AI-LearnMath: An Artificial Intelligence Based Interactive Learning Platform to Assist Visually Impaired Children in Learning Mathematics
Motivation

Blind and visual impaired people:

They can have great difficulties with math. They can have access issues in that their screen reader is not able to correctly read the mathematical concepts as written on a page. Vision impaired people will struggle with graphs that are color coded and with understanding what shapes and structures look like.

Source: 2015, Cornell University Disability Study, Math Tutor – Best Math Learning & Quiz Game App
Problem Statement

Since new technologies have developed many softwares and platforms that help normal students learning mathematics which didn’t consider students with disabilities. Thus, students with disabilities will always have difficulties keeping the same study pace of normal students. They must have some special assistances that help them improve efficiency.

In this case, we plan to conduct a research which target the solution of helping visually impaired people learning and practicing mathematics independently.

Here, we plan to adopt auditory and tactile feedback to conduct a smartphone based platform with the design of artificial intelligence. The platform will realized the functions that help visually impaired people to practice certain types of mathematical problems by themselves. Also, it will be able to assist teachers in class with introduction and explaining mathematical concepts and questions.
Previous Work

Figure 1 – Braille box and tactile simulator array

Figure 2 – The MathPractice framework structure

Figure 3 – The schema of alternative description of mathematical equation

Source: Sribunruangrit et al. [3], Elkabani et al. [4], Maćkowski et al. [2]
Proposed Framework

Steps for Self-practice

1. A pair of earphones and a haptic controller device are provided;
2. Choose types of mathematical questions through interactive learning module by voice control;
3. System automatically search questions of chosen type from the question bank;
4. Question will be analyzed in a certain way according to the specific solutions;
5. Output information from both text-to-speech device and haptic controller synchronously;
6. Visually impaired people interact with system through auditory feedback;
7. Judge the correctness of the answer;
**Proposed Framework**

**Steps for Class Interaction**

1. Teachers will be able to design their own questions and input into the system.
2. Teacher spread questions uniformly through central control system;
3. Student will accept their question and upload their test-taking process, so that teachers can monitor the performance of the students and give right response.
Mathematical Problem Solution

Solution for Systems of Linear Equation
\[ \begin{align*}
2x + 4y &= 4 \\
y &= x - 2
\end{align*} \]

- Choice: substitute directly OR extract common factor
- VI & Blind Users: Choose y as substitute
- No, substitute directly
- Waiting for the result of x
- Substitute x to another equation and ask for result of y
- x is 6
- y is 4
- Result is correct

Solution for Quadratic Equation of One Variable
\[ 2x^2 + 2x - 40 = 0 \]

- Choice: factorization directly OR extract common factor
- Extract 2
- Factorization in brackets
- Factorization correct, ask for the results of x
- x = -5 and x = 4
- Result is correct
Mathematical Problem Solution

Solution for Simple Derivative \( f(x) = 3x^2 + 4x \), what is \( f'(x) \)?

Systems

- What is the coefficient of the derivative of first item
  - The coefficient is 6

- What is the power of the derivative of first item
  - The power is 1

- What is the coefficient of the derivative of second item
  - The coefficient is 4

- What is the power of the derivative of second item
  - The power is 0

Result is correct, the derivative is \( f'(x) = 6x + 4 \)
Text-To-Speech

Source: Spinczyk et al. [1]
Text-To-Speech Solution

Demo

Put Text-to-Speech into action

Type what you want, select a language then click "Speak It" to hear.

Text to speak:
This is a demo of speech-to-text module, 2x^2+2x-40=0

Language / locale
- English (United States)

Voice type
- WaveNet

Voice name
- en-US-Wavenet-D

Audio device profile
- Default

Speed: 1.00
Pitch: 0.00

Request URL
https://texttospeech.googleapis.com/v1beta1/text:synthesize

Source: https://cloud.google.com/text-to-speech
Braille is an universal language for blind or visually impaired people. But for mathematical learning, we can make it to be more vivid.
Proposed Haptics Solution

Solution for Systems of Linear Equation

\[
\begin{align*}
2x + 4y &= 4 \\
y &= x - 2
\end{align*}
\]

Systems
- Choice: substitute directly OR extract common factor
- Waiting for the result of x
- Substitute x to another equation and ask for result of y
- Result is correct

VI & Blind Users
- Choose y as substitute
- No, substitute directly
- x is 6
- y is 4

Voice Repeating
- Back to Previous Page
- Substitute
- y
- Extract common factor
- Enter
Solution for Quadratic Equation of One Variable

\[ 2x^2 + 2x - 40 = 0 \]

- Choice: factorization directly OR extract common factor
- Factorization in brackets
- Factorization correct, ask for the results of \( x \)
- Result is correct

\[ (x + 5)(x - 4) \]

\[ x = -5 \text{ and } x = 4 \]
Proposed Haptics Solution

Solution for Simple Derivative

\[ f(x) = 3x^2 + 4x, \text{ what is } f'(x)? \]

- **Systems**
  - What is the coefficient of the derivative of first item
  - What is the power of the derivative of first item
  - What is the coefficient of the derivative of second item
  - What is the power of the derivative of second item
  - Result is correct, the derivative is \( f'(x) = 6x + 4 \)

- **VI & Blind Users**
  - The coefficient is 6
  - The power is 1
  - The coefficient is 4
  - The power is 0

- **Voice Repeating**
  - Back to Previous Page
  - Voice Repeating
  - power
  - coefficient
  - Enter
Proposed Solution for Result Input

Enter Braille as Solution

BRAILLE ALPHABET
ENGLISH VERSION

ALPHABET:
A B C D E F G H I
J K L M N O P Q R
S T U V W X Y Z

NUMBERS:
1 2 3 4 5 6 7 8 9 0

PUNCTUATION:
., ?, ! : ; ‘ ’ ” ”

SOUNDS:
CH GH SH TH WH ED ER OU OW
and for of the with

SIGNS:
capital, decimal

Confirm
Continue
Proposed Solution for Result Input

Voice Recognition as Solution (Speech-to-Text)

This is a demo of speech-to-text module, $2x^2 + 2x - 40 = 0$

1. Watson
2. Google Cloud
3. Microsoft Azure

Source: https://speech-to-text-demo.ng.bluemix.net/
Proposed Solution for Result Input

Voice Recognition as Solution (Speech-to-Text)

This is a demo of speech-to-text module, $2x^2 + 2x - 40 = 0$

1. Watson
2. Google Cloud
3. Microsoft Azure

Source: https://cloud.google.com/speech-to-text#section-2
Proposed Solution for Result Input

Voice Recognition as Solution (Speech-to-Text)
This is a demo of speech-to-text module, $2x^2 + 2x - 40 = 0$

1. Watson
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3. Microsoft Azure

Source: https://azure.microsoft.com/en-us/services/cognitive-services/speech-to-text/#features
Designed Experiment

The targeted experiment participants are middle school students who are visually impaired or blind.

We plan to distribute the software to those students and keep them practicing these three types of mathematical problems for one week with the assistance of AI-LearnMath. An evaluation will be designed to assess the performance of students on the improvement of mathematics compared with the control group, students of which will maintain their study plan using normal teaching techniques. Beside, we need to conduct an interview to investigate the satisfaction of the students to the proposed platform.

In addition, the software will also be tested in class. In this case, we may need teachers to cooperate with our experiments. An interview will be designed for teachers to evaluate the accessibility of software as well as its efficiency.

The results will be organized in form of tables, bar charts, and interview lists.
Expected Results

We expect to foresee the result of improvement of our proposed platform, to an extent that can help to enhance the efficiency of learning mathematics for visually impaired or blind students.

On the other hand, we assume the combination of auditory and tactile feedback with the help of interactive platform will also intrigue students’ interests in learning mathematics.

At the last, teachers will also get more conveniences to teach students learning mathematics.
Future Work

1. Question bank can be enlarged to give plentiful and more diverse practice questions.

2. More mathematical question types can be explored to make the whole system to be more universal.

3. We may decide to explore the feasibility of connecting the external tactile device that interact with the visually impaired or blind users through braille.

4. To make the interaction more intelligent, we can refer some previous works like adaptive auditory feedback to make the interaction more smooth.

Source: Shoaib, M. et al. [5]


Thank You!