, it is often difficult for them to find somebody to help them. In general, they tend to review the textbook, or ask classmates or their teacher later. In addition, after they complete practice exercises or homework, students often have to wait for their teacher to check it and provide feedback. These interruptions reduce students' interest in learning as well as learning efficiency.

The research of the Expert Panel on Mathematics (2004) shows m athematically literate students look at the numbers in a problem and think flexibly about how to best solve the problem. For example, when they see 1001*23=?, they are likely to choose a method that is efficient and based on their feel for the numbers, perhaps splitting 1001 into 1000 and 1, and finding the new and easier algorithm (1000*23+1*23) to compute. Even so, most approaches that even mathematically literate students adopt are distributed in textbooks or tutoring books. These instructional approaches are usually designed for a group of students at a particular level and static. For example, many classes have only one textbook designed for all students, but literate students may need a higher-level tutoring book. Therefore, the depth and flexibility of ability gained from these textbooks are restricted. Some programs based on e-learning technology may provide personalized contents for learners by collecting the learning process. But primary students may become restless and unfocused when staying in front of computers for learning mathematics during long periods of time.

However, with the proliferation of fast, Internet-capable, mobile devices today, there may be an alternative. For example, in the UK, over 90% of young people own mobile phones (Crabtree, Nathan, & Roberts, 2003), and similar percentages can be found in other European countries. In Asia, roughly 75% of South Koreans and 99% of Taiwanese have a mobile phone (Forsberg, 2005; NCC, 2008), and over 432 million people (33.2%) are mobile users in China (Nystedt , 2006). The report of the Not-for-Profit Organization of Information Security Forum (2005) also shows that many primary students now own or have access to mobile devices (4th grade: 13.3%, 5th grade: 16.2%, 6th grade: 37.2%).

In addition, the mobile technology being used is changing rapidly. For example, v arious news sources recently reported that 85% of mobile phones used in Japan were 3G phones and that in January 2008, Japanese stores took no delivery of second-generation mobile phones for the first time ever (AsiaOne Digital, 2008).

Phones with Internet capabilities can provide a variety of digital media (images, speech, animation, and video) on the spot, and their rapid adoption is making it possible for us to work and study at any time and in any place. The report of Tanla (2008) shows that more people are now accessing Internet content on their phones than on other devices in Japan, China, South Korea, and Taiwan. In 2007, Yahoo News in Japan reported that primary students spent more than 26 minutes per day accessing Internet content on their mobile devices. Empowered by mobile computing, teachers and students can benefit from computing in locations and at times outside the traditional classroom. Although only learning content in simple formats (such as text messages) can be displayed well on mobile devices because of their limitations, learning content of primary mathematics is mostly just numeric text. Therefore, mobile devices could be an effective tool for mathematics learning in the primary grades.

Building on available capabilities, this paper proposes a Mobile Mathematics Tutoring (MoMT) system for primary students, a system that analyzes needs and preferences of learners and then provides them with personalized tutoring. Moreover, contents provided by MoMT are also adaptable to the particular mobile device used. MoMT enables learners to study seamlessly improving learning efficiency and maintaining students' interest in learning.

This paper is organized as follows. The section which follows describes the MoMT system, followed by the question definition model and related research results. The paper concludes with a discussion of findings and directions for future research.

Mobile Mathematics Tutoring System

We developed the Mobile Mathematics Tutoring (MoMT) system for primary students (also see our project site at http://www.ourglocal.com). It supports mathematics learning with mobile devices for young students any time and any place. MoMT provides tutors for four kinds of integer operators (+,-,*, /). After the learner enters two operands and selects the operator between the two operands, MoMT can provide a personalized solution. Figure 1 shows a screenshot of the main interface (A) and an example of addition between two 3-bit integers (B), running on a Smartphone 2003 SE Emulator.

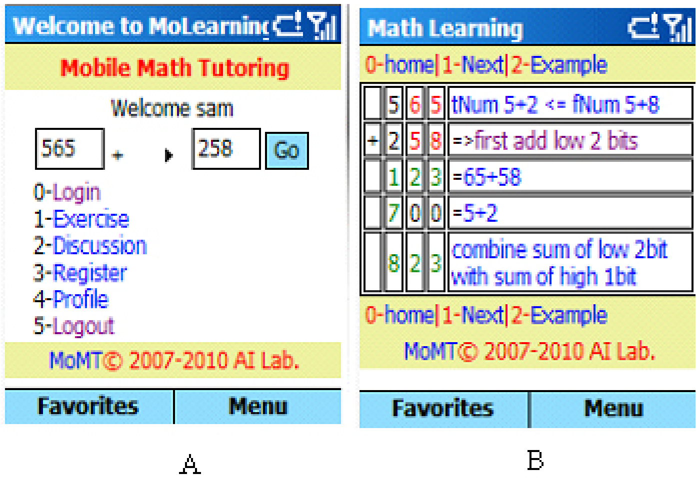


Figure 1: The MoMT System

Question Definition Model

In MoMT, the tutor can help learners at any time and in any place. The system adopts a divide-and-conquer model to tutor learners (Figure 2). The tutor provides many different solutions (W_1, W_2, …, W_n) for any question, based on the learner's ability and the degree of difficulty of the question (divide). To any solution W_k, the tutor divides any problem into many sub-questions (S_1, S_2,… S_n) and gives related solutions, explanations, or examples for any sub-solution S_k (conquer). For example, for the problem 95 * 95, MoMT may provide a general explanation such as 95*(100 - 5) or (9 + 1)0 * 90 + 5 * 5. Another, a solution such as 95* (100 - 5) may be divided into sub-questions: first multiplication (95 * 100 and 95 * 5); then subtraction (9500 - 475).

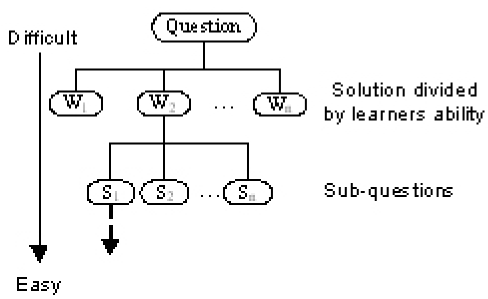
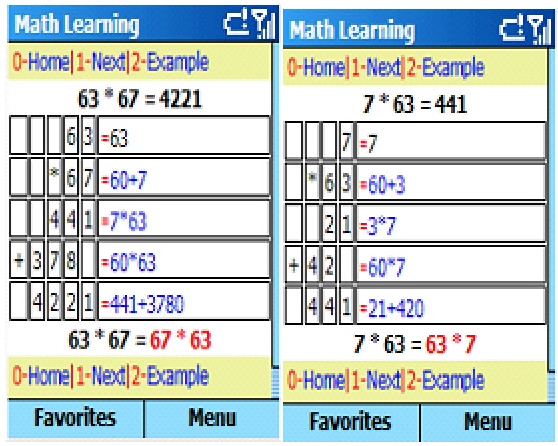


Figure 2: The Question-Definition Model of Divide and Conquer

If learners don't understand the solution, they can follow links to sub-solutions and study the problem in greater detail. Of course, learners may get explanations or examples for any computational step of a math problem, as illustrated in Figure 1, where learners may get the details about 65 + 58 = 123.

Personalized Tutoring

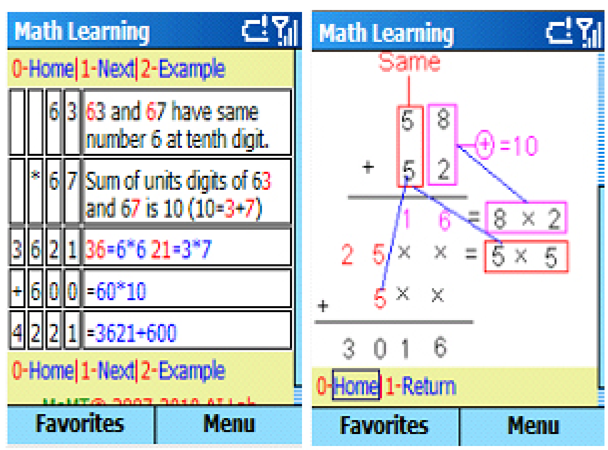
While studying, any learner may get tutoring from MoMT. When a learner logs in, MoMT analyzes his or her learning context and provides customized tutoring based on his previous learning state. If not, MoMT only provides general solutions for users. Figure 3 shows examples of a general way to solve 63 * 67 (Image A) and a deep link to a sub-question (7 * 63) (Image B).



A B

Figure 3: General Tutoring

The computational processes shown in these examples are easy to understand as they are based on textbook content. However, when MoMT detects that a learner possesses a higher level of knowledge in this area, it recommends another easy or quick solution based on the learner's knowledge (Screenshot A in Figure 4). If learners can't understand the alternative solutions, they may click the EXAMPLE to learn the computational process for this type of question (Screenshot B in Figure 4).



A B

Figure 4: Personalized Tutoring

Adaptive Exercises

In general, young learners use workbooks or exercise books to reinforce their mathematical knowledge. Unfortunately, these materials are usually designed for average learners, and it is often difficult to find the best-fitting content for students with differing abilities. MoMT can combine a learner's tutoring and practice history and provide personalized exercises which aim at building on what he/she has already learned and improving on what he/she has not mastered. Learners will not spend much time on exercises dealing with concepts they have mastered already. Consequently, these adaptive exercises are more likely to reinforce and expand knowledge, as opposed to workbooks or exercise books, thereby improving learning efficiency. Figure 5 provides some screenshot examples of a division exercise on an HP iPAQ 112 (the content in the red rectangle is the question).

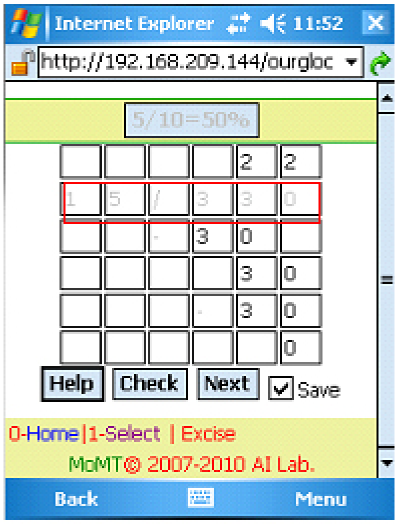
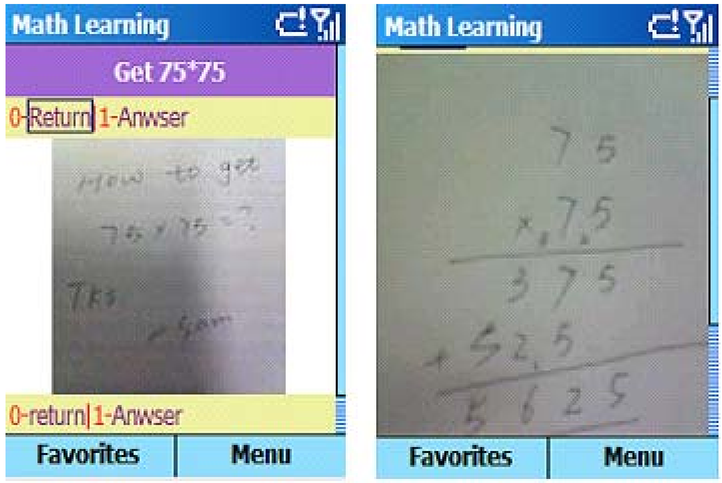


Figure 5: Division Exercise

Versatile Discussion

Discussion among participants is a good way to gain knowledge during learning. However, it is inconvenient to type in text messages using a mobile device. Learners will not spend a long time on this, and moreover, it is impossible to enter some types of information such as mathematical formulas. In order to engage learners to participate in collaborative discussion during mobile learning, MoMT also provides a community to share ideas and experiences among them. Learners can use their mobile devices to email questions (including text message, photos and video or audio captured by cameras or recorders embedded in mobile device) to other participants in the discussion. Thus, MoMT combines text messages with photos and audio/video to foster rich contexts for discussion. The process of discussion is divided into three steps:

- First, a learner may write a question on paper and then take a picture of it or record the question in sound or video.
- Second, the learner sends the multimedia message by email (MoMT sets up individual email accounts for each learner) to MoMT system for discussion.
- Finally, MoMT analyzes the message and publishes it in the discussion community (The email's subject line becomes the topic title of the discussion and the email's body is the body of the discussion). Figure 6 shows an example of this discussion process. Screenshot A asks about how to compute 75 * 75; Screenshot B shows another learner's answer to the question.



A B

Figure 6: Question and Discussion

Conclusion and Future Work

This paper proposes a personalized mobile mathematics tutoring system for primary students based on individual learner's abilities. The strength of MoMT lies in its combination of anytime, anyplace access to personalize customized mathematics exercises with a virtual, multimedia discussion space to get help or share ideas and experiences. By expanding the more traditional and textbook-based math curriculum in this way, MoMT can improve learning efficiency and student interest in learning mathematics concepts.

An important issue for us to consider is the fact that mobile devices have many different specifications and attributes. For example, if a mobile device only supports GIF format, a learning object in JPG format will not be displayed correctly by that device. Therefore, learning content should be matched with or adaptable to the varying capabilities of mobile devices. At this point in time, MoMT supports the transcoding among a limited number media formats, such as JPG to WBMP, and lays out its content based on the markup languages XHTML Basic, cHTML, and XHTML MP (but not supporting WML). Therefore, future research will examine how we can adapt MoMT to accept a much wider variety of media formats and evaluate the system amongst primary students using rich and personalized content for learning mathematics.

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References

AsiaOne Digital. (2008, March 12). Japan marks funeral for second-generation phones. Retrieved April 23, 2008, from http://digital.asiaone.com/Digital/News/Story/A1Story20080312-53982.html

Crabtree, J., Nathan, M., & Roberts, S. (2003). *MobileUK: Mobile phones and everyday life.* London: The Work Foundation.

The Expert Panel on Mathematics . (2004). *Teaching and learning mathematics* . *Report of the Expert Panel on Mathematics in Grades 4 to 6 in Ontario* . Toronto, Canada: Ontario Ministry of Education. Retrieved April 23, 2008, from
http://www.edu.gov.on.ca/eng/document/reports/numeracy/panel/numeracy.pdf

Forsberg, B. (2005, March 13). The future in South Korea: Tech firms try out latest in world's most wired society. *San Francisco Chronicle*. Retrieved April 23, 2008, from http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2005/03/13/BROADBAND.TMP

Johnson, J. (2000). *Teaching and learning mathematics Using research to shift from the "yesterday" mind to the "tomorrow" mind.* Washington: Superintendent of Public Instruction. Retrieved April 23, 2008, from http://www.k12.wa.us/research/pubdocs/pdf/mathbook.pdf

National Communications Commission (2008, February 5). *Mobile phone subscribers H2 2007*. Retrieved April 23, 2008, from http://www.find.org.tw/eng/news.asp?pos=1&subjectid=13&msgid=332

Not-for-Profit Organization of Information Security Forum. (2005). Report of information security fact-finding of primary and secondary students. Retrieved on November 21, 2007 from http://www.isef.or.jp/report/200511.pdf (available in Japanese only).

Nystedt, D. (2006). *China hits 432 million mobile phone uses. InfoWorld IDG News Service (August 24, 2006)* . Retrieved April 23, 2008, from http://www.infoworld.com/article/06/08/24/HNchinamobileusers_1.html?source=NLC-WIR2006-08-24

Tanla. (2008). Tenla mobile marketing and advertising guide. Retrieved March 19, 2008, from http://www.tanlamobile.com/case_studies/case_studies.htm

Yahoo News. (2007). It is surprising for Japanese young student to use Internet. Retrieved on January 11, 2008 from http://xk.cn.yahoo.com/articles/071217/1/6u8k.html (available in Japanese only).