MathTOUCH

Mathematical Input Interface in E-Assessment Systems

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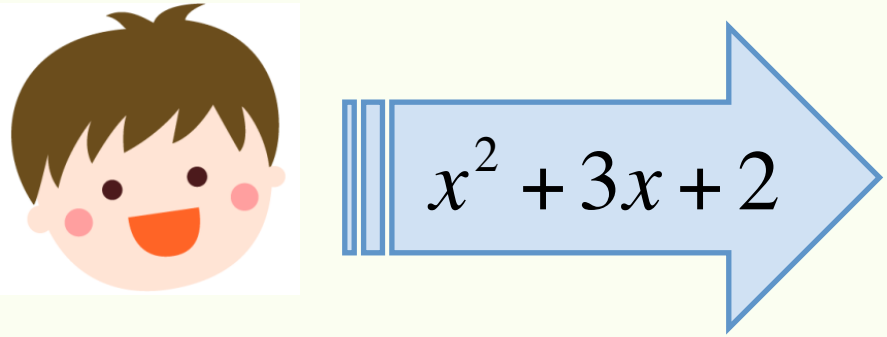
Outline

1. Motivation and Background of the Study
2. Reconstructed **MathTOUCH**
3. Evaluation
4. Summary and Future Plans

1

MOTIVATION AND BACKGROUND OF THE STUDY

Text-based interfaces



$x^2 + 3x + 2$

Structure-based interfaces

STACK
Maple T.A.
Math on Web

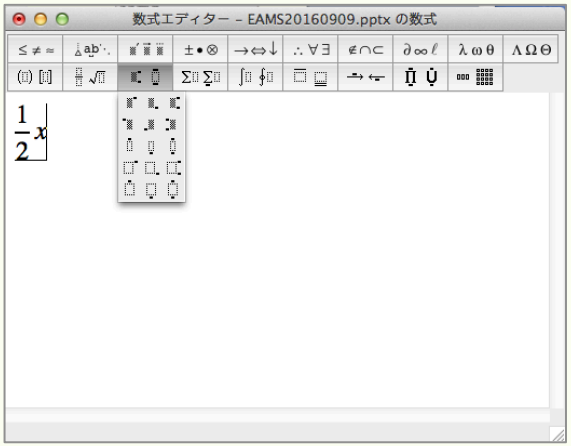
$(x+1)(x+2) = ?$

Text-based UI

3*y^4/2*x

- Input only keyboard
- Input fast

Structure-based UI



$\sqrt{5}$ sqrt(5)

$\sin^2 x$ sin(x)^2  sin^2*x

$\begin{pmatrix} -2 & 1 \\ \frac{3}{2} & -\frac{1}{2} \end{pmatrix}$ matrix([-2,1],[3/2,-(1/2)])

- **Must remember CAS command syntax**
- **Not WYSIWYG**

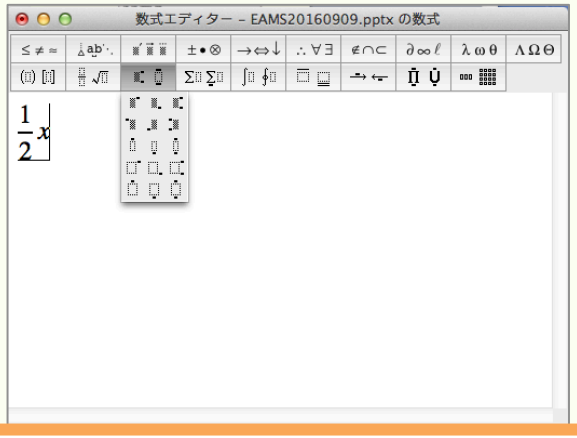
Text-based UI

3*y^4/2*x

- Input only keyboard
- Input fast

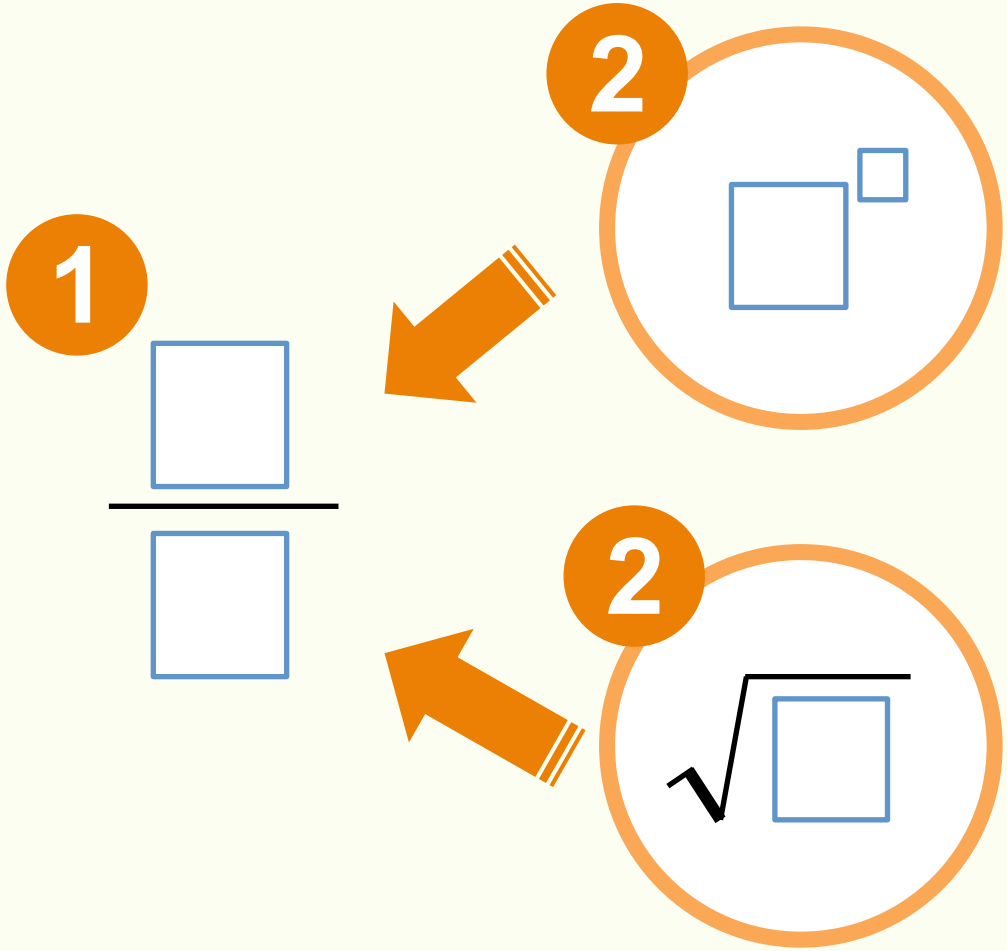
- Must remember CAS command syntax
- Not WYSIWYG

Structure-based UI



- WYSIWYG editor
- Don’t need to remember CAS command syntax

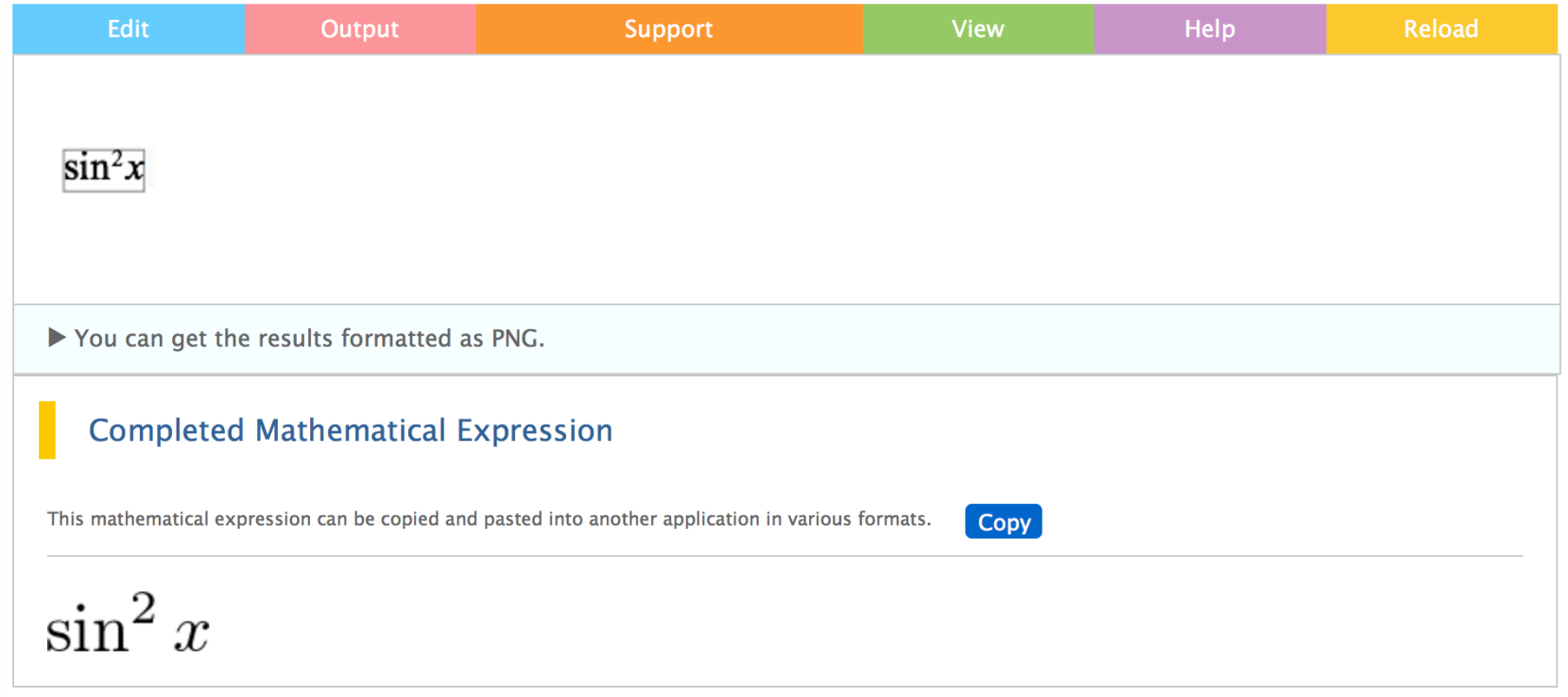
$$\frac{3x^2 - 1}{4\sqrt{2x}}$$



- First, need to understand structure
- Troublesome correcting errors

MathTOUCH

http://math.mukogawa-u.ac.jp/en/



MathTOUCH

http://math.mukogawa-u.ac.jp/en/

STEP 1

Enter colloquial-style text.

First, Enter the mathematical expressions using a colloquial-style linear string.

STEP 2

Chose the desired element from the list.

A list of the conversion candidates is shown under the target letter. You can chose the desired element from this list.

STEP 3

$$x = \frac{1+\sqrt{5}}{2}$$

LaTEX , MathML

JPEG, PNG, EPS

Maxima, Maple
Mathematica

Use the output expression in various formats.

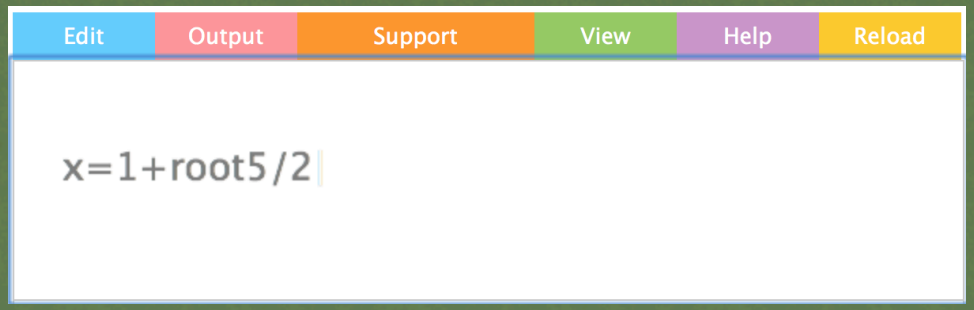
You are able to paste the output expression onto a document with another application in various formats.

MathTOUCH

http://math.mukogawa-u.ac.jp/en/

STEP 1

Enter colloquial-style text.



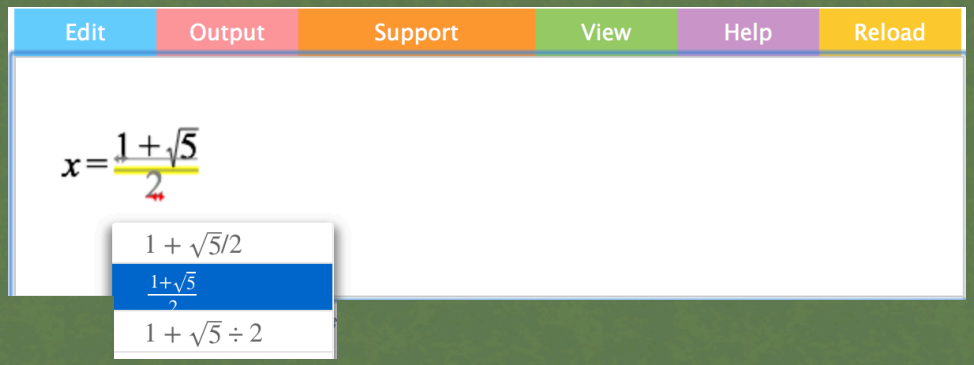
First, Enter the mathematical expressions
Using colloquial-style linear string.

MathTOUCH

http://math.mukogawa-u.ac.jp/en/

STEP 2

Chose the desired element from the list.



A list of the conversion candidates in shown under the target letter. You can choose the desired element from this list.

MathTOUCH

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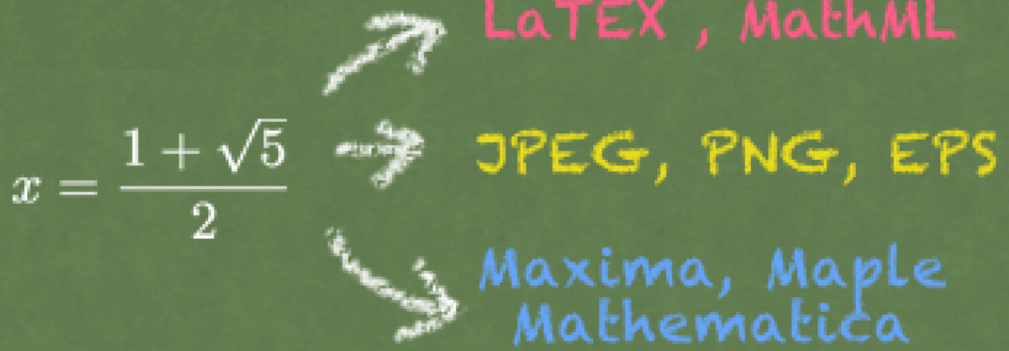
STEP 3

Use the output expression in various formats.



You are able to paste the output expression onto a document with another application in various formats.

MathTOUCH

http://math.mukogawa-u.ac.jp/en/

- Proposed by Fukui (2011)
- Developed with **JAVA**
- **Text-based** + **GUI**
- **No need to learn**

  new command syntax

Linear String Rules

Set the key letters (or words) corresponding to the elements of a mathematical expression **linearly in the order of colloquial (or reading) style**, without considering two-dimensional placement and delimiters.

e.g. $\frac{1}{\alpha^2+3}$

1 over alpha to the **2**nd power **plus 3**

Rules	Inputting Linear string
Colloquial style	1/a2+3
CAS command (e.g., Maxima)	1/(a^2+3)
LaTeX	¥frac{1}{a^2+3}

Linear String Rules

Example	MathTOUCH	Mathematica	Maple	Maxima
$5x^2+2$	5x2+2	5*x^(2)+2	5*x^(2)+2	5*x^(2)+2
$\sqrt{2}$	root2	Sqrt[2]	sqrt(2)	sqrt(2)
$\sin^2 x$	sin2x	Sin[x]^(2)	sin(x)^(2)	sin(x)^(2)
$\log_{10} x$	log10x	Log[10,x]	log[10](x)	log(x)/log(10)
$e^{\pi x}$	epx	Exp[Pi*x]	exp(Pi*x)	e^(%pi*x)
$\sum_{k=1} k^2$	sumk=1nk2	Sum[k^(2),{k,1,n}]	sum(k^(2),k=1..n)	sum(k^(2),k,1,n)
$\lim_{x\to 1} \frac{x}{2}$	limx-->1x/2	Limit[x/2,x->1]	limit(x/2,x=1)	limit(x/2,x,1)
$\frac{df}{dx}$	df/dx	D[f,x]	diff(f,x)	diff(f,x)
$\int_0^1 x\,(1-x)\,dx$	int01x(1-x)dx	Integrate[x*(1-x),{x,0,1}]	int(x*(1-x),x=0..1)	integrate(f,x,0,1)

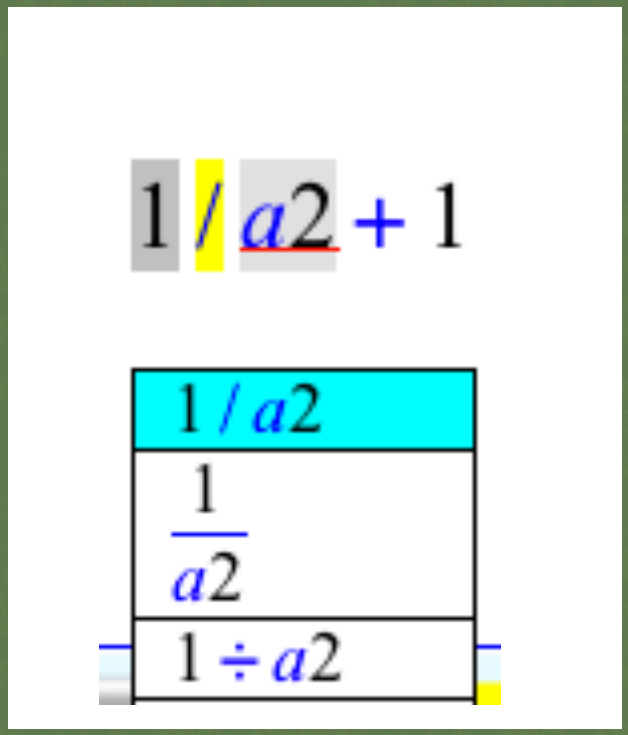
Just enter in colloquial style

Input Procedure for $\frac{1}{a^2+1}$

Step 1

Input a linear string using a colloquial style.
Not need to input **^** or **( )**.
e.g. 1/**(**a**^**2+1**)**

Input Procedure for $\frac{1}{a^2+1}$



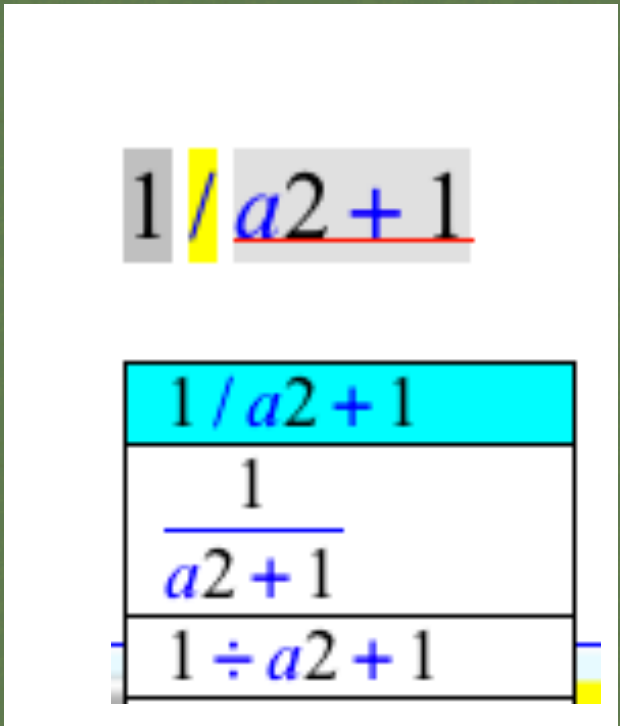
Step 2

Hit the space key to start conversion process. A list of the conversion candidates is shown.

: Conversion target

: An operand

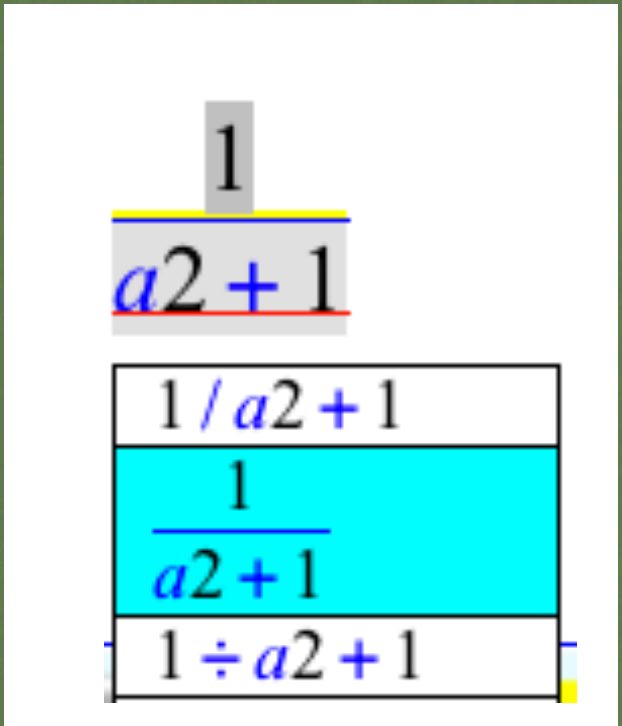
Input Procedure for $\frac{1}{a^2+1}$



Step 3

Extend the red line to include 1 by using the right arrow key.

Input Procedure for $\frac{1}{a^2+1}$

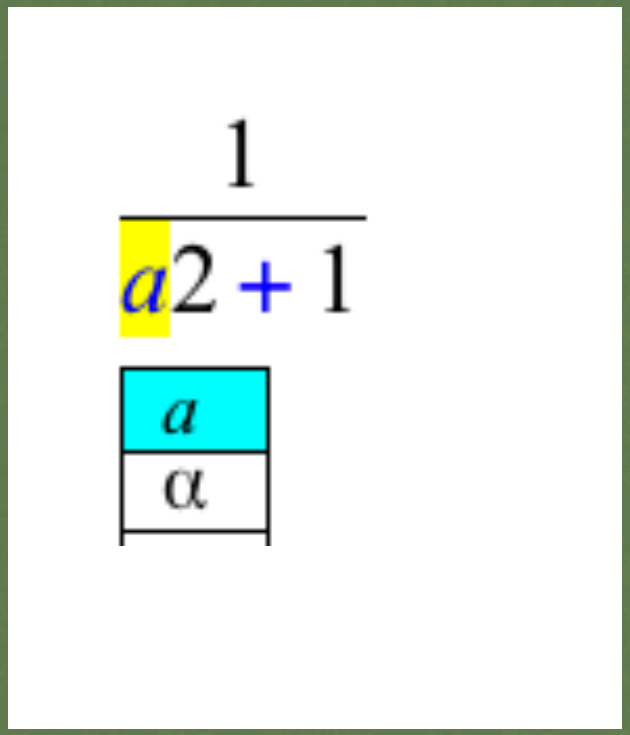


Step 4

Chose the desired operator from among the candidates.

To switch the current candidate
: Space or Arrow key
To confirm the candidate
: Enter key

Input Procedure for $\frac{1}{a^2+1}$

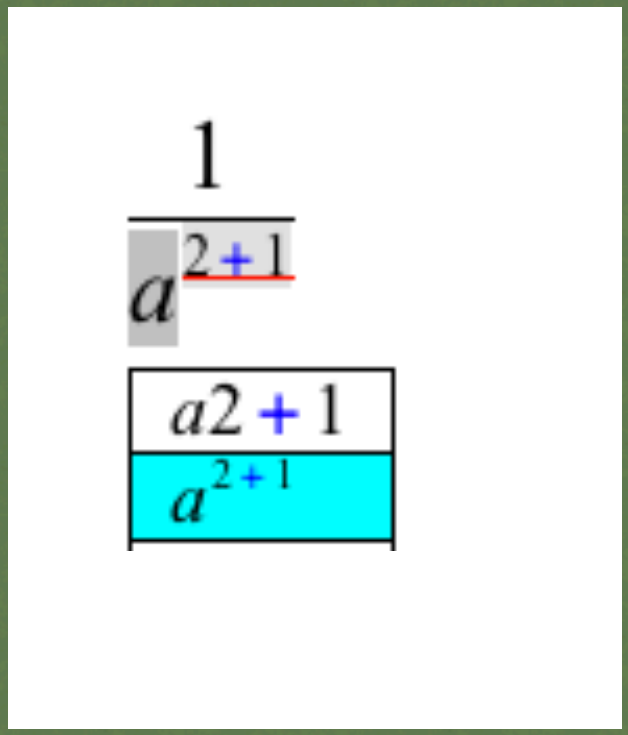


Step 5

The conversion target moves on to next element to the right.

To switch the current candidate
: Space or Arrow key
To confirm candidate
: Enter key

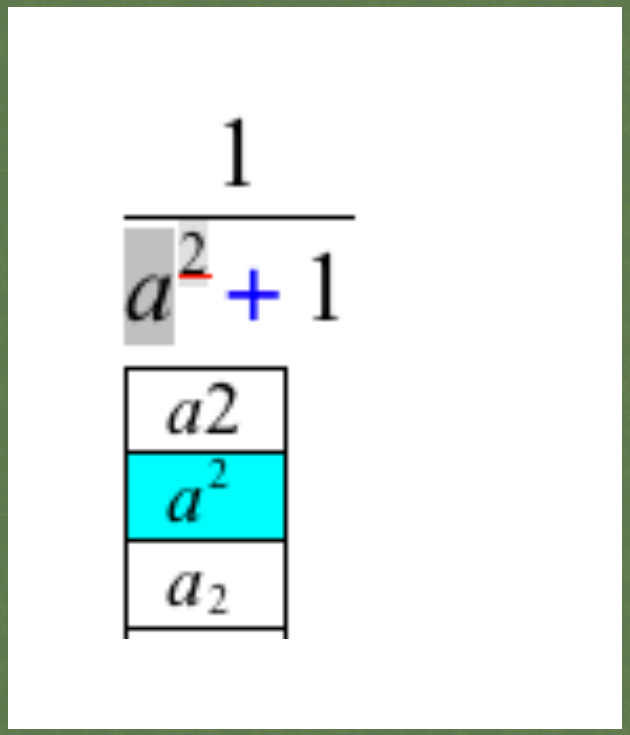
Input Procedure for $\frac{1}{a^2+1}$



Step 6

The conversion target moves on to an unexpressed operator.

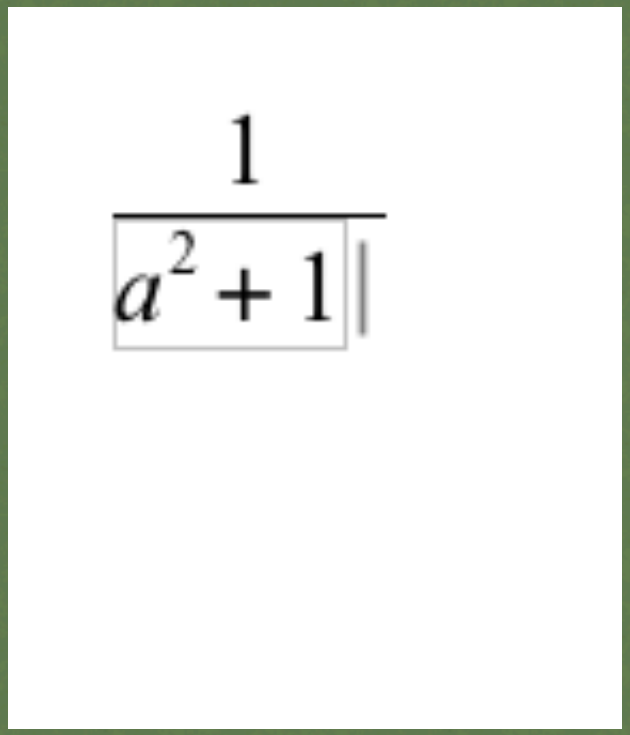
Input Procedure for $\frac{1}{a^2+1}$



Step 7

Shorten the red line by using the left arrow key.

Input Procedure for $\frac{1}{a^2+1}$



Step 7

Process completed.

LaTEX , MathML

JPEG, PNG, EPS

Maxima, Maple
Mathematica

問題 7

未解答

最大評点 1.00

問題にフラグ付けする

次の式を入力してください。

$x^2 - 9x + 18$

space 数式変換 | delete 削除 | Enter 確定 | ← → 移動 | shift + delete 全削除

←ここをクリックして
数式文字列を入力してください。

次へ

実験(MT)

Characteristics of MathTOUCH

- ✓ **Input in WYSIWYG** with **only keyboard**
- ✓ **No need** to **learn complex syntax**

User-friendly for novice math learners

Evaluation of MathTOUCH

- ✓ **Performance**

  Experimental performance test [1]

- ✓ **Mathematical work**

  The eight-week survey [2]

[1] S. Shirai, Y.Nakamura and T. Fukui, An Interactive Math Input Method for Computer Aided Assessment Systems in Mathematics (in Japanese), IPSJ Transactions on Computers and Education, Vol.1, No.3, pp.11 -21(2015).

[2] S.Shirai and T.Fukui,ImprovementintheInputofMathematicalFormulaeintoSTACKusing Interactive Methodology (in Japanese), Computer & Education 37, pp.85-90 (2014).

Evaluation of MathTOUCH

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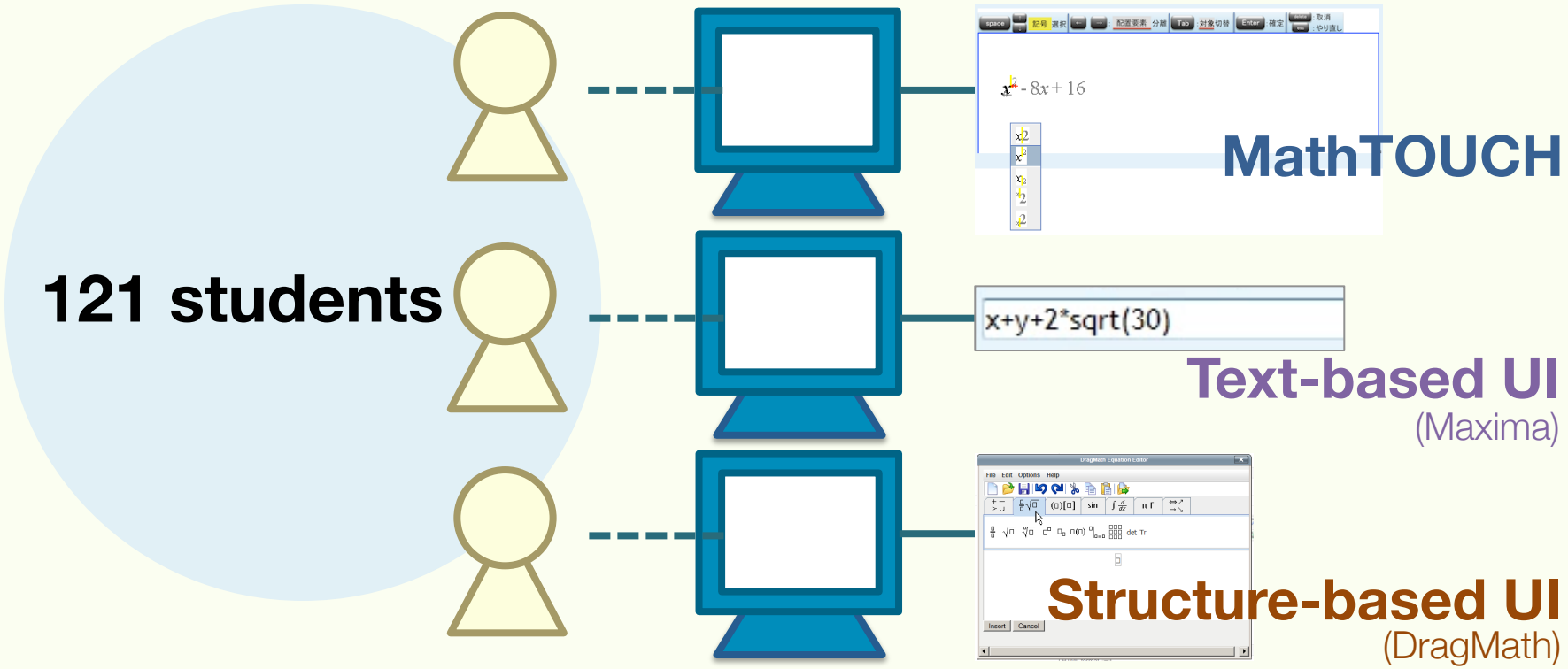
Objectives

We have investigated whether students are able to input mathematical expressions using **MathTOUCH** more smoothly than with the standard interfaces.



Results

Effectiveness Task-performance rates

MathTOUCH : **97.1**%

Text-based UI : 89.7% **Structure-based UI** : 94.1%

Efficiency Task-performance times

MathTOUCH : **24.3** seconds

Text-based UI : 28.8 sec. **Structure-based UI** : 39.0 sec.

Satisfaction Questionnaire

Efficiency : **MT** > **Text-based UI**

Memorability : **MT** > **Text-based UI**, **Structure-based UI**

Loyalty : **MT** > **Text-based UI**

Evaluation of MathTOUCH

- ✓ **Performance**

  Experimental performance test [1]

- ✓ **Mathematical work**

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Objectives

We have investigated whether students were able to practice mathematical work using **MathTOUCH** on **STACK**.

1. Are students able to practice mathematical work using **MathTOUCH** **with the same learning rate** as with the current interface on **STACK**?
2. Is **MathTOUCH** able to improve the usability of math input on **STACK**?

Results

1. **Are students able to practice mathematical work using MathTOUCH with the same learning rate as with the current interface on STACK?**

➡ They were able to practice using **MathTOUCH** with the same proficiency rate.

2. **Is MathTOUCH able to improve the usability of math input on STACK?**

➡ Satisfaction of **"Memorability"** was significantly higher than the current interface.

Characteristics of MathTOUCH

- ✓ **Input in WYSIWYG** with **only keyboard**
- ✓ **No need** to **learn complex syntax**
- ✓ **Has better input performance** than **structure-based** and **Text-based interfaces.**

However, the user has to use a JAVA-compliant device

Advantage and Disadvantage Developed with JAVA

Advantage

- JAVA will allow us to easily plug JAVA applet into various systems.

Disadvantage

- The user has to use a JAVA-compliant device.
- It’s hard to use in institutions due to security concerns.

Objectives in this study

We make MahTOUCH available not only on JAVA-compliant devices but also **on various devices.**

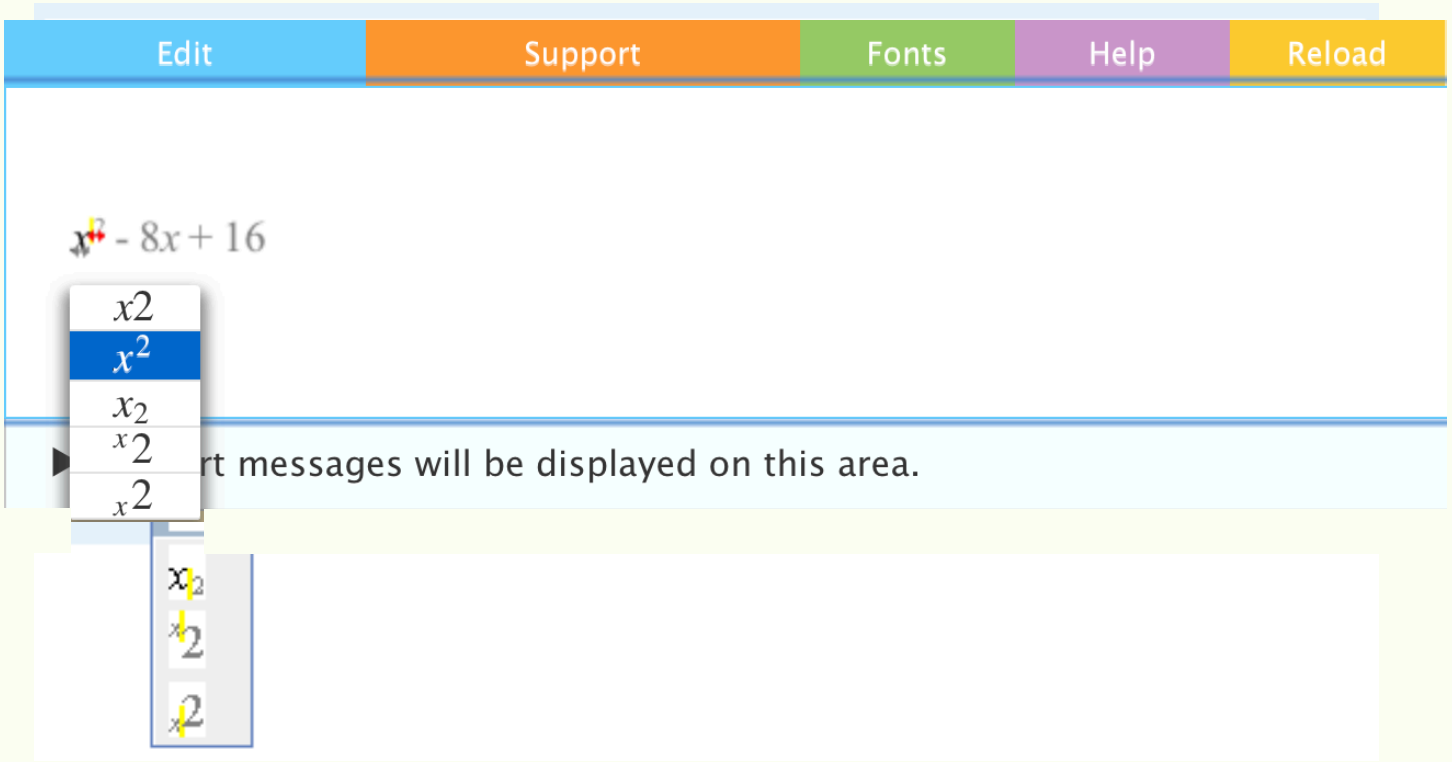
1. We **reconstruct MathTOUCH** using **JavaScript**.
2. We investigate whether students are able to practice mathematical work using **reconstructed MathTOUCH** with the same learning rate as with **MathTOUCH with JAVA**.

2

RECONSTRUCTED MATHTOUCH

MathTOUCH

http://math.mukogawa-u.ac.jp/en/



MathTOUCH

http://math.mukogawa-u.ac.jp/en/

- Developed with **JaveScript (HTML5).**
- Used **MathJax** for **conversion candidates**.
- Added **an edit function**
- Enhanced **the support function**.

DEMO

Please enter the following expression.

Tidy question | Question tests & deployed versions

$$x^2 - 8x + 16$$

Edit | Support | Fonts | Help | Reload

Click here to enter a colloquial-style mathematical text.

▶ Support messages will be displayed on this area.

3

EVALUATION

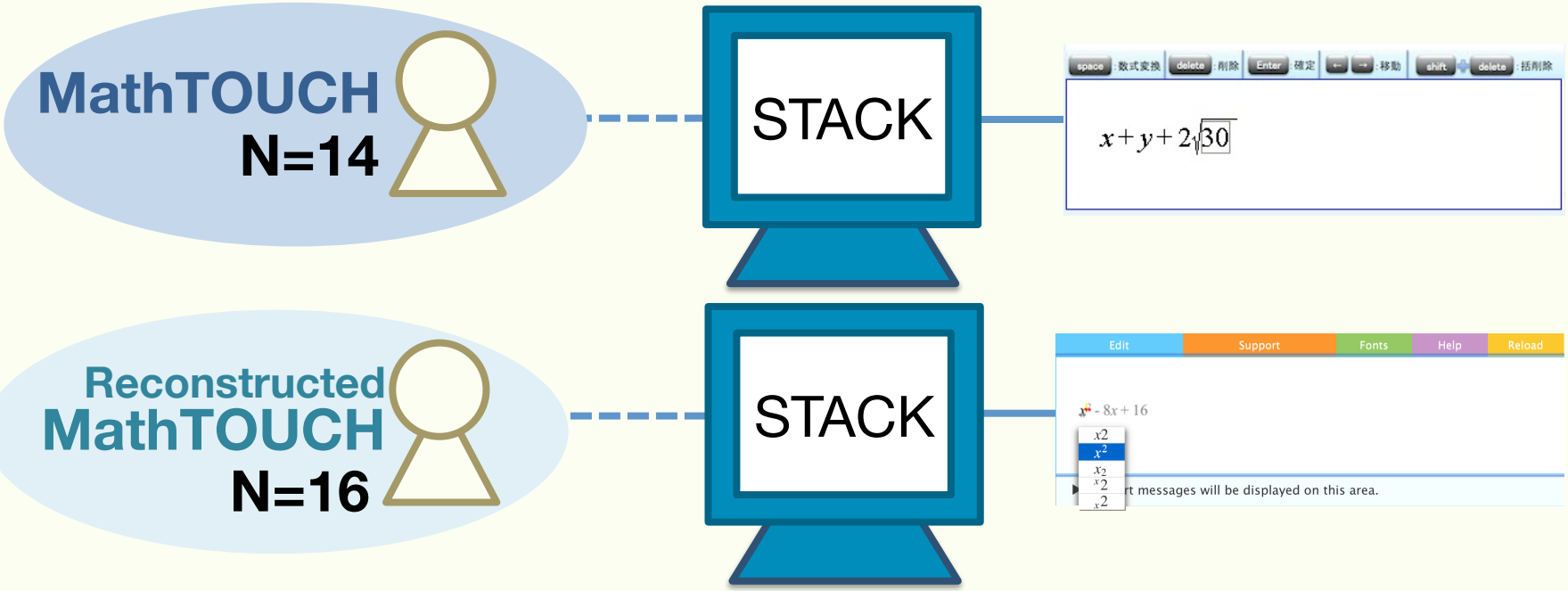
Objectives

We have investigated whether students were able to practice mathematical work using **reconstructed MathTOUCH** on **STACK** .

1. Are students able to practice mathematical work using **reconstructed MathTOUCH** **with the same learning rate** as with **MathTOUCH using JAVA**?

2. Is **reconstructed MathTOUCH** able to improve the usability of math input on **STACK**?

Procedure



- **30 students** are assigned to **two groups**.
- They practiced mathematical work on STACK for **5 weeks**.
- Made a measurement of **the solving times**, **the percentage of correct answers**, **learning rates** and **Questionnaire of Usability**.

Learning Contents

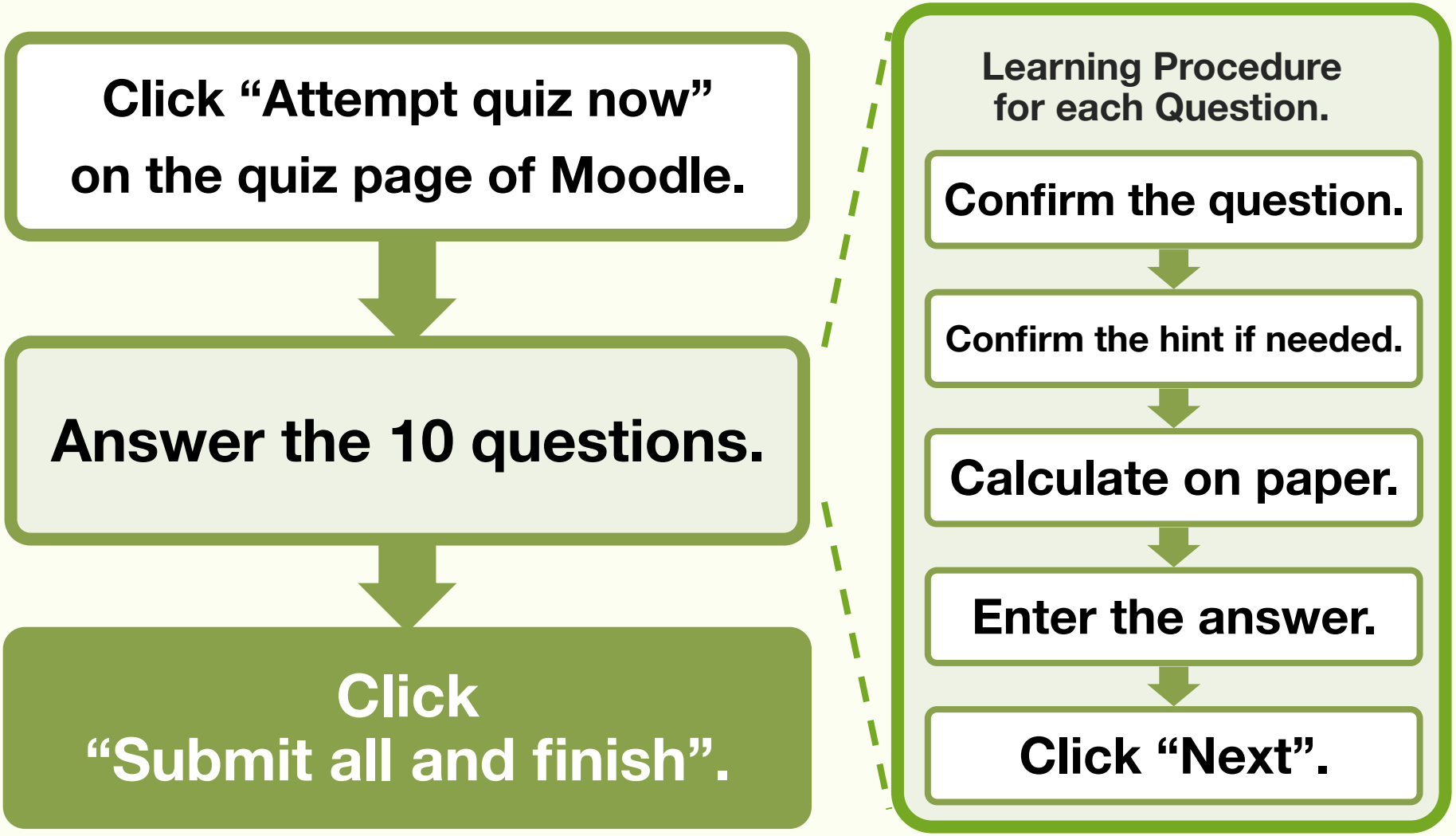
Example of mathematical expressions used in mathematical work

$$\sqrt{20} \times 2\sqrt{2} \div \sqrt{5} \qquad \sqrt{50} - 4\sqrt{2} + \frac{6}{\sqrt{2}}$$

- **Simple mathematical calculation**
- **10 questions once a week**

Measurement of Solving Times

Use response time by measurement of Moodle



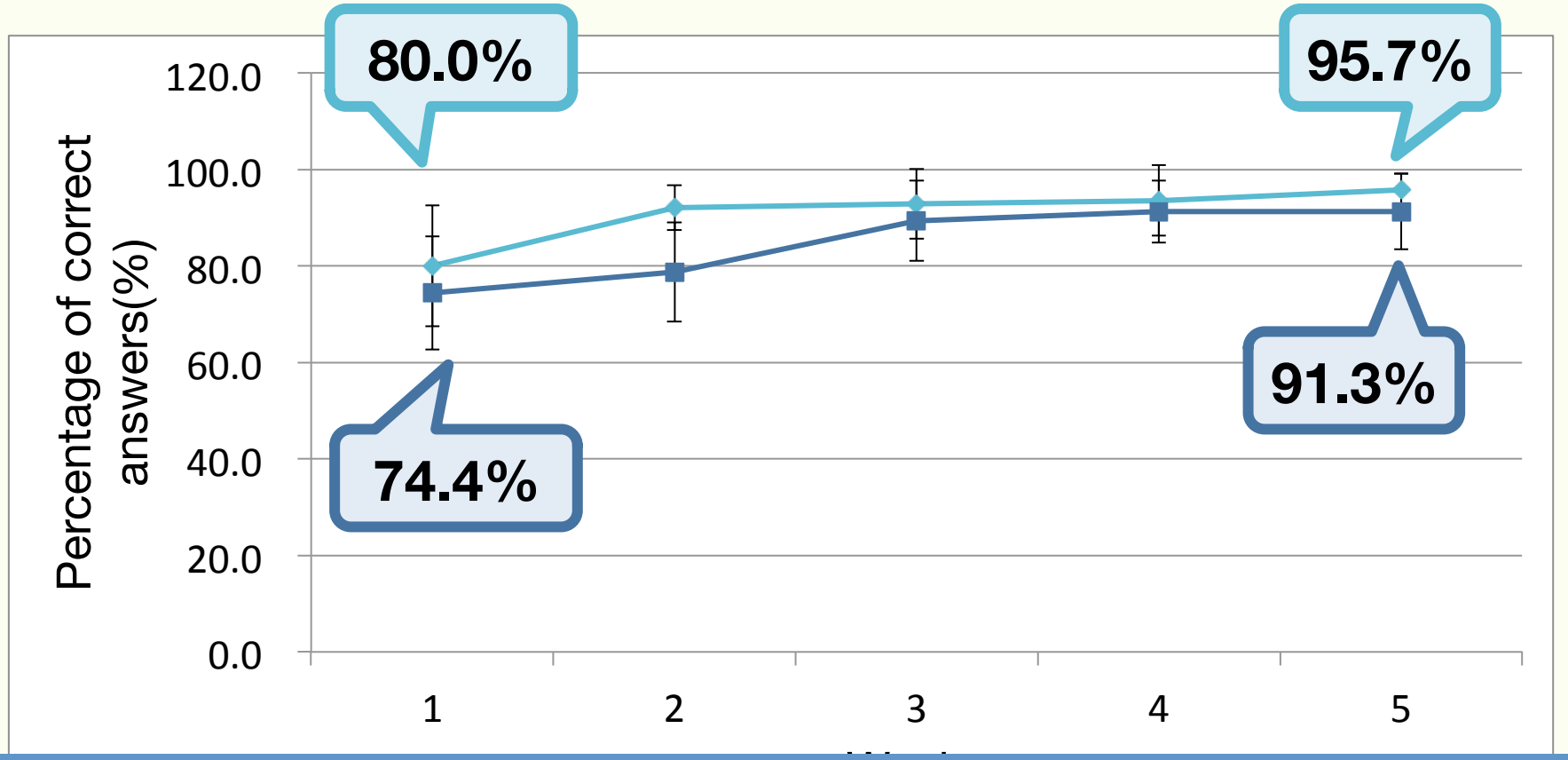
Questionnaire of Usability Satisfaction

We gave a questionnaire regarding subjective satisfaction about each interface using a 5-point rating scale from 1(strongly disagree) to 5(strongly agree).

	Contents of the questionnaire	
1	**It was easy to master the use of this UI.**	**Learnability**
2	**Mathematical expressions could be inputted smoothly using this UI.**	**Efficiency**
3	**It was easy for me to correct mis-entered operations.**	**Error**
4	**I remember how to use this UI from first time which is given the explanations later.**	**Memorability**
5	**Would you like to use this UI when you enter the mathematical expressions?**	**Loyalty**

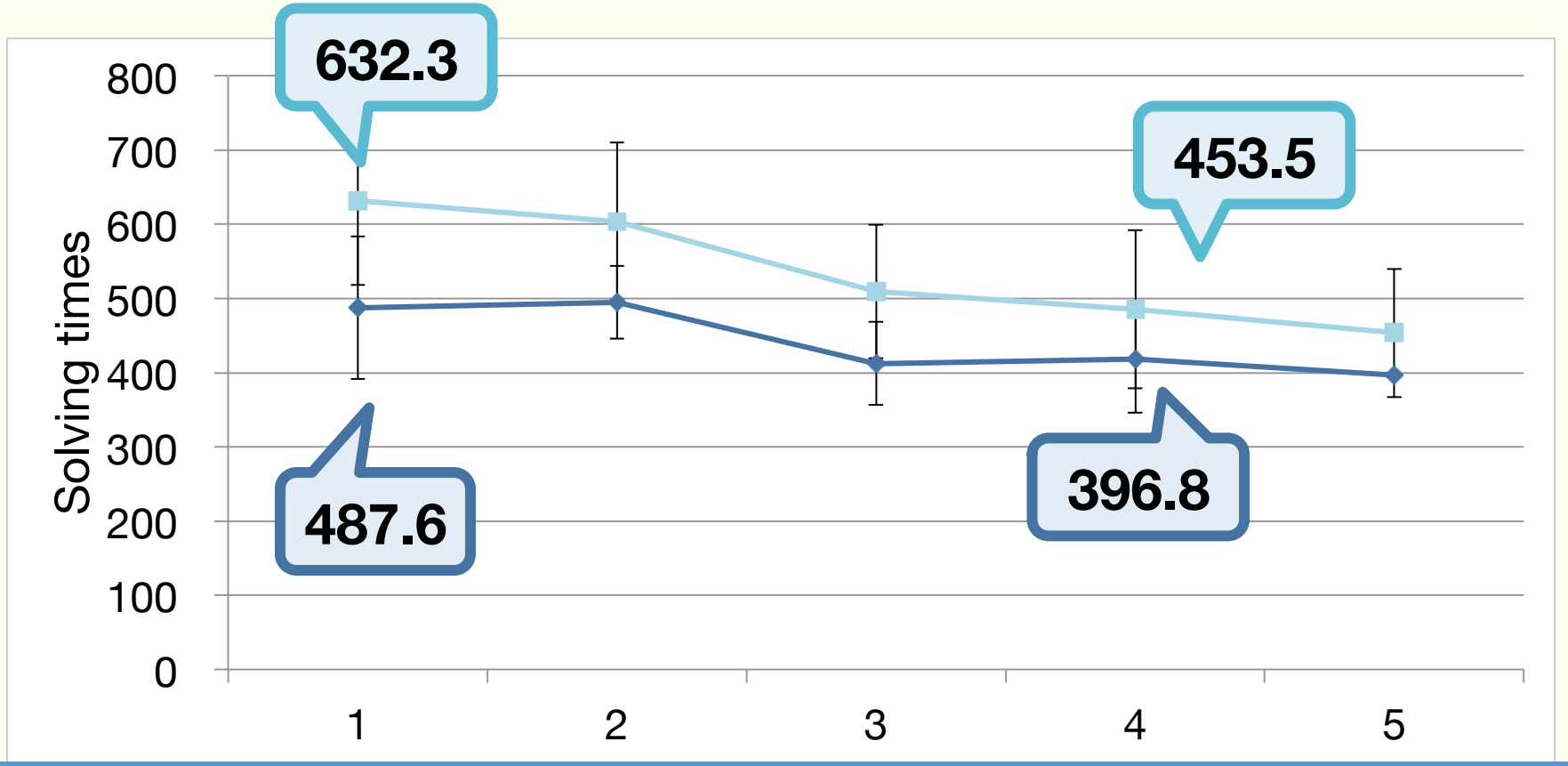
RESULTS

Percentage of correct



No significant difference for the percentage of correct answers between MathTOUCH and the reconstructed MathTOUCH for each week.

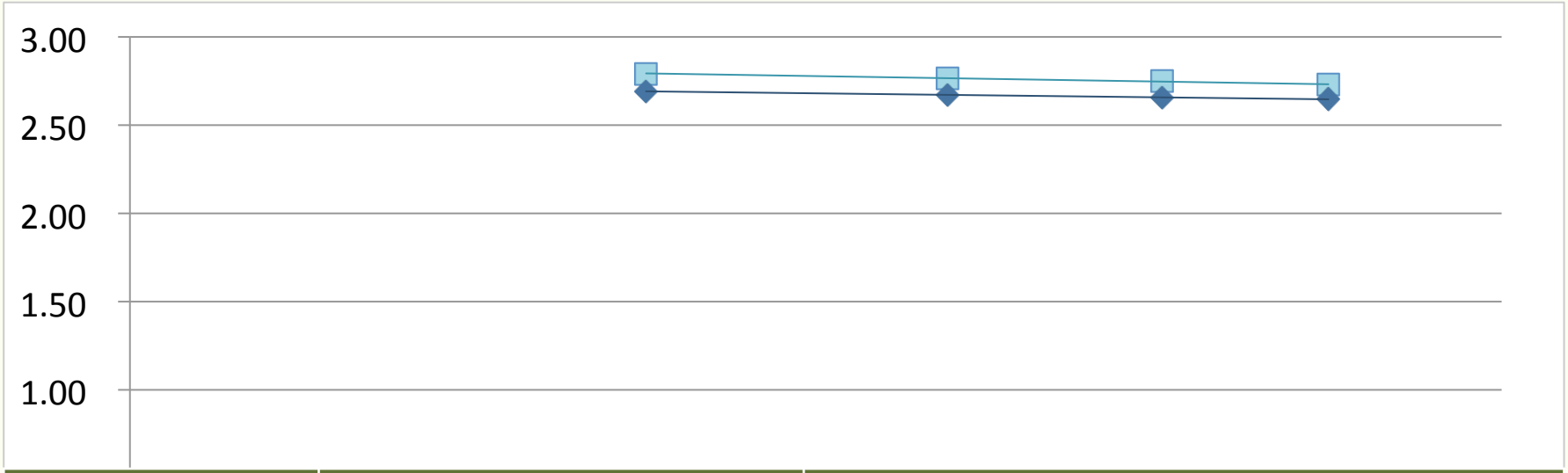
Solving times



No significant difference for the solving times between MathTOUCH and reconstructed MathTOUCH for each week.

Learning rate

Calculated using the transition of response time. Evaluated proficiency rates on the presumption that it follows a log-linear model by progressive average [4].



R^2	MathTOUCH	Reconstructed MathTOUCH
5 weeks	0.91025	0.80184
4 weeks	0.99841	0.99191

[4] Kozi Morooka: Proficiency Engineering, Kenpaku-sha (1994)

Learning rate

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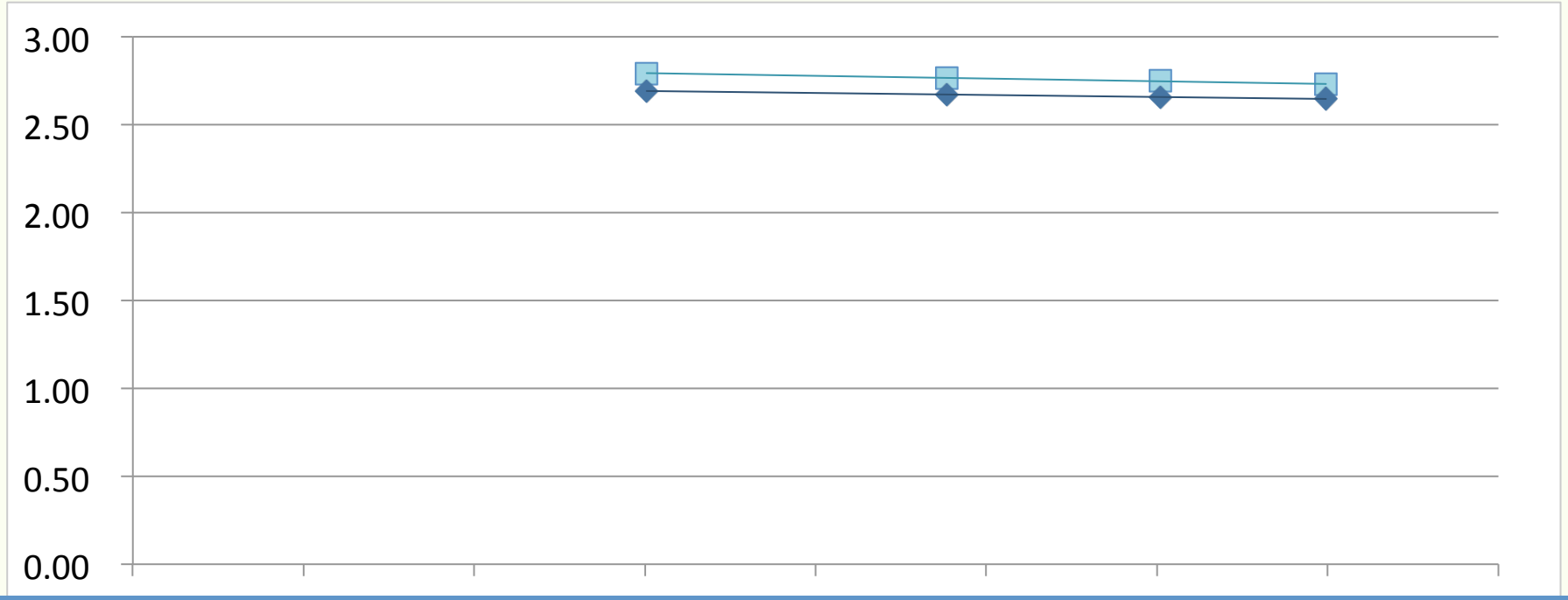
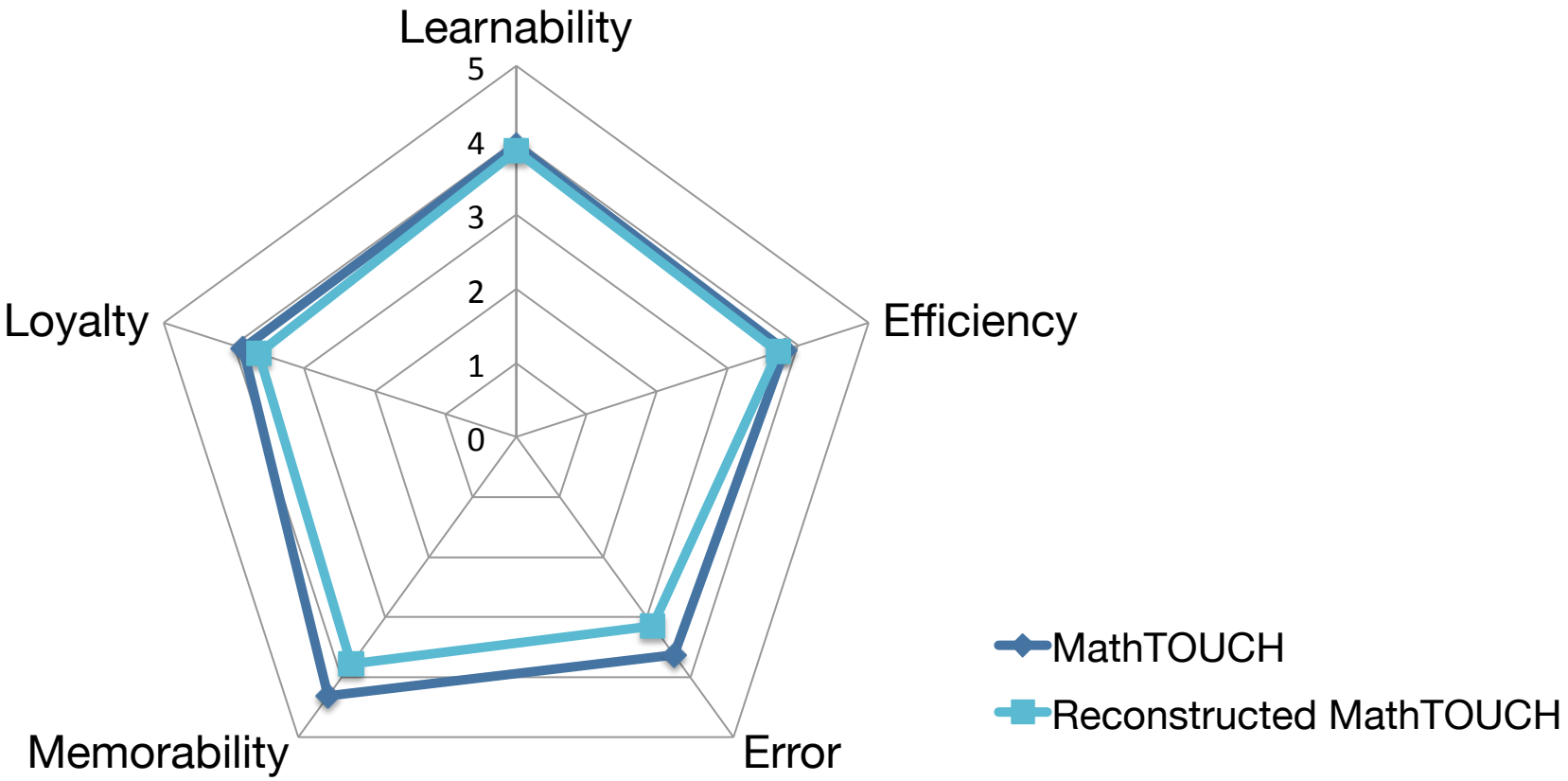


Reconstructed MathTOUCH : 92.4%
MathTOUCH : 89.9%

Results of Questionnaire



No significant difference between MathTOUCH and reconstructed MathTOUCH.

4

SUMMARY AND FUTURE PLANS

Summary and Future Plans

- We have reconstructed **MathTOUCH** using **JavaScript.**
- Our experiments have shown that students are able to practice mathematical work using **reconstructed MathTOUCH** with the same proficiency rate as with **MathTOUCH by JAVA**.

Future plans

- Make the conversion prediction of **MathTOUCH** intelligent using machine learning.
- Develop interface for smart devices.