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To cite this article: L A D Arbes et al 2019 IOP Conf. Ser.: Mater. Sci. Eng. 482 012023

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Tagalog text-to-braille translator tactile story board with 3D printing

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Abstract. - New technologies create new challenges, especially for those who cannot read, count, and write. It has been reported that out of 161 million blind people or visually impaired people in the world, 90% of them live in developing communities. However, only 3% are capable to read, write, or count. The Philippines is estimated to have half a million blind Filipinos. National Library’s Division for the Blind contained 922 Braille titles, 880 cassette titles, and 462 large print titles. A report concluded that Braille reading materials are lacking in schools and despite the condition of blind Filipinos, many still want to read. This study is focused on developing an assistive system for visually impaired children under kindergarten. The developed system enhanced the existing reading materials that is used by visually impaired students by providing a 3D visual representation of children’s book. Significant story lines of a book were translated to Braille text to tactile board then made into a 3D printed product as a learning material presented to visually impaired students in class. The developed system was tested and used by the target users to their full learning potential.

1. Introduction

The overall prevalence of blindness around the world is 0.7 % and mostly 90% of visually impaired lives in developing countries like the Philippines. Prevalence of childhood blindness is about 0.3 in every 1000 children aged 0-15 years old [1].

In accordance to the 2015 annual report of the Resources of the Blind Incorporated, the Braille literacy rate of the Philippines is only 8% and the Braille reading materials that are being produced yearly are only 300,000 – 500,000 pages and most of the said reading materials are mainly for adults. Considering these reports, the researchers came up with the idea of producing a tactile storyboard that will be printed in 3D, giving the children a new approach of learning the Braille and as well as increase the Braille literacy.

Assistive technology is composed of equipment, programs, or product which is used to either increase or improve one’s functional capability. In the Philippines, there is an existing law for the disabled persons which is the “Magna Carta for the Disabled Persons (Republic Act no. 7277)”, which states that “The state shall adopt polices ensuring the rehabilitation, self-development and self-reliance of the disabled persons. It shall develop their skill and potentials to enable them to compete favorably for available opportunities.” This act helps the disabled persons in the advancements of technology. When it comes to blind education, one known method for learning is the Braille [2]. In the Philippines, there is a school that is managed by the government that specializes in teaching visually-impaired students. This school is known as the Philippine National School for the Blind [2].

Braille is the disposition of raised dots that can be read using the fingers of the individuals who have visual impairments. There are 2 different ways to write using Braille, grade 1 or uncontracted and grade 2 or contracted. Most story books for children are written in grade 1, while grade 2 is used for reading materials meant for adults. Contrary to popular belief, Braille is not a dialect. Rather, it is a code by which numerous dialects might be composed and read. Braille code was created by a blind youth named Louis Braille at the age of 15 [3].
Tactile approach is a method on how visually-impaired person read. The current literacy tool that is used for the visually impaired person is embossed braille. In the research “3D Literacy Aids Introduced in Classroom for Blind and Visually Impaired Students,” the product of their project is a 3D printed literacy aid that contains the debossed Hangul Characters or Korean alphabet alongside the braille translated character. The children trace the debossed Hangul character allowing them to properly visualize each character. This product has been concluded to have a positive effect on the students’ learning on how to read and write Hangul [4].

The goal of the study is to create an assistive technology where tactile story board will be produced by using Braille translator and 3D printing system. The developed system consists of built-in 3D models [5] used by teachers through drag and drop and a canvass for editing and/or designing the storyboard. For every storyboard, it requires the text or story to be inputted by the teacher and the system translates it in Braille.

1.1. Objective of the Study
The research specifically aims to provide a platform that transforms 2D images into 3D models and enable text-to-Braille feature embedded in to the story board. The main goal of the research is to create 3D tactile story board as a supplementary learning material for the visually impaired children and their teachers.

1.2. Scope of the Study
The text-to-Braille translator and 3D modelling software is integrated into one system. The system translates Tagalog and English language into grade 1 Braille. The content of the storyboard will be a short story or riddles. The design of the system has a registration and logging of accounts for the user. It also allows the user to have the option of creating and editing of storyboard. As for the design of the storyboard, it has a default size of 8x6 inches. The target evaluators are kindergarten students and teachers at Philippine National School for the Blind (PNSB). The school entertains students that are partially blind, totally blind, and light perception.

2. Review of Related Literature
There is an increase of new technologies for almost everything in the lives of everyone, especially those who have disabilities. Different assistive technologies or technologies that provide assistance or enhancement to the person using it. Assistive technologies also provides a person to be capable of performing tasks that they cannot normally do [6][7].

3D printers have been a trend from the past few years. These printers were used by different people with different agendas. Some people use it for their hobbies, while some people use it for industrial purposes [8][2]. 3D printers are quite expensive and takes several hours to process and print an object, however, it would still largely benefit people who use it in different fields like in the field of medicine or education.

Braille code is composed of six dots that is read using the fingers of a visually-impaired person [2]. The code is used for reading materials meant for both children and adults. The dots are arranged in three rows of two called a “cell” [5]. These cells translate to a particular character depending on which dots are raised. Braille is very useful for those who want to learn to read even if they are limited because of their disability. A sample illustration of a Braille alphabet can be found on figure 1.

![Figure 1. Braille Alphabet](image)

Some 3D modelling systems are too complex for a person to understand. However, new developments made 3D modelling easy because of simple interfaces and designs. Similar studies show that improvements are made, thus, making 3D modelling easier to use, reliable, and responsive. Paper3D is a 3D modelling system. It went through a natural, user-guided evaluation and the feedbacks
that were given back were used as basis for the improvement of the system. The modelers that tested the systems said that the application is very mobile in terms of access for it can be used through smartphones that has multi-touch display. Paper3D was also said to be precise and the modelers also wanted more sub-modes or techniques that can be used in the system [5][6][8].

Technologies help people make their lives easier. For the visually impaired people and those who are concerned with them, text to Braille conversion applications benefits them. Fast conversions of text to Braille or vice versa using a software saves more time than converting it traditionally. This will also provide the visually impaired person to learn faster because the materials that they need can be produced quickly [9][10].

Combining the said technologies from different studies, the researchers came up with a 3D Printing System with Text-to-Braille Translator which can produce a 3D printed storyboard for the visually impaired. Similar studies analyses the need for the visually impaired to have reading materials to effectively teach them how to read and even write by tracing the character on the board. The developed technology is a success to improve the literacy rate for the visually impaired [11][12].

3. Methodology
The research is composed of using 3D printers and a translator that converts text to Braille. Both component would work together to form an assistive system that can aid people ease activities. The review of related literature provided information which is used for the study. The researchers used the research and development approach upon developing the study. This approach is composed of six phases; data gathering, analysis, design, implementation, testing, and development and evaluation.

The system is designed to convert text will be translated to braille and allow creation of 3D models that can be used in the 3D storyboard, which will produce a product that is done by a non-visually impaired user. The product allows the visually impaired to visualize the story.

3.1. Designing of 3D models
The researchers used Lithophane Creator for 3D modelling. It is an open source image based 3D modelling software. The researchers used this for the user to input an image with a file format of either JPG or PNG and that will be converted to STL (stereolithography) file format for 3D printing. This allows the creation of 3D models from a 2D image. This tool simply takes any image, calculates the grayscale value for each pixel, and then creates a 3D model that represents the extrusion of those grayscale values. The researchers also considered the use of ‘Blender’ software to learn more about 3D modelling [13][14].

Figure 2. Braille Translator

3.2. Translation of Braille
The system used grade 1 Braille because the product is produced for the academic use of visually-impaired students under kindergarten. Grade 1 Braille is Braille that in every possible arrange of dots corresponds to one letter, punctuation, or number. The teachers of the Philippine National School for the Blind also said in their interview that they use grade 1 Braille for teaching the children. The system
focused on translating Tagalog language into Braille but it can also be able to translate English language because it only supports grade 1 Braille.

The Braille translator of the system, which is presented in Figure 2, requires the input of the user in the first textbox. The system will provide the translated Braille in the second textbox once the “Translate” button is clicked. The system also has a Braille code that is mainly for checking.

### 3.3. Tactile 3D Printing

A 3D storyboard will be created through the use of the system. Figures 3 to 7 illustrate the digital 3D story tablet product of the system. These examples illustrate a Tagalog or local Filipino language version of a riddle which is also called *bugtong*.

![Figure 3. The Riddle in Braille and Butterfly printed in 3D as the answer.](image)

![Figure 4. Example 1 Riddle in Braille -](image)

![Figure 5. Riddle (Top view)](image)

![Figure 6. Example 2 - Riddle in Braille](image)

![Figure 7. Example 3 - Riddle in Braille (Top View)](image)

### 3.4. Databases

The system has a repository to store unfinished or finished work. This lets the user to save their work and continue whenever they can. The database is only for the storage of the 3D tactile story board created by the user.

### 4. Result and Discussion

The first phase of developing the system is the gathering of needs of the researchers to create the system. The researchers conducted interviews with teachers at Philippine National School for the Blind and have gathered related literatures that supports the development of the system. These data were assembled and were analyzed by the researchers.

The system is developed using Java language. The windows forms is created using NetBeans IDE and the researchers used open-source APIs for the Braille Translation and 3D Modelling Tool. The system allows users to be able to upload their previous works for them to continue or make changes.

The process flow of the system will start wherein the user will be prompted to create or edit a storyboard and will be required to input a text that will be translated to braille. It will then be connected to a 3D printer to print the product. The system will have three main functions. The creation of tactile story board, text-to-Braille translator, and creation of 3D models from 2D images.

Evaluation of the developed system in terms of functionality and usability were tested by target users who are language teachers of kindergarten level who teaches English, Filipino, and Braille and the product was evaluated by visually impaired children at the Philippine National School for the Blind.

The researchers gathered ten students from Philippines National School for the Blind (PNSB) and assessed their fluency with braille code by giving them an exam. The six students who scored less than 40% were chosen to be part of the user acceptance test was divided into two groups. The first group
were taught braille code with the aid of the story tablets and the second group were taught using the traditional method. The story tablets were lent to the language teachers of kindergarten level who teaches English, Filipino, and Braille for them to use as a learning material for a month. The data gathered by the researchers are shown below:

| Group # | Student # | Exam #1 | Exam #2 |
|---------|-----------|--------|--------|
| Group #1 | Student #1 | 30%    | 70%    |
|         | Student #2 | 20%    | 50%    |
|         | Student #3 | 20%    | 60%    |
| Group #2 | Student #4 | 40%    | 50%    |
|         | Student #5 | 30%    | 50%    |
|         | Student #5 | 20%    | 40%    |

Figure 8. Result of User Acceptance Test

After a month the participants took the assessment exam again. As shown in Figure 8, the group of students that were taught with the product became more familiar with the braille code and was able to finish the assessment exam faster. The teacher in charge of the students was interviewed about how the students interacted with product. She stated the having a visual representation of the text enhanced the students’ interest in reading and fluency with braille code.

5. Conclusion
Technologies can make work easier and faster. Due to the rapid increase in technology, persons with disabilities, especially visually-impaired persons, face struggle in keeping up. The study focused on producing a system that is used as a supplementary academic material for the visually-impaired which is used through tactile approach. The product provided an opportunity for the visually-impaired person to enhance his reading skills at a young age. The product and system undergone a user acceptance test in the Philippine National School for the Blind which proved that product is more efficient and effective as a learning material compared to embossed braille. The researchers also conducted interviews with professionals that specializes in this field which provided an ample information that made the system more reliable.

6. Recommendation
The advancements of technology will continuously incline as years will pass by from now. It will require more research to improve the system especially in the field of tactile education, wherein, it will provide a study of the students that will present where they engage more in learning. It will require a long-term study to provide a more interactive reading material for their academic use.

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