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Abstract
As the holy book for Muslims, Al-Quran is revealed and never changed in the form of a structure where Muslim learn and memorise the content. Understanding and remembering the Quran, however, is difficult for visually handicapped Muslims due to their restricted vision. The Braille Quran imprinted paper encompasses massive characters and codes, resulting in a massive book produced in many volumes. A board game, in the meantime, is a 3D board game employing scores, requiring exceptional word recognition skills. This gamification technique enables visually challenged individuals to learn the braille Quran letters (Hijaiyyah) in an entertaining manner. This study intends to apply the notion of a word board game with Hijaiyyah imprinted tiles by means of a defined module including braille lesson, word structure, game activity, and evaluation for studying the Quran. 3D printed braille Hijaiyyah letters were produced, and a teaching module was developed based on word game. Eventually, braille Quran class was conducted by applying the word game module to the beginners in braille character. Accordingly, a vocabulary-enhancing word game was included in the 3D printing of a reel-to-reel tape. The results showed that 3D printed word game tiles imprinted Hijiayyah braille has been developed and applied in a teaching module. It was found that the program was successfully coordinated by 87.5% of participants showed interest in the module implementation. The participant as beginners also showed improvement in learning skills to recognise and memorize the Hijaiyyah letters. In addition, word gamification activity portrayed that the participants able to constructed up to seven letters Conclusively, this engaging word board game is ideal for blind and sighted players to enjoy together for developing vocabulary and Quran recitation. The addition of a 3D printed

reel-to-reel cassette for Braille Quran was designed for easy touch and memorisation at an affordable price.

Keywords: 3D Printing, Blind, Braille Code, Integration Naqli and Aqli (INAQ), Word Game

Introduction

As a Muslim, reciting al-Quran as the Muslim's holy book is necessary to learn Allah's magnificent words. It contains eternal advice and direction for humanity. Therefore, the dignity of Al-Quran was maintained in the form in which it was revealed, allowing it to be learned and memorised globally by millions of Muslims. Improving the Muslim Ummah can be accomplished through the study of Al-Quran recitation, which has significant meaning (Tengku Puji et al., 2015). Therefore, a substantial strategy must be devised to encourage and entice Muslims, particularly among the younger generations, to study the words via the growth of national education, obtaining an effective framework by reciting, remembering, and comprehending the substance of the Quran (Tengku Puji et al., 2015).

Nevertheless, this process can be feasibly executed for sighted Muslims, and this will be a challenge for disabled people, specifically for visually impaired people in learning and memorising Al-Quran who possess a limited sense of sight (Tengku Puji et al., 2015). Therefore, many ingenious plans and actions have been consummated to meet the needs of visually impaired people in studying Braille Quran. However, without any proper teaching tool, the process will be a challenging task for them. Due to their superior tactile sensory abilities, the invention of Braille code letters is a wonderful answer for overcoming their learning difficulties (Awad et al., 2020; Bettelani et al., 2020; Noor & Mujani, 2016). Furthermore, the degree of difficulty in comprehending the Braille code as the fundamental premise for studying Braille Quran has discouraged people from learning Braille Quran owing to the lack of adequate resources (Tengku Puji et al., 2015).

Despite the establishment of Braille Quran among Muslims, the proliferation of the future young Muslim generation and the visually impaired in learning and memorising al-Quran must be intensified. The Quran's braille imprinted paper has enormous characters and codes, resulting in a bulky book that must be produced in many volumes. The dot code of Braille can easily be impaired after being used frequently (Noor, 2016). Hence, it is crucial in determining the Braille characters. Today, a better learning solution for visually impaired people has been developed, including education for al-Quran studies. The electronic Braille al-Quran Teaching Aid (Abdul Khoni et a., 2010; Najjar et al., 2021) and the vibration of the al-Quran in Braille code (Abualkoshik & Omar, 2010) have been the subjects of research. This study demonstrates that al-Quran studies among the visually challenged are attracting the attention of a growing number of parties. Although it allows visually challenged individuals to recite the Quran in their own manner, the use of the paper-embossed Braille Quran presents a number of significant difficulties. A full set of the paper-embossed Braille Quran has a large number of characters, causing it to be overly thick and necessitating the printing of many volumes. These variables make the teaching and learning process challenging and constrained. Additionally, the paper embossed with Braille dots is susceptible to rapid deterioration with prolonged usage, which makes it difficult to detect Braille letters (Abualkoshik & Omar, 2010).

In the meantime, the technical advancements of Industrial Revolution 4.0 (4IR) have addressed eleven components, one of which is 3D printing technology (Jayarajah et al., 2013). Thus, to fulfil the requirements of the industrialised world, particularly for the Muslim ummah, the education field must be consistent with the technological requirements and

equip these students with better skills and a deeper understanding without incurring additional costs through the enjoyable incorporation of 3D printing and Industry 4.0 into learning al-Quran in Braille form. The 3D printed reel-to-reel cassette for the Braille Quran framework in studying Braille Quran was developed to foster profound conceptual comprehension, resulting in remarkable success for youngsters in the twenty-first century. In association with the education system, there are plenty of additive manufacturing technologies in development. However, 3D printing is the economical tool which can be used for the fabrication of advanced prototypes and final products (Ford & Minshall, 2019; Pai et al., 2018; Mohan et al., 2021a).

The Word board game is a 3D board game employing scores, requiring exceptional word memory skills using a variety of three-dimensional game pieces with letters and connections (Aung & Iida, 2018). Gamification is the intentional use of game design components in non-game environments to encourage desired behaviours or address issues (Ofosu-Ampong, 2020). Adapting the notion of gamification has enabled the visually challenged to learn Quran using braille letters (Hijaiyyah) in a practical and enjoyable manner (Sulaiman, 2019; Manzano-Leon et al., 2021). Consequently, the purpose of this module is to apply the notion of a word board game utilising imprinted tiles, braille Hijaiyyah, and a dedicated module for studying Quran using the 3DP method. The influence of braille class on students' skills in learning Hijaiyyah braille letters was investigated, and the impact of Braille word game activity in enhancing the proficiency of students in memorising Quran among students was studied. To conclude the process, the 3D-printed reel-to-reel cassette Quran in braille was tested to see how it worked.

Methodology

Development of Gamification-based Teaching Module

A gamification-based teaching module with different learning stages for different activities was created. The content of the module includes letter recognition, finger touching, braille writing, word-structuring and matching, and a word-braille game. Each piece embraced the instruction of the activity and the type of activity. At the end of the module, there was an assessment model that was used to assess the effectiveness of the module.

Designing Hijaiyyah Braille Tiles and 3D Printed Cassette

The tiles for Hijaiyyah letters were designed according to the size of word game tiles, but the dimension of the braille dots was designed according to the imprinted braille dots used in the Quran book. These braille Hijaiyyah letters tiles were used during the module implementation. Meanwhile, a 3D printed cassette was designed to follow the conventional cassette design. To create the braille dots, a roll of craft paper was used. The dots for the verses of surah Al-Fatihah were physically printed on the craft paper for this study. The roll paper is then integrated into the cassette to create a reel-to-reel cassette for braille Quran that has been 3D printed.

Printing Hijaiyyah Braille Tiles and 3D Printed Cassette

The tiles and cassette were transformed into 3D models using TinkerCAD, a computer-aided design programme for 3D models. For the 3D printing process, the stereolithography (.stl) file was converted to g-code and then tweaked with PrusaSlicer. Original Prusa MINI then performed the 3D printing process.

Module Execution in Braille Quran Class

The implementation of the module was executed towards 10 students of Kolej GENIUS Insan by imitating the visually impaired (with eyes closed) and, consequently, assessments (summative and formative) were performed after the module was executed. During the implementation process, theory and concepts were delivered by the educator using a hands-on activity demonstration approach using word games. Figure 1 shows the flow of activities in this module. A survey was conducted at the end of the class activity to assess its effectiveness.

Implementation of Braille Strip 3D Printed Cassette

Students were given access to a 3D-printed reel-to-reel cassette in order to evaluate its validity and usefulness as a teaching tool for visually impaired learners. The students were told to close their eyes, and then they traced the braille dots on the craft roll paper with their fingers as they read the Quran verses.

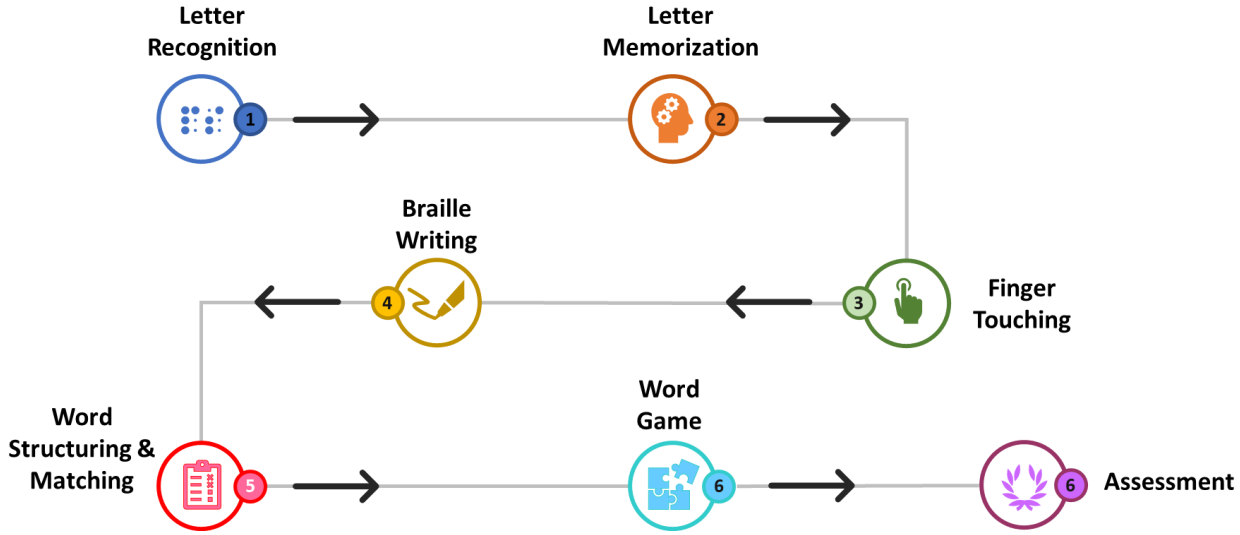


Fig. 1. Flow Activities for Braille Word Game

Results and Discussion

Hijaiyyah Braille Tiles and 3D Printed Cassette Models

Figure 2(a) shows the 2D sketch of the braille tiles designed according to the braille dots of the braille Quran. This 2D drawing was transformed into a 3D model using TinkerCAD, which functioned as a graphical modelling tool. As shown in Figure 2, the created 3D model of braille tiles in the form of graphs was then converted into g-code (b). This technique is crucial since g-code is the format that the 3D printer reads once the file has been transformed into a stereolithography (.stl) file, particularly designed for 3D models. The .stl file contains information about the model, such as the orientation, position of structure, and generated mesh (Mohan et al., 2021b) Finally, the 3D model was converted into a 3D printed model. Figure 3 shows the process to produce the product of the 3D printed braille tiles and 3D printed cassette. The tiles and the cassette were printed according to the .stl file for the 3D model for both products using the Original MINI Prusa. Polylactic acid (PLA), which is one of many thermoplastic polymer filaments that can be used for 3D printing (Mohan et al., 2021a, Mohan et al., 2021b), was used as the printing filament. During the printing process, the

components were sliced from the assembled model due to the large size of the model to be printed using a 3D printer for a facile printing process.

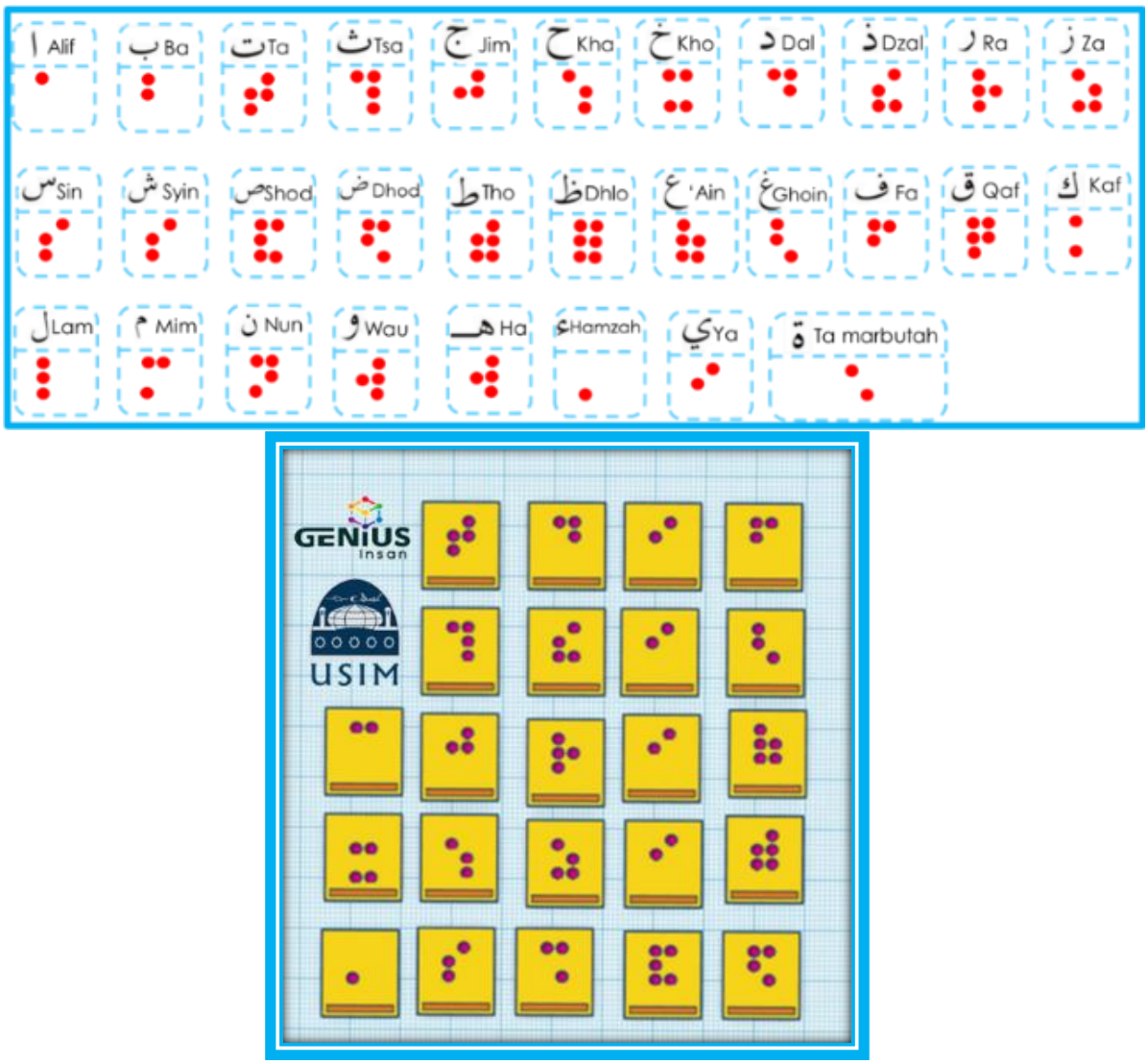


Fig. 2. (a) Sketch of braille tiles and 3D model of (b) braille tiles

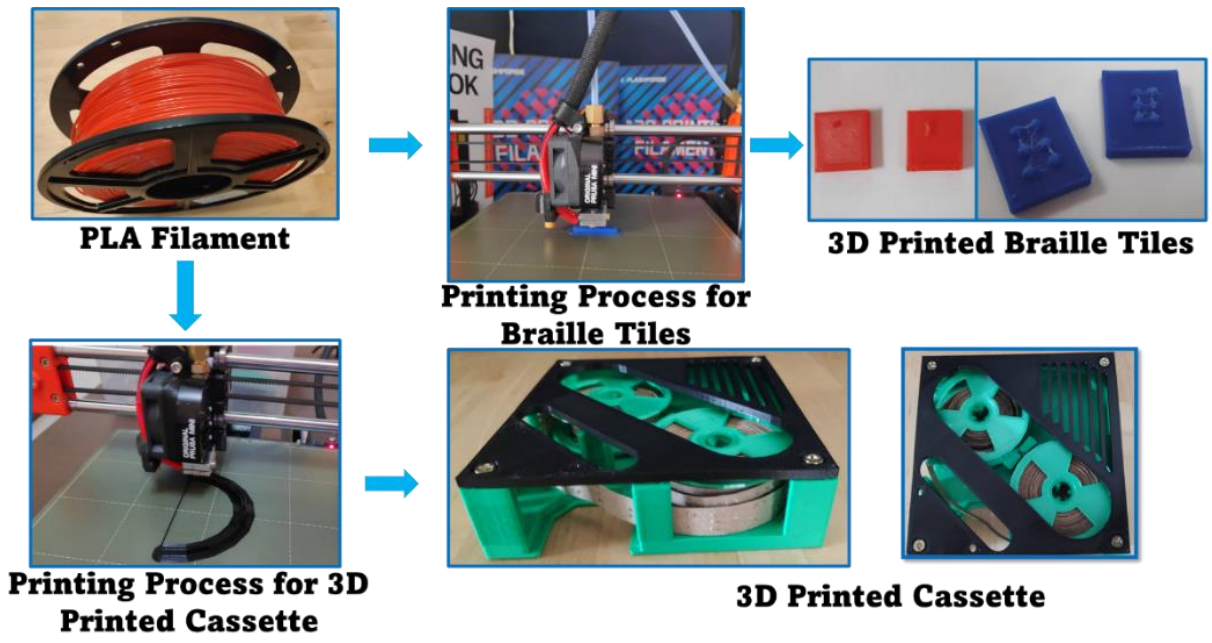
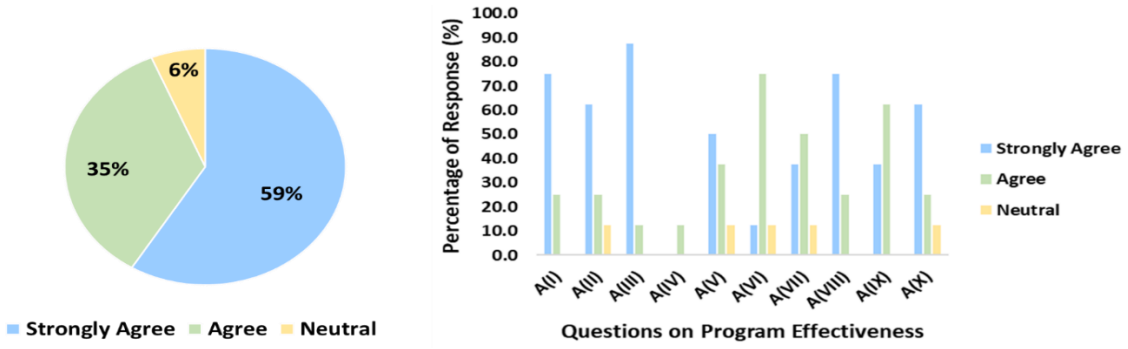


Fig. 3. 3D printed braille tiles

Effectiveness of the Braille Quran Class

Program Effectiveness

Figure 4 (a) depicts the percentage of student responses based on the program's effectiveness. It shows that more than half have chosen “strongly agree” and are followed by “agree” and “neutral” at the least. Generally, it shows a positive response towards the overall programmes. Specifically, 87.5% of students think that this program is useful in introducing braille letters (A (III)) to sighted people, where this is the highest percentage of “strongly agree” based on the survey questions summarised in Table 1. As shown in Figure 4 (b), they also expected this programme to be enjoyable (A (I)) and that they would recommend it to other people (A (VIIII)) to participate in this type of programme. Hence, the implementation of this programme as gamification education can promote student participation and involvement during the programme where students increased their interest exponentially towards learning braille (A (V)). Therefore, when this programme is gamified with the goal of promoting healthy behaviours, the physical surroundings improve because a playful setting is created in which students may be more physically active while having fun, as shown by the positive reaction of (A (VII)) (Manzano-Leon et al., 2021).



(a) (b)

Fig. 4. Percentage of responses based on programme effectiveness

Table 1
Questions on programme effectiveness

Question	Survey Question
A (I)	I enjoy this programme.
A (II)	I wish this programme can be conducted again in the future.
A (III)	This programme is useful in introducing braille letters.
A (IV)	I have learnt more about braille Hijaiyyah letters from this programme.
A (V)	I became more interested to learn braille letters and Quran memorisation.
A (VI)	I became unaware of the passage of time during the conducted session.
A (VII)	This programme encourages active learning.
A (VIII)	Overall, I recommended this programme to others.
A (IX)	Overall, I am satisfied with this programme.
A (X)	This program is beneficial to me.

Student's Performance

Figure 5 shows students' performance based on the activities carried out according to the module developed. The students were given a set of questions and they were required to answer the questions according to the activities carried out. It demonstrates that the participant can perform effectively in each braille class activity, with the majority of tasks scoring higher than 80%. However, only letter memorisation and finger tracing were performed at less than 80%. This finding can be correlated to the percentage of responses for each activity, as shown in Figure 6. It shows that finger tracing has "neutral" as the highest percentage and the presence of students who choose "difficult" and "very difficult" for this activity. The trend is similar for letter memorisation. Meanwhile, braille writing activity shows the highest percentage of "very easy" option. Therefore, the results showed that both activities required more training and students must emphasise more on both activities for them to obtain the utmost skills in learning braille Quran. Concurrently, Table 2 shows the percentage of correct words that can be answered by the students after each activity. It can be correlated to Figure 5 and Figure 6, whereby 12.5% of students can only feel the braille dots on the 3D printed tiles, less than 10 correct words, and no one can achieve up to 30 correct words. This demonstrated that for sighted people, the touch sense still is less sensitive as compared to the visually impaired, where they can read braille books or braille Quran correctly where tactile spatial acuity is enhanced in blindness. The fingers of skilled braille readers, who spend hours reading with their fingertips every day, are far more sensitive than

those of sighted people (Cho, 2021).

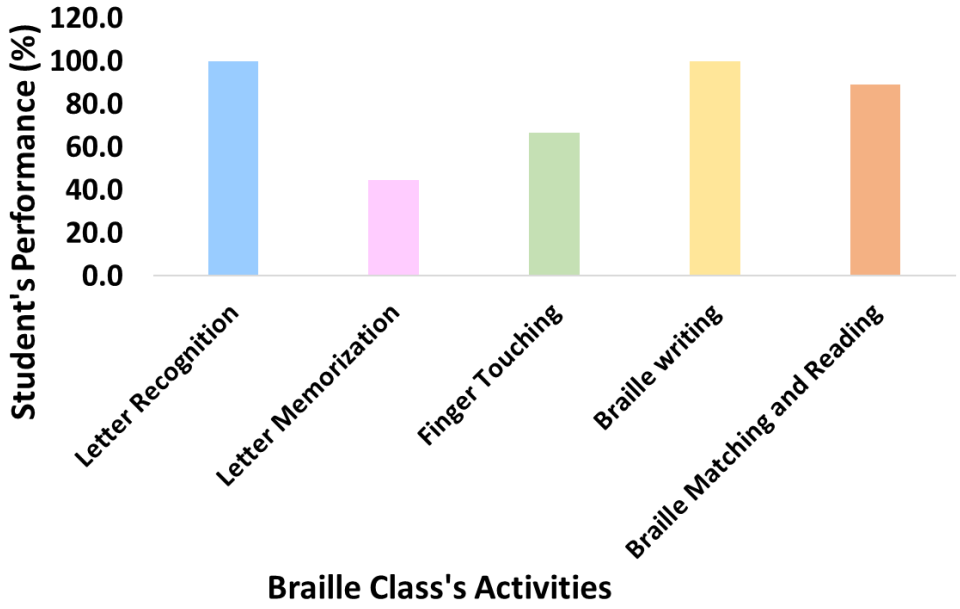


Fig. 5. Students' Performance based on Braille Quran Class Activities

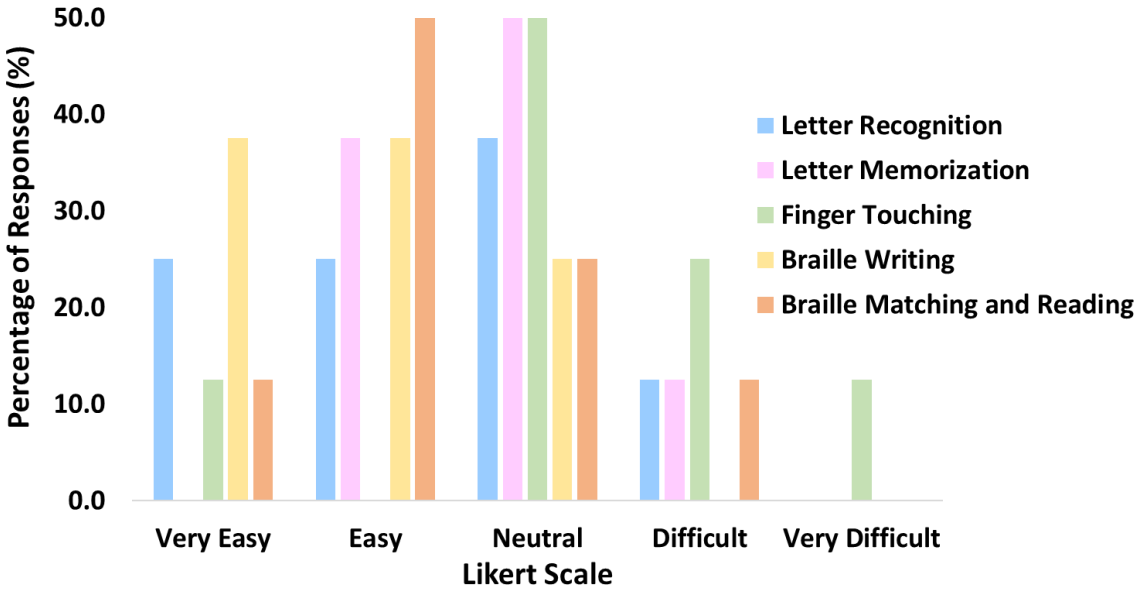


Fig. 6. Percentage of responses based on braille class activities

Table 2
Percentage of correct words based on braille class activities

Activities	**Percentage of correct words (%)**				
Number of letters	< 10 words	< 15 words	< 20 words	< 25 words	≤ 30 words
Letter Recognition	0.0	12.5	25.0	37.5	25.0
Letter Memorisation	0.0	25.0	50.0	25.0	0.0
Finger Touching	12.5	12.5	62.5	12.5	0.0
Braille Writing	0.0	0.0	25.0	50.0	25
Braille Matching and Reading	0.0	12.5	37.5	37.5	12.5

Word Gamification 3D Printed Tiles and Cassette

Figure 7 depicts the implementation of a word game using 3D-printed tiles. During the game, the children were expected to build four-to-five-letter words, followed by six-to-seven-letter words. At the conclusion of each step, students must match the generated word with its meaning or wording in the Quran. All of the pupils were able to create their words in accordance with the rules of the game and include the words and phrases into the Qur'an.

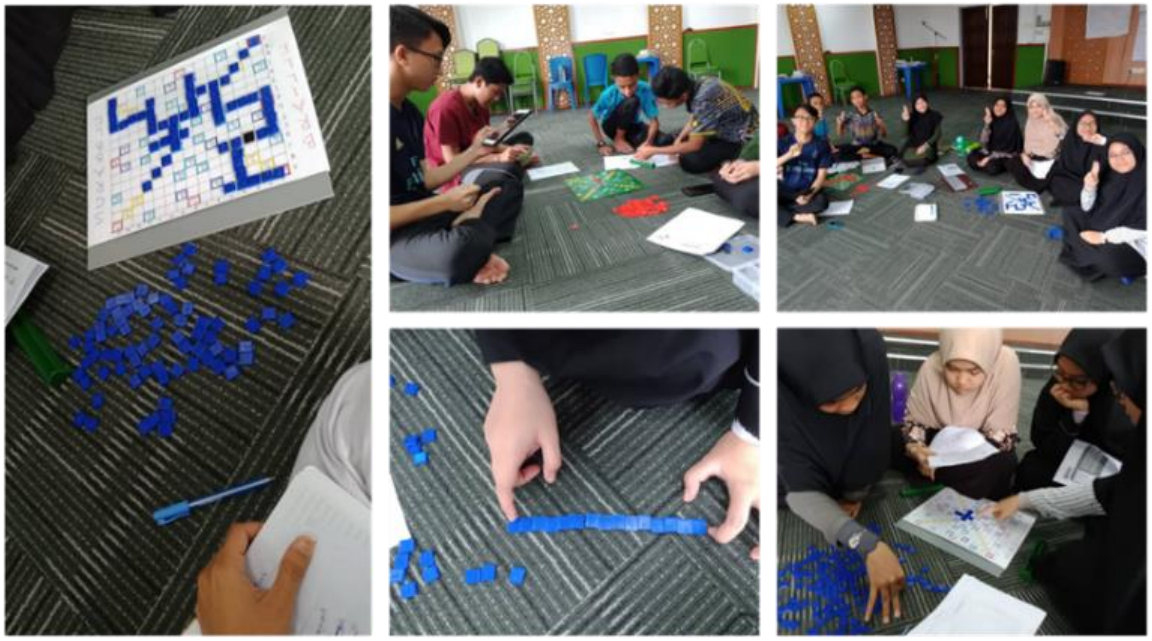


Fig. 7. Word Game Activity

In addition, the students were provided with braille cassettes that were 3D printed. Figure 8 illustrates how the cassette was applied with the students' eyes closed. The students were instructed to read and identify the braille dots' printed words on kraft paper by placing their index finger on the braille dots. At this point, all students can also decipher the words slowly, but they require additional training and exposure to the braille dots. This is consistent with the findings presented in Figure 6 and Table 2, which indicate that

finger-touching activity is challenging to perform. Nonetheless, this method can improve children's fine motor skills and pique students' interest in learning the Quran, particularly for the visually impaired. It is also inexpensive and portable.

Figure 8: Implementation of 3D printed cassette towards students

Conclusion

Ultimately, the module establishment has deviated the exemplar to visibly move the problems facing visually impaired Muslims towards an exceptional learning approach, hence engaging the concept of tangible 3D printed models in a module by virtue of braille. With the aid of a braille strip imprinted with braille Hijaiyyah on a 3D-printed reel-to-reel cassette model, a stunning effect is created for novices learning braille words and, consequentially, for reciting the Qur'an, particularly among Muslims, with the aid of a braille strip imprinted with braille Hijaiyyah.

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