DEVELOPMENT OF A MATH INPUT INTERFACE WITH FLICK OPERATION FOR MOBILE DEVICES

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ABSTRACT

Developing online test environments for e-learning for mobile devices will be useful to increase drill practice opportunities. In order to provide a drill practice environment for calculus using an online math test system, such as STACK, we develop a flickable math input interface that can be easily used on mobile devices. The number of taps required on a mobile device is considerably reduced using the new math input interface.

KEYWORDS

e-Learning, Math-input, Smartphone, STACK.

1. INTRODUCTION

In recent years, learning management systems (LMSs) have been used for learning courses in many educational institutions. One of the most popular LMS features is online testing in order to confirm students' level of understanding. Typical types of online tests include multiple-choice, true-or-false, and numerical input, but the math input type of online test is gathering attention in science education. In the math input test, mathematical expressions are entered as answers and they are automatically assessed, usually using a Computer Algebra System (CAS). Maple T.A.[1], MATH ON WEB[2], and STACK (Sangwin 2013)[3] are examples of the online assessment system that are used in educational institutions worldwide.

Online testing is useful for confirming students' understanding of the learning subject; it has the advantage of instant feedback by automatic assessment, and students can practice by solving many online test questions by themselves. Furthermore, if questions are designed such that they are automatically generated with random variables, students can repeatedly practice different questions, which is suitable for drill practice.

Online drill testing can be delivered not only using PCs, but also using mobile devices such as smartphones to enhance the opportunities for students to practice anytime and anywhere. However, the problem of math input complexity arises for questions requiring entry of mathematical expressions as answers, rather than multiple-selection or number input types of questions. For example, when students answer x^2+5x+6 to the question of expanding $(x+2)(x+3)$, they have to enter the expression `x^2+5*x+6` in the answer space. However, when the user enter the expression in which numbers and symbols are mixed using smartphone, it is necessary to switch the smartphone keyboard screen many times, requiring 19 key touches.

In fact, the difficulties of entering mathematical expressions are not limited to the case of using smartphones; there are difficulties as well when using a PC. There are some approaches to overcoming the difficulties, as discussed in the next section. In this paper, we introduce a new type of math input interface for mobile devices with a flick operation, in order to enable students to enter mathematical expressions easily and to give them more opportunities to practice through online testing in e-learning systems by using mobile devices.

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[1] Maple T.A. - Web-based Testing and Assessment for Math Courses, Maplesoft, http://www.maplesoft.com/products/mapleta/
[2] MATH ON WEB Learning College Mathematics by webMathematica, http://www.las.osakafu-u.ac.jp/lecture/math/MathOnWeb/
[3] maths/moodle-qtype_stack, GitHub, https://github.com/maths/moodle-qtype_stack/
Ja STACK.org, http://ja-stack.org/

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This paper is organized as follows. We survey few math input interfaces and identify some problems with them in the next section. A flickable type of math input interface is introduced in Section 3 and its math input efficiency is considered briefly. We summarize this paper in the last section.

2. EXAMPLE OF MATH INPUT INTERFACES

As described above, in order to reduce the difficulties in math input, several interfaces have been proposed. For example, Maple T.A. features an "Equation Editor," and mathematical expressions are displayed in a "two-dimensional" style (example: $x^2+\frac{x+1}{2}$). The equation editor increases the recognition efficiency of mathematical expressions, especially with indexes and fractions, and supports input on smartphones and tablets. When users enter mathematical expressions with those devices, however, switching the keyboard between letters and numbers/symbols is required, and the editor is not intended to reduce the complexity of the math input.

In order to increase the input efficiency of STACK, MathTOUCH (Shirai et al. 2014) and interfaces utilizing MathDox (Nakamura et al. 2014) have been proposed. However, it is assumed that they are used mainly on PCs. MathTOUCH runs as a Java plug-in, and it does not support some mobile OSs such as iOS. MathDox was developed in JavaScript but it does not support mobile devices because touch operation is not considered.

In order to reduce the complexity of entering mathematical expressions using mobile devices, we propose the use of flick input often used in mobile devices. We assumed the use of STACK and developed a math input interface with flick operation, which are expected to increase the opportunities for drill practice through online testing on mobile devices. We introduce this new type of math input interface in the next section.

3. MATH INPUT INTERFACE WITH FLICK OPERATION

We decided to use JavaScript in order to minimize the dependencies on mobile device OSs. We have already developed a conversion filter from MathDox to Maxima, and we use MathDox for describing entered mathematical expressions, which is another reason to adopt JavaScript to develop the new interface. This section provides an overview of the interface and introduces how to enter mathematical expressions using a simple example. In order to confirm the efficiency of math input using the new interface, we compare the number of key touches of the new interface with that of a conventional keyboard.

3.1 General Specification

Figure 1 shows the basic layout that is displayed when the interface is activated. The user can input numbers using the "123" key and alphabetic or Greek letters using the "*xy*" key in the left column. When the user taps the "*fx*" key, functions such as exponential functions and trigonometric functions become available. Basic operation keys are assigned to the right-hand column.

3.2 Entering Mathematical Expressions

An example of entering the expression x^2+5x+6 as an answer for expanding $(x+2)(x+3)$ is shown in Figure 2. By a flick in the upward direction of the key "*x*" (Figure 2, upper left), the index input state appears (Figure 2, upper middle) and the user can tap the key "2" to enter the index (Figure 2, upper right). Then, by tapping the key "+/-" and flicking in the upward direction (Figure 2, lower left), the operation "+" is entered. In order to enter 5x, the user simply taps the key "5" and flicks in the leftward direction (Figure 2, lower middle). After entering "+", 6 is entered by tapping the "6" key in the end (Figure 2, lower right). As seen in Figure 2, the product of a number and *x* or *y* that often appears in the expressions is built into the flicking choices, resulting in a reduction in the number of tap operations.

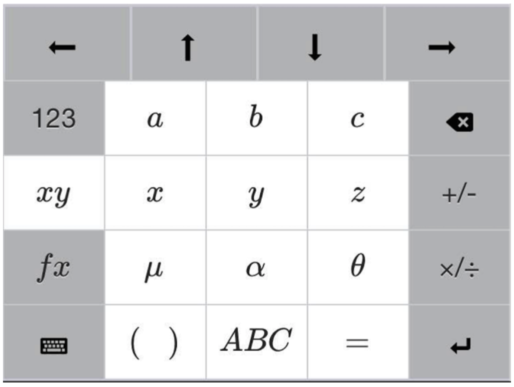

Figure 1. Basic layout of the flickable math input interface

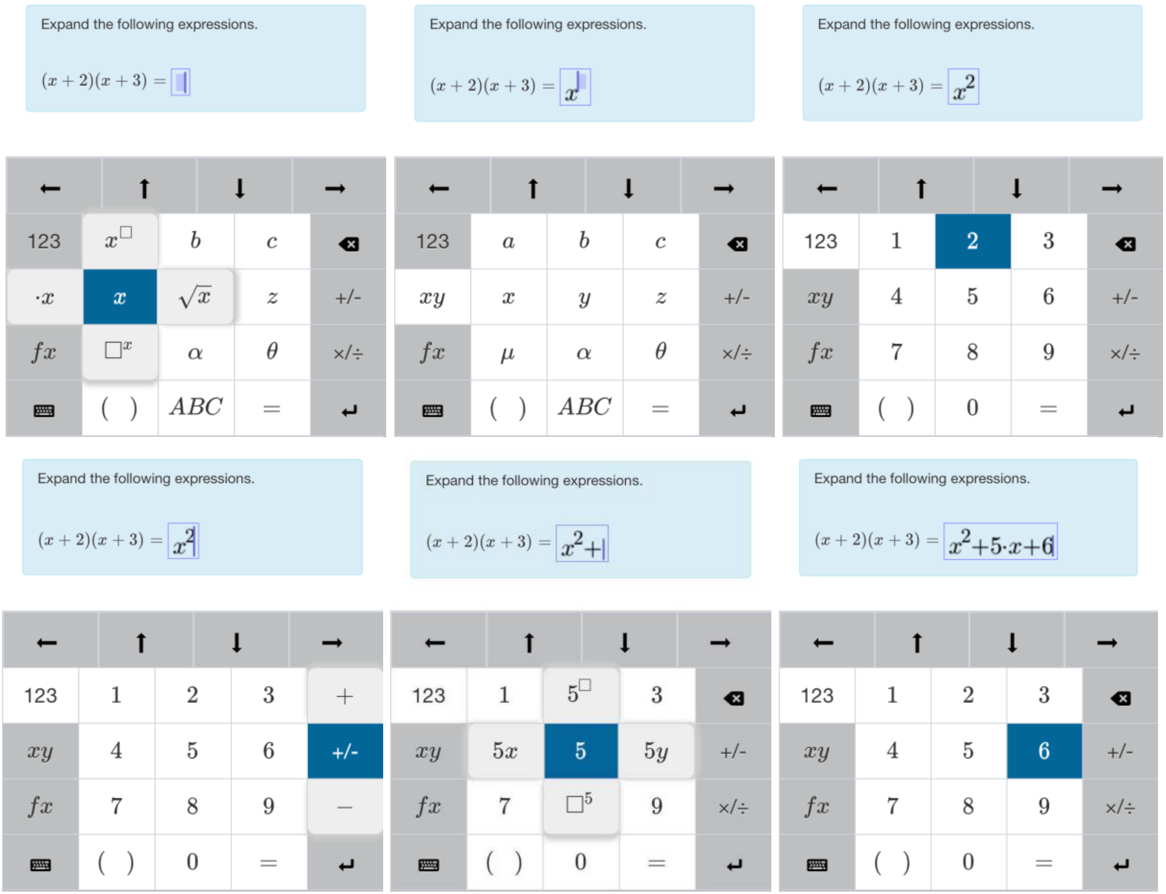

Figure 2. How to enter the expression $x^2 + 5x + 6$.

3.3 Estimation of Input Efficiency

The number of key taps needed in the proposed math input interface is compared with direct input for several mathematical expressions in Table 1. Note that direct input starts from the alphabet keyboard and flick input starts from the state displayed in Figure 1. In addition, the way to input numbers by leaving the alphabet keyboard and holding down the number switching key is not adopted. As seen in Table 1, the number of key touches is obviously reduced, leading to a reduction of the work of math input. It is remarkable that the number of key touches is especially decreased for the input of functions, e.g., trigonometric functions.

Table 1. Comparison of the number of tap operations.

Mathematical expressions	Number of tap operations	
	Direct input	Flick input
x^2+5x+6	19	8
$3x^2-\frac{2x}{(x^2+1)^2}$	36	13
$2x\cos x^2$	23	7

4. CONCLUSION

For students taking online mathematics tests, providing an environment for mobile devices such as smartphones is considered to lead to increased drill practice opportunities. Therefore, we developed a math input interface with flick operation assuming the use of STACK for online mathematics testing. By using the interface, it was confirmed that the number of key touches is reduced. We have not yet carried out a usability test; this is necessary for further improvements of our interface.

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