DIGITAL ASSISTANT TO AID INDIVIDUALS WITH PRINT DISABILITIES TO INTERPRET PRINTED MATERIALS

Project Id: 2022-024

Project Proposal Report

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B.Sc. (Hons) Degree in Information Technology

Department of Computer Science and Software Engineering

Sri Lanka Institute of Information Technology

Sri Lanka

January 2022

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Declaration

We declare that this is our work, and this proposal does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any other university or institute of higher learning, and to the best of our knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

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Prabash K.V.A.S	IT19117492	

The above candidates are researching the undergraduate Dissertation under my supervision.

Name of supervisor: Dr. Anuradha Jayakodi

Name of co-supervisor: Ms. Shashika Lokuliyana

Signature of supervisor: Date:

Signature of co-supervisor: Date:

Abstract

In today's world, mathematics is a core essential for all human beings. It is critical for everyone to enhance their math skills in college or through self-study. Students with vision impairments, on the other hand, have limited access to printed materials. They will need the assistance of a human reader if they want to learn through printed materials. However, it is unbiased due to the human's expense and availability. but, the Braille materials are in the possession of the VI student and at the same time, the braille materials are few, and the braille language is complex.

VI students benefit greatly from video and audio technology resources as the other sources provide a limited contribution to their studies. For those students, the audiobook is difficult to comprehend. But they must continue to listen to the audiobooks. However, these limited resources had a negative impact on the math skills of VI students. Text-to-speech Technic is extremely popular all across the world. VI students can use the camera to read printed texts. However, just a few applications for mathematical reading have been developed. MathTalk and Math-Player[1-2] are both available in English. Math Genie is available in English, French, and German,[3] as well as AudioMath, which is available in European Portuguese [4]. Regrettably, their mobile apps have a lot of math reading and listening limitations. Many applications cannot read or recognize advanced mathematical equations (ME). So we are developing a mobile application capable of reading mathematical equations. As a result, VI students can use their mobile phones to read printed content without interruption or external assistance.

Keywords: VI Students, Mathematics, Braille System, Mobile Application

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1. Introduction

1.1. Background & Literature Survey

The number of people who are visually impaired is steadily rising in the world today. In 2015, there was a significant amount of 39.0 million blind population in the world [5]. When compared to the general population visually impaired (VI) people face many difficulties in their day-to-day life due to their disability. Blind students are more likely to experience challenges when it comes to educational achievements, accessing services and information, and searching for job opportunities [6]. Unlike normal students, they cannot easily learn by looking at pictures and videos. Furthermore, visually impaired students do not have access to educational resources easily. Even though they are having challenges when it comes to accessing resources in education it is their right to get educated. VI students face several learning difficulties, from preschool to higher education as they cannot get educated in regular places.

According to the findings, a public literature survey acknowledges that blind people lack the resources to learn.

Do you think vision impaired students have enough resources to study? (දෘශ්‍යාබාධිත සිසුන්ට ඉගෙනීමට ප්‍රමාණවත් සම්පත් ඇතැයි ඔබ සිතනවාද?)
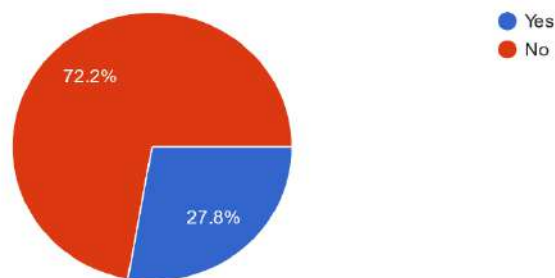
54 responses

Figure 1.1 Summary response of VI students to enough resources to study

Visually impaired students find it very difficult to learn mathematics as the mathematical formulas and the nature of those are very complicated to learn. Mathematics is considered

1

a universal language. Reading and writing mathematics is completely different from reading and writing ordinary letters [7].

The braille system is considered as the method blind students are using globally. Therefore, many blind students learn Braille. There are two methods in Braille. Six and eight dots represent letters on a flat surface [8]. When it comes to the braille system, the problem is that there are no international standards for printing mathematics in Braille for mathematical characters, but it is done by local experts. [9]

The braille system has a finite character in the mathematical formula such as algebra, square roots, logarithms, series, additions, products, theorems, integration, boundaries, trigonometry. But Braille shows a limited number of characters. If upper- and lower-case letters and 10 digits and common punctuation are included, then 6 dots represent a total of 64 (2^6) characters. Therefore, Braille characters range up to 8 dots. Then get 256 (2^8) characters. But the increase in Braille dots increases the difficulty of the Braille language in the same way.[8]

Therefore, visually impaired students use video and audio equipment. They must listen to audiobooks for a long time. Therefore, their focus is more likely to be diverted in comparison to the normal students.

Developing the Text-to-Speech (TTS) process makes it easier for visually impaired students to read printed material as they can read any printed material via mobile phone or web application. In this process, we are mainly focusing on reading ME as TTS reads like a paragraph and it does not explain ME correctly[10].

In the survey, we found students using the TTS process. We found that students tried to read math and tried to translate the math equation into English using TTS.

Did you ever used the text-to-speech (TTM) feature to read the printed materials? (මුද්‍රිත ද්‍රව්‍ය කියවීමට ඔබ කවදා හෝ the text-to-speech (TTM) විශේෂාංගය භාවිතා කර තිබේද?)

58 responses

- Yes
- No

60.3%

39.7%
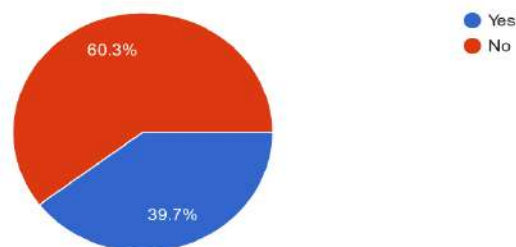
Figure 1.2 Summary response using the TTS feature

Did you ever tried to read the mathematics equation in your mobile phone? (ඔබ කවදා හෝ ඔබගේ
ජංගම දුරකථනයේ ගණිත සමීකරණය කියවීමට උත්සාහ කර තිබෙද?)

58 responses
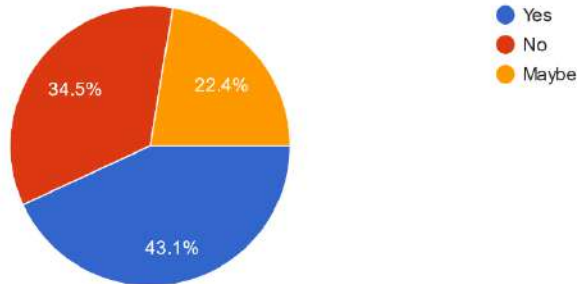
Figure 1.3 Summary response to attempts to read mathematical equations using TTS

From pre-school through Advanced Level, the majority of students in the world study in English [11]. When it comes to visually challenged students, the majority of their studies are conducted in English. They can listen in English if they try to read the printed information utilizing TTS. Students who are blind or visually challenged must learn mathematics, and we should force them to listen to TTS. However, they are unable to obtain the correct English output.

As a result, we're concentrating on employing TTS to assist visually challenged pupils in reading written ME in English.

1.2. Research Gap

According to the survey, most of the survey participants say it is important to have the vision-impaired students read the ME in English. In most of the English TTS systems wasn't described the ME correctly. Therefore, VI students can read most of the mathematics and science books including the ME using the app.

This research A [12] paper points to identifying and recognizing the handwritten Bangala numbers. It was used to develop the convolutional neural network. But the problem is that the research paper only points to identifying the Bangala numeral. It did not go beyond recognizing the mathematical numbers. This research B [13] paper explores the LaTex mathematical expression recognition. These researchers face the problem of identifying ME with parentheses. Equations with multiple parentheses cannot give the correct output. and also the process cannot be stopped by identifying long ME in this research. In the next research C [14] paper is written to recognize the handwritten mathematical expression via bi-directional mutual learning. It also recognizes LaTex ME.

	Research A	Research B	Research C	
Explain the mathematic equation and plain text in simple English.	✗ (Text only)	✔ (Math only)	✔ (Math only)	✔ (Math and Text)
Mathematics equation recognition	✗	✔	✔	✔
Add grammar rule to explain mathematical equation	✗	✔	✗	✔

Optimized for mobile, cloud use	✕	✕	✕	✓

Table 1.1 Comparison of former researches

1.3. Research Problem

According to the survey, many say that students with visual impairments have certain materials they need to learn. Audiobooks, Braille language books, and human readers support are just a few of them.
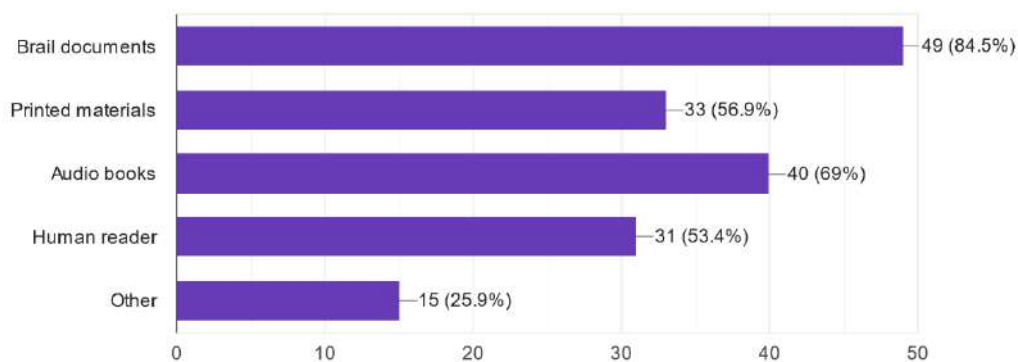
Figure 1.4 Summary response of materials used by visually impaired students

Visually impaired students take classes from preschool to high school to use the above material. But as the subjects of learning expand, they face many difficulties.

- Using Braille, the advanced mathematical formula equation becomes complex.

- Lack of the audiobooks

- Human assistance is a very expensive and time-consuming problem.

- Lack of Braille books

- Many books are printed material and cannot be used for vision-impaired students.

In the pre-school to ordinary levels, Vision Impaired students can get support from human readers like the teachers, and others. But after the ordinary level's Vision, impaired students have to learn by themselves. After also they can get the support of the human readers. But it is too expensive. And maybe they do have not much time to spend with them. Therefore it is not a very practical solution.

They can then be studied using Braille material. But the problem is that Braille is also difficult. For example, visually impaired students may want to learn advanced math, but they may have some problems with a lack of characters. This is because the Braille language has two different modes, which are 6 dots and the expanded version of the previous version is 8 dots. Then the language also expanded.

Do you think it is efficient to use Braille for math? (ගණිතය සඳහා බ්‍රේල් භාවිතා කිරීම කාර්යක්ෂම බව ඔබ සිතනවාද?)
57 responses

- Yes
- No
- Maybe

49.1%
17.5%
33.3%
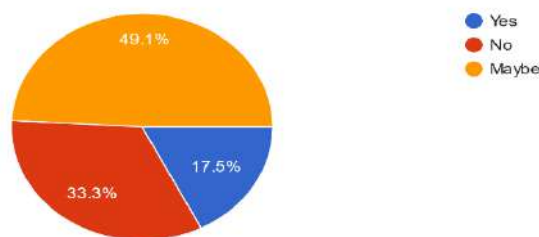
Figure 1.5 Summary response to learning mathematics in Braille

Therefore, they can use audiobooks. Today, some authors publish their books in parallel with the audiobook for the visually impaired [15]. Audiobooks are very effective because visually impaired students can easily access the audiobook and listen to it wherever they want. But the problem is that not all books are available in audiobooks. Therefore, visually impaired students cannot read all the books they need. And the main problem is that many of them do not like to listen to books. Continuing to listen to audiobooks makes it feel boring. This can be seen from the survey we conducted below. Therefore, most students do not like audiobooks.
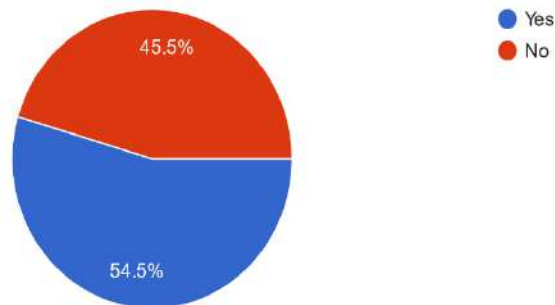
Figure 1.6 Summary response to attempts to use audiobooks

Are you satisfied with listening to audio books?

53 responses
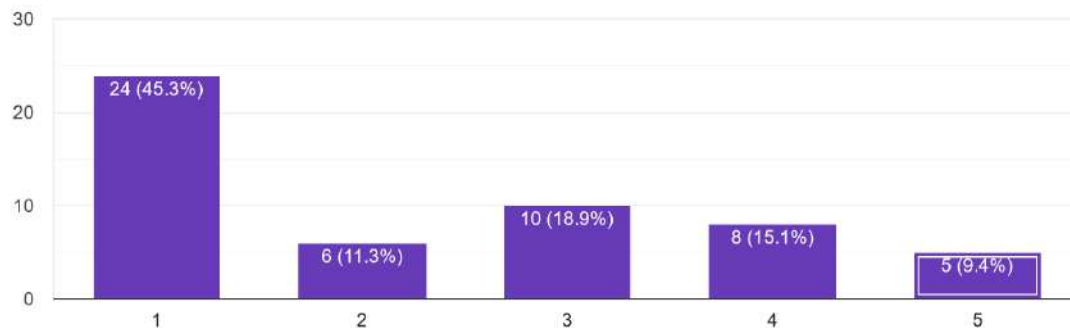
Figure 1.7 Summary Response to Listening to Satisfied Students' Audio Books

Visually impaired students also use the screen reader option when using computers. The GUI-based interface allows them to type whatever they want and read what they type. But if a visually impaired student writes a ME, it reads like a word. As a result, they may not have a good understanding of what they want.

This is why the TTS and Optical Character Recognition (OCR) processes are so important. The TTS and OCR systems for English are based on computers and mobile phones. OCR converts printed text into computer-readable text. TTS then re-translates the text and delivers the audio output of the computer's processing.

However, visually impaired students have some difficulty in learning math. The use of TTS and OCR does not provide good accuracy in reading ME. This is because ME are read as a word. Then it is not read mathematically. Because reading math is different than reading ordinary words. If visually impaired students can read ME using a mobile app, it will be very useful for their life goals.

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2. Objectives

2.1. Main Objective

The main objective of this research is to identify and comprehend parts of mathematical equations that can be read mathematically. The software uses the camera on the phone to identify the arithmetic equation. It detects the math section and converts it to text, which it then reads in English. This smartphone application might help you improve your math skills by using simple math to advanced math.

2.2. Specific Objectives

In addition to the main objectives, there are some specific objectives related to the implementation.

- To improve the accuracy of the text-to-speech math equation
- Improve accuracy of the advanced math detection
- To improve the math equation to English TTS

3. Methodology

The proposed program is an excellent tool for visually impaired students learning English Mathematics. To create the application, we must first gather the required data.

To train and develop a network, we will also need to find a printed mathematical dataset. I hope to use CHROME, IME, IM2LATEX-100K datasets.

For the development process, we use the SDLC lifecycle. To get the desired result. We can plan the mobile app stage for the following life cycle.
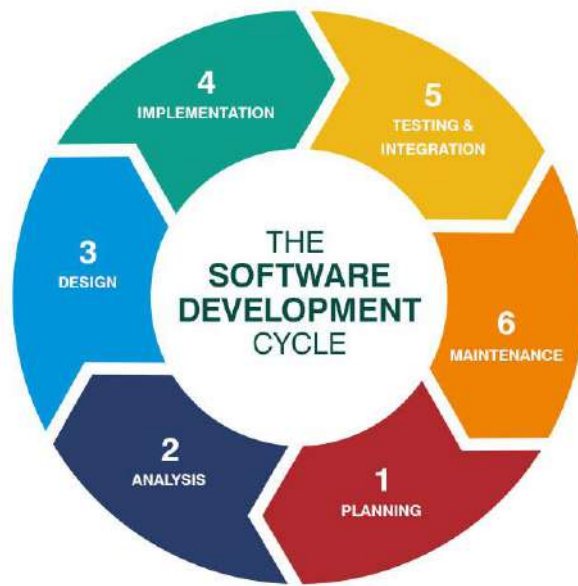
Figure 3.1 Software development life cycle

First, we try to preprocess printed math. Because first we take the image from the mobile phone and clean the image to extract the math part. Since mobile pictures are taken with a colorful image, therefore reduced in size and detail to capture to extract the math part.

Then extract the math part and each letter separately. Character separation means that we can identify that character wisely. Then the characters were put in order. That means we need to identify the symbol.

Then sort the math section and rearrange the math section to match the English language. Finally, give the output as an English audio

3.1. The System Overview Diagram
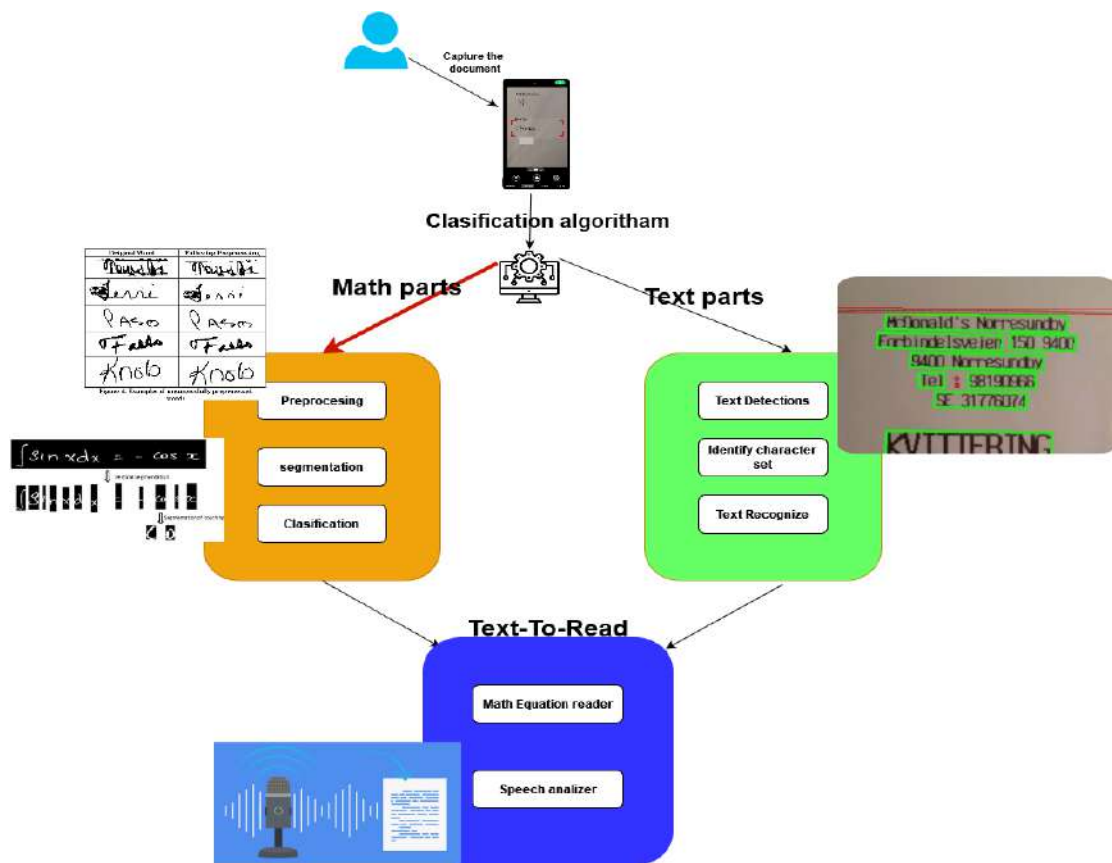
Figure 3.2 System overview

3.2. Tasks and Sub Tasks flow of the project

3.2.1. Main task

The main purpose of this research is to develop a mobile-based application for capturing mathematical equations through the camera and to provide plain English audio output via TTS using a pre-trained machine learning model.

3.2.2. Sub-task

- Improve accuracy of the text capturing.
- Identified the ME.
- Identified mathematics symbols.
- Divide the mathematical equation into readable parts.
- Convert to the English language to the readable parts.

4. Requirement

1.1 User requirements

- User should have basic knowledge of the app manage
- Capture the text correctly through the camera.

1.2 Functional requirements

- This app should be equally impressive the vision-impaired people and normal people.
- After the text capture give the alert to the user.
- Capture result delivers high-volume audio in plain English.

1.3 Non - functional requirements

- Usability – VI students can easily use this app without any hassle
- Availability – This app should be able to use anywhere they want.
- Performance – Capturing the text of the printed material is with the high accuracy
- Reliability – Always provide high accuracy of capture output

1.4 Use cases scenario

Use case ID	• 01
Use case name	• Read the math equation in the book

Pre-condition	• Install the mobile application properly
Actor	• Mobile application user
Main steps	1) Open the mobile application. 2) Capture the page 3) Inform the page identified segments 4) If math equation is available using the gestures give the command to read the math equation 5) Identified math part give the output as the voice
Extensions	3) - check the math equation available

5. Grant chart

#	Task Name	Nov-2021	Dec-2021	Jan-2022	Feb-2022	Mar-2022	Apr-2022	May-2022	Jun-2022	Jul-2022	Aug-2022	Sep-2022	Oct-2022	Nov-2022	Dec-2022
01	Background study	▮													
02	Identify the problems	▮													
03	Requirements gathering	▮													
04	Literature survey		▮												
05	Analyze requirements		▮												
07	Project registration		▮												
08	Topic assessment			▮											
09	Project charter and cover sheet				▮										
10	Project proposal and presentation				▮										
11	System Designing				▮	▮									
12	System implementation					▮▮▮▮▮▮▮▮							▮		
13	Testing											▮▮	▮		
14	Progress evaluation I							▮							
15	Research paper submission								▮						
16	Final report draft submission											▮			
17	Progress evaluation II											▮			
18	Final documentation												▮		
19	Student logbook submission												▮		
20	Final presentation and viva													▮	

6. Budget and justification

Item	Cost(RS)
App publishing cost on google play	5000.00
Backend hosting cost	10000.00
Paper publishing cost	5000.00
Total	20000.00

Table 0.1:Budget and budget justification

REFERENCE LIST

[1]   Susperreguy, M. I., & Davis-Kean, P. E. (2016). Maternal math talk in the home and math skills in preschool children. *Early Education and Development*, *27*(6), 841–857. https://doi.org/10.1080/10409289.2016.1148480

[2]   Soiffer, N., Cancro, R., & Li, D. (n.d.). *MathPlayer: Fully accessible web-based math*. Radford.Edu. Retrieved January 24, 2022, from https://php.radford.edu/~ejmt/deliveryBoy.php?paper=eJMT_v1n3n2

[3]   Gillan, D. J., Barraza, P., Karshmer, A. I., & Pazuchanics, S. (2004). Cognitive analysis of equation reading: Application to the development of the math genie. In *Lecture Notes in Computer Science* (pp. 630–637). Springer Berlin Heidelberg.

[4]   Sánchez, J., & Flores, H. (2005). AudioMath: Blind children learning mathematics through audio. *International Journal on Disability and Human Development: IJDHD*, *4*(4). https://doi.org/10.1515/ijdhd.2005.4.4.311

[5]   D. S. S. De Zoysa, J. M. Sampath, E. M. P. De Seram, D. M. I. D. Dissanayake, L. Wijerathna and S. Thelijjagoda, "Project Bhashitha - Mobile Based Optical Character Recognition and Text-to-Speech System," 2018 13th International

Conference on Computer Science & Education (ICCSE), 2018, pp. 1-5, doi: 10.1109/ICCSE.2018.8468858.

[6]   Temesgen, Z. (n.d.). *School challenges of students with visual disabilities*. Eric.Ed.Gov. Retrieved February 11, 2022, from https://files.eric.ed.gov/fulltext/EJ1196725.pdf

[7]   Nazemi, Azadeh & Murray, Iain. (2013). An Open Source Reading System for Print Disabilities. Retrieved 13 January 2022

[8]   O. M. Omone, Z. Tímca and M. Kozlovszky, "The Impact of Braille Systems on Advanced Mathematical Geometry," 2021 IEEE 19th World Symposium on Applied Machine Intelligence and Informatics (SAMI), 2021, pp. 000399-000404, doi: 10.1109/SAMI50585.2021.9378682.

[9]   Thomas, Cathy & Van Garderen, Delinda & Scheuermann, Amy & Lee, Eun. (2015). Applying a Universal Design for Learning Framework to Mediate the Language Demands of Mathematics. Reading & Writing Quarterly. 31. 207-234. 10.1080/10573569.2015.1030988.

[10]   Wood, S.G., Moxley, J.H., Tighe, E.L. and Wagner, R.K., 2018. Does use of text-to-speech and related read-aloud tools improve reading comprehension for students with reading disabilities? A meta-analysis. *Journal of learning disabilities*, *51*(1), pp.73-84.

[11]   Asoka Premarathna (Team Leader) Prof. S. J. Yogaraja Dr. Vivimarie
        Medawattegedara Dr. Chamindi Dilkushi Senarathna Dr. Mohamed Rameez
        Mohamed Abdullah (Ed.). (Research Series-2014). *i STUDY ON MEDIUM OF
        INSTRUCTION, NATIONAL AND INTERNATIONAL LANGUAGES IN
        GENERAL EDUCATION IN SRI LANKA: Vol. No. 09* (Issue 2014). NATIONAL
        EDUCATION COMMISSION NAWALA ROAD, NUGEGODA SRI LANKA.

[12]   R. Noor, K. Mejbaul Islam and M. J. Rahimi, "Handwritten Bangla Numeral
        Recognition Using Ensembling of Convolutional Neural Network," 2018 21st
        International Conference of Computer and Information Technology (ICCIT),
        2018, pp. 1-6, doi: 10.1109/ICCITECHN.2018.8631944.

[13]   S. Bender, M. Haurilet, A. Roitberg and R. Stiefelhagen, "Learning Fine-Grained
        Image Representations for Mathematical Expression Recognition," 2019
        International Conference on Document Analysis and Recognition Workshops
        (ICDARW), 2019, pp. 56-61, doi: 10.1109/ICDARW.2019.00015.

[14]   Bian, X., Qin, B., Xin, X., Li, J., Su, X., & Wang, Y. (2021). Handwritten
        mathematical expression recognition via attention aggregation based Bi-
        directional mutual learning. In *arXiv [cs.CV]*. http://arxiv.org/abs/2112.03603

[15]   *How can publishers create accessible math textbooks?* (n.d.). Washington.Edu.
        Retrieved January 25, 2022, from https://www.washington.edu/doit/how-can-
        publishers-create-accessible-math-textbooks?384=

Appendices

1.5   Online surway

Data collection survey for vision impaired students learning mathematics (ගණිතය ඉගෙන ගන්නා දෘශ්‍යාබාධිත සිසුන් සඳහා දත්ත රැස් කිරීමේ සමීක්ෂණය)

We are 4th year students of Sri Lanka Institute of Information Technology (SLIIT). We are currently researching digital aids to help people with print disabilities use ICT-based technology (information and technology) to interpret printed materials. We would appreciate it if you could save us some time and give us the following information which will help us to measure our parameters accurately.

Furthermore, we will ensure that the information you provide is kept confidential with us.

මෙය ශ්‍රී ලංකා තොරතුරු හා තාක්ෂණ ආයතනයේ 4 වසර සිසුන් විසින් මුද්‍රිත ද්‍රව්‍ය අර්ථ නිරූපණය කිරීමේදී මුද්‍රණ ආබාධ සහිත පුද්ගලයින්ට සහාය වීම සඳහා ඩිජිටල් සහයකයින් පිළිබඳ දත්ත මැනීම සඳහා නිර්මාණය කරන ලද මූලික ප්‍රශ්නාවලියකි.

පර්යේෂණ කටයුත්ත සාර්ථක කර ගැනීම සඳහා ඔබගේ සහය ලැබෙනු ඇතැයි අපේක්ෂා කරන අතර පර්යේෂණ ආචාර ධර්මවලට ගරු කරමින් ඔබ ලබා දෙන තොරතුරුවල රහස්‍ය භාවය සුරකින බව තහවුරු කරමි.

Have you ever communicated with blind people in your life? ? (ඔබ ඔබේ ජීවිත කාලය තුළ අන්ධ පුද්ගලයන් සමඟ සන්නිවේදනය කර තිබෙනවාද නැද්ද?) *

◯ Yes

◯ No

Did you know what are the learning material of the vision impaired student using ? (දෘශ්‍යාබාධිත *
සිසුවෙකු භාවිතා කරන ඉගෙනුම් ද්‍රව්‍ය මොනවාදැයි ඔබ දන්නවාද?)

☐ Brail documents

☐ Printed materials

☐ Audio books

☐ Human reader

☐ Other

If you know other materials using the vision impaired student using, please let them know below? (
දෘශ්‍යාබාධිත සිසුන් භාවිතා කරන වෙනත් ද්‍රව්‍ය ඔබ දන්නේ නම්, කරුණාකර පහතින් ලියන්න.)

Short answer text

Do you think vision impaired students have enough resources to study? (දෘශ්‍යාබාධිත සිසුන්ට *
ඉගෙනීමට ප්‍රමාණවත් සම්පත් ඇතැයි ඔබ සිතනවාද?)

○ Yes

○ No

Have you ever tried listening to audio books? (ඔබ කවදා හෝ ශ්‍රව්‍ය පොත්වලට සවන් දීමට උත්සාහ කර *
තිබේද?)

○ Yes

○ No

Are you satisfied with listening to audio books?

	1	2	3	4	5	
low	○	○	○	○	○	High

Do you think it is efficient to use Braille for math? (ගණිතය සඳහා බ්‍රේල් භාවිතා කිරීම කාර්යක්ෂම බව *
ඔබ සිතනවාද?)

○ Yes

○ No

○ Maybe

If you say 'yes', what are the reasons for it? ('ඔව්' කිව්වොත් ඒකට හේතු මොනවද?)

Short answer text

Did you familiar with the using of the vision impaired helping apps? (දෘශ්‍යාබාධිත උපකාරක යෙදුම් *
භාවිතය ගැන ඔබ හුරුපුරුදුද?)

◯ Yes

◯ No

If you say 'Yes', please let know the what are the apps? (ඉහත ඔබ 'ඔව්' කිව්වොත්, කරුණාකර දුරකථන යෙදුම්
මොනවාදැයි දන්වන්න?)

Short answer text

Did you ever used the text-to-speech (TTM) feature to read the printed materials? (මුද්‍රිත ද්‍රව්‍ය *
කියවීමට ඔබ කවදා හෝ the text-to-speech (TTM) විශේෂාංගය භාවිතා කර තිබේද?)

◯ Yes

◯ No

1.6   Work breackdown chart