A VIRTUAL REALITY APPROACH TO SUPPORT MALAYSIAN SIGN LANGUAGE INTERACTIVE LEARNING FOR DEAF-MUTE CHILDREN

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Abstract

Malaysian Sign Language (MSL) is a primary sign language in Malaysia for the deaf-mute people including people with either hearing impairments or physically unable to speak. Communication is a main aspect that impacts the life of deaf-mute people. Learning MSL is very challenging as it is different from oral languages and has complex interpretation given the variability of size, shape and position of fingers or hand gestures. MSL is the only form of sign language that is recognized by the Malaysian Ministry of Education in formal education settings for deaf students. All teachings are provided visually, and students must be able to split their visual attention between signed narration and visual aids. Therefore, this paper presented a virtual reality (VR) approach to support MSL learning for deaf-mute children and their hearing parents. The VR application was assessed using a user acceptance test and pre-posttest. The findings showed that the VR application provides an innovative way for fast and efficient MSL learning compared to the conventional method.

Keywords: deaf, learning Malaysian Sign Language, virtual reality.

Introduction

Malaysia Sign Language (MSL) is a visual language that uses hand, facial, and body movements as a communication tool for deaf-mute people in Malaysia [1]. MSL was formed in 1998 with the foundation of the Malaysian Federation of the Deaf (MFD) [1]. Although it is based on American Sign Language (ASL), these two languages are considered separate, and Indonesian Sign Language is based on MSL [1].

MSL is used for daily communication for people with hearing impairments, those physically unable to speak, deaf people, and the deaf-mute community. There were 40,743 registered hearing-impaired adults and children in Malaysia as of December 31, 2021 [2].

In addition, Manually Coded Malay Language, also known as “Kod Tangan Bahasa Malaysia (KBTM)”, another teaching strategy developed by hearing educators and linguists between 1980 and 1986, continues to be the sole sign language format approved by the Malaysian Ministry of Education as a means of teaching Malay to deaf students in formal educational settings [3].

Communication is a main aspect that impacts the life of deaf-mute people [1], [4], [5]. Most of the time, the intended meaning that deaf-mute people wish to convey during interaction is always misunderstood or difficult to comprehend by others [1], [4], [5]. Most of ordinary people are unfamiliar with and incapable of comprehending

MSL [1], [4], [5]. These concerns had led to a communication gap or problem between deaf-mute people and society [1], [4].

Learning MSL is very challenging as it is really different from oral languages. [1], [4], [5]. [6], [7], [8]. It has complex interpretation given the variation in finger size, shape and position or hand gestures in an image [6], [7]. All teachings are provided visually, and students must be able to split their visual attention between signed narration and visual aids [8].

Graphical books or letter cards are used to aid children in reading more easily, as the emphasis is on seeing rather than hearing [5].

Therefore, this paper presented a virtual reality (VR) approach to support MSL learning for deaf-mute kids and their hearing parents. VR is a three-dimensional (3D), totally digital, computer-generated world [9]. This technique creates a computer-generated world while allowing the user to remain aware of and manage their physical surroundings [9].

Unlike traditional user interfaces, which just enable users to see a screen, virtual reality allows users to immerse themselves in and interact with a 3D environment that may either mimic or radically depart from reality [9]. The virtual world that exists in VR can provide the opportunity for users to enter and walk through the virtual world, as well as the ability to control or handle virtual objects using only hand gestures, which makes VR interactive [9].

Related works

VR was introduced in the 1980s, and it has been extensively utilized in education, with pilot training being its most popular application [5]. VR has become widely used for teaching various disciplines. VR provides interactive educational environments that can enhance learning outcomes at all educational levels and across a diverse range of disciplines, including science and the humanities [5]. Consequently, students are encouraged to explore in-depth and can develop a deeper comprehension of learning [5].

VR has demonstrated to be a useful tool for assessing cognitive abilities including attention, memory, and executive functions [10]. The virtual learning environment allow the children to learn in more sophisticated and higher-level cognitive way [5], [10]. VR offers them an innovative way and allows contextual learning, which is essential for acquiring linguistic knowledge [5], 10].

J. Schioppo et al. in [11], developed a virtual environment for learning sign language, using a virtual reality headset, where leap motion sensor was attached to it. The system was then assessed on the 26 letters of the alphabet.

Furthermore, L. Quandt et al. in [12], created an avatar who functioned as the instructor in a virtual environment for teaching introductory ASL to a beginner. The users could also see a digital image of their hands due to the utilization of leap motion. Nevertheless, the system was unable to capture signs that involved body part occlusion.

Besides, J. Joy et al. in [13] developed a quiz web-based tool to learn finger spelled signs for Indian sign language. The results indicate that the developed quiz is better than the printed medium for finger spelled sign learning.

D. Bogusevschi et al. in [14] conducted a study on the effect of a virtual 3D physics learning environment on 12-13-year old students. As a result, over 74% of the participants found the simulation helpful for gaining a better understanding.

Gamification, a recent innovation, is the application of video game mechanics in other fields. A serious educational game is a different approach to teaching that uses game technology to encourage players' learning and provide them good cognitive and affective experiences while they are learning [15], [16]. The intention is to maximize pleasure and involvement by capturing the student’s interest and encouraging them to continue learning [15], [16].

H. P. Pontes et al. in [17] developed an educational game to teach numbers in Brazilian Sign Language for deaf children and adolescents. The results demonstrated a promising future for this game in academic environments.

Gamification will improve conventional learning techniques in the form of scalability, upgrading learning modules [15]. Rahouti et al. in [18] proposed the use of VR and serious game technology for healthcare fire safety training, and it was developed with Unity game engine. The outcomes showed that it was more efficient compared to the conventional slide-based lecture in terms of knowledge acquisition and retention.

Materials and Methods

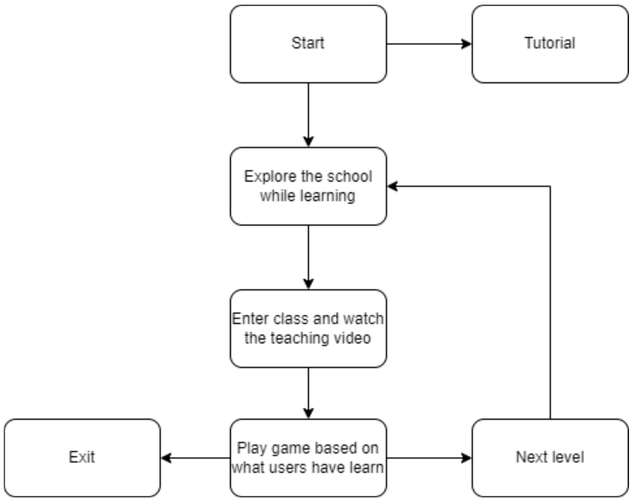
The purpose of this paper is to propose an interactive VR website with a combination of VR games episodes as a learning platform to help deaf-mute kids achieve higher quality communication by using sign language. Besides, it is affordable and does not require any specific technical skills.

This VR web will give guidance for deaf kids to get their early knowledge on how to do sign language in addition to learning it in school. It consists of basic levels that will teach kids easy levels of conversation.

Each level has many graphics that will attract them to learn, and every stage has quizzes or games that they have to answer virtually based on what they have learned. Besides only exploring, they can also watch the video on learning the sign language in different stages. Consequently, it will assist parents in learning sign language and give them the opportunity to communicate with their children easily.

Fig. 1 shows the system architecture for the proposed VR.

Fig. 1 System Architecture.



This system architecture explains the overview of the application. Initially, this VR web will display a "start" button to enable users to start their journey, then users can explore and enjoy the VR environment while viewing and learning about MSL. After they explore all the learning materials, they can enter a class and view the teaching videos that conclude about that level's learning syllabus. After that, they can choose if they want to try playing games about what they have learned in that level. After playing those games, they can choose to exit the level or continue to explore the next level.

For development purposes, specific software has been used including Canva, Blender and Unity. The development process is further described in the following subsections: 1) production of texts, 2) production of graphics and textures, 3) production of 3D models, and 4) media integration.

Production of texts

This section describes the types of texts that have been used in each part of the proposed VR, which include text's font, format and size as shown in Table I.

Table I Production of Texts

Use	Texts Description	Produced Texts Example
Logo text	Font: Playfair Display Format: Bold, Italic Size: 24.6, 43.9	
Title of main web page	Font: Playfair Display Format: Bold, Italic Size: 4.8	
Title of Level 1 (Alphabet in MSL)	Font: Homemade Apple, Kollektif Format: Bold Size: 3.3, 5.6	
Title of Level 2 (Numbers in MSL)	Font: Glacial Indifference Format: Regular Size: 29.1	
Each alphabet	Font: Driod Serif, Amiko Format: Bold Size: 14.1, 3	

This production is important as it give clearer instruction for user through the exploration of the VR web.

Production of Graphics and Textures

The production of graphics includes the image that is used for the background of each canvas title, button, logo, and texture. There are several steps in the production of these graphic as shown in Fig. 2.

Initially, a new template is created with the accurate size of the panel in the project in Canva, Next, the background is created using elements like hand signs that are suitable for sign language with color. For an icon, import the suitable PNG (portable network graphic) image. Then, we have to export it from Canva in PNG format and import into Unity.

The next step is to produce the texture as shown in Fig. 3. A seamless texture is downloaded in JPEG (Joint Photographic Experts Group) format, and the image is imported into Unity. Then a material is created for each texture, and the colour and shading effects are adjusted in the inspector window. Then, the texture material is dragged into the 3D model.

Fig.2 Production of Graphics using Canva

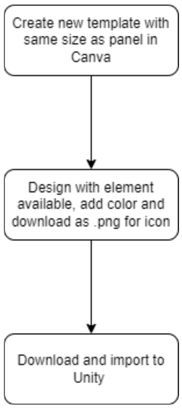


Fig.3 Production of Texture into Unity

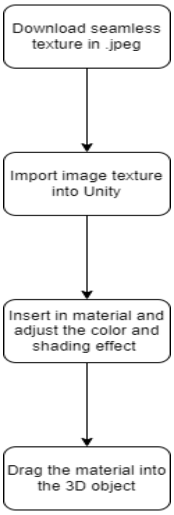
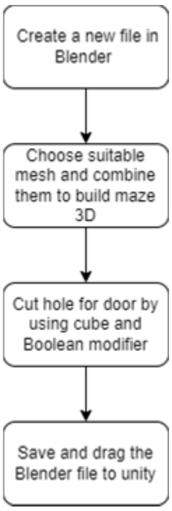


Fig.4 Production of 3D Maze Model using Blender



Production of 3D Models

There are two types of 3D models in this study: the maze model and other additional models like a frame and student desk. The maze was created using Blender as shown in Fig. 4. Firstly, a new Blender file is created, and a combination of several cubes is produced as the wall of the maze and a plane as the floor. Next, a cube and Boolean modifier in Blender were used to cut a hole for a door frame. The model is then saved and imported into Unity by dragging the Blender file directly into Unity.

Besides, the process for creating additional models initially involves the Free3D.com [19] open-source model based on Fig. 5. For example, in order to create the classroom desk, we have to search for the 3D desk model on Free3D.com, and the model is saved as a blender file. Next, the model is further edited in Blender and exported into Unity. Then, a texture material is created and assigned to the model. Fig. 6, 7, and 8 show some of the 3D models that had been created.

Fig.5 Production of Additional 3D Models

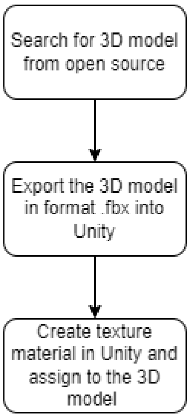


Fig.6 3D Model for Wall Lamp

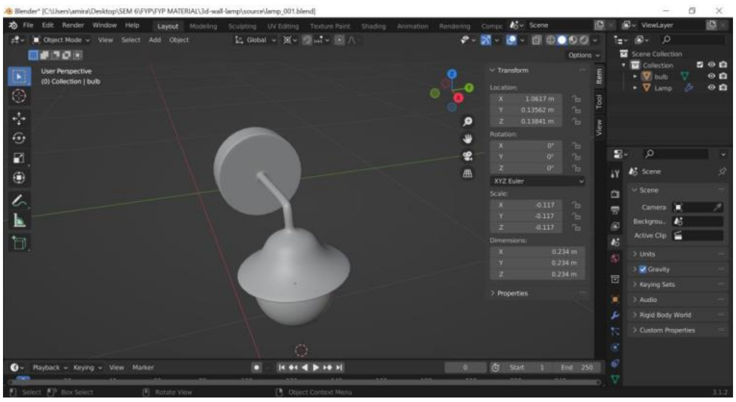


Fig.7 3D Picture Frame Model for Level 1

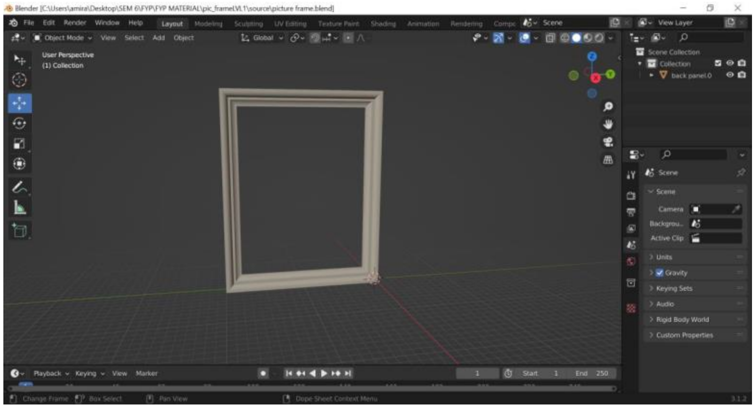
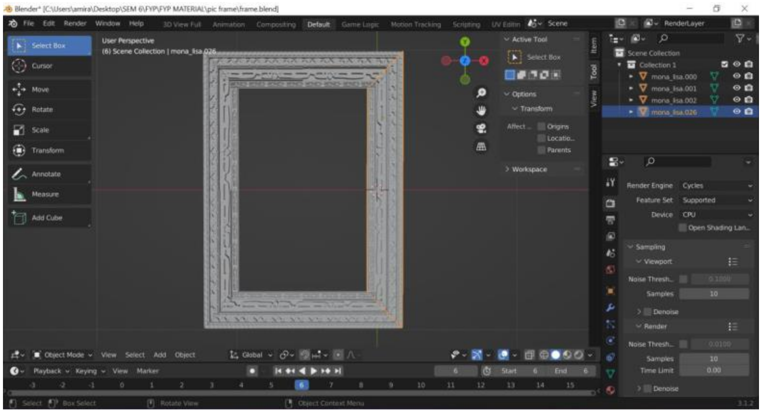


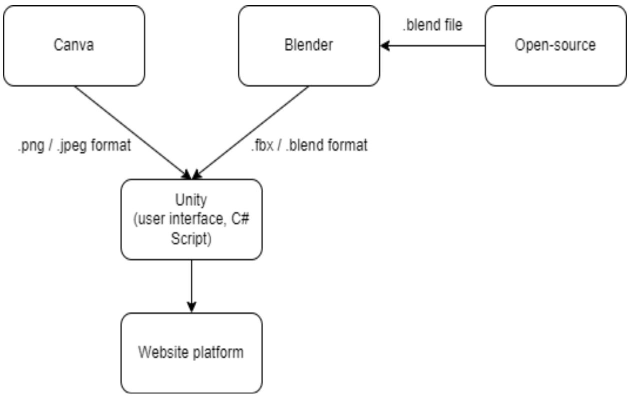
Fig.8 3D Picture Frame Model for Level 2



Media Integration

Based on Fig. 9, the media integration will combine all the media creation with the virtual reality technology (WebGL) by using Unity and develop into a website platform. The Unity version used in this media integration process is version 2019.3.3f1 (64-bit). At first, the background design, texts, logo, and button design are created using Canva.

Fig.9 Process of Media Integration



Next, maze 3D models are created using Blender, as well as the open-source models that must be edited using Blender. All media creation is imported to the new scene in Unity to produce the user interface and design.

Besides, C# scripts are used to link all the scenes, and when all of these processes are done, the proposed VR will be built and run on the website platform.

In addition, the following figures show the logo design (Fig. 10) and user interface (UI) designs of several scenes of the proposed VR (i.e. Fig. 11, 12 and 13). The logo design consists of the name Malaysian Sign Language with the combination of three hand signs as a substitute for the "M," "S," and "L" alphabets. The background colour is a solid colour that has been made transparent to represent the minimalist element. The hand signs represent our VR as sign language, which is what we want to highlight in every scene.

Fig. 10 Logo Design

Fig. 11 UI Design for Level 1 – MSL Alphabet

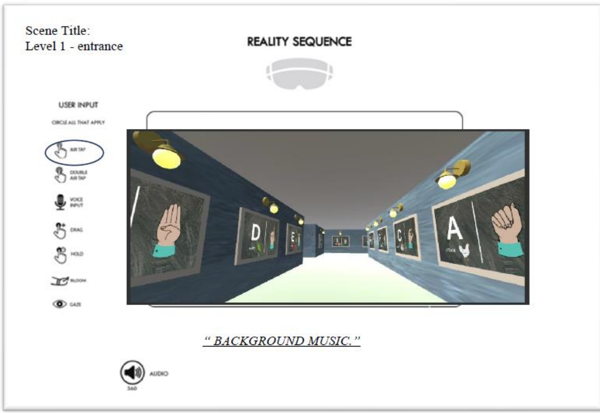


Fig. 12 UI Design for Level 2 – MSL Number

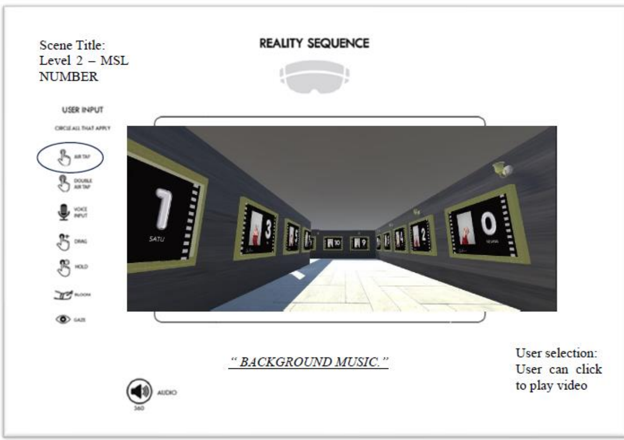
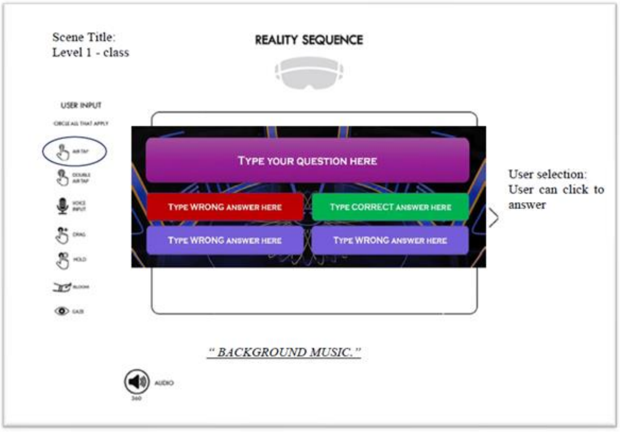


Fig. 13 UI Design for Level 1 Class



Testing and Evaluation

The developed VR was assessed using pre-posttest and user acceptance test (UAT). Fig. 14 shows the testing process in this phase. There are 20 public respondents that will be involved in this testing phase. The testing process is divided into three parts: pre-test, post-test, and user acceptance test. So, the user must answer the pre-test first before they experience the VR, and the post-test and UAT test after they experience the VR.

Testing will be conducted through the Google form, along with the link to access the VR web. The test forms will be delivered on messaging platforms like WhatsApp and Telegram. The link for VR web was produced by uploading the build file from Unity to the Simmer.io platform, so the testing will be easily delivered to the respondents.

Fig. 14 Testing Process

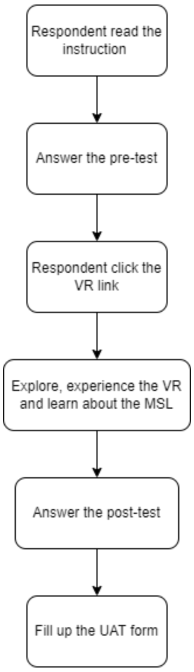


Fig. 15 Percentage of Marks in Pre-test and Posttest

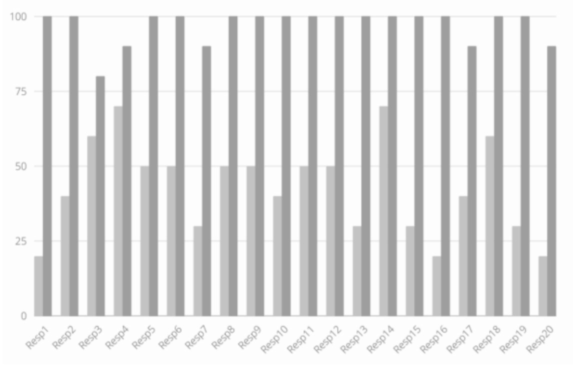
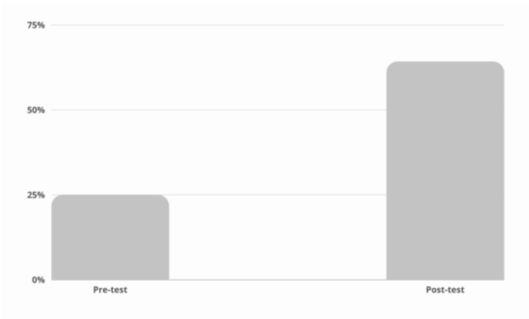


Fig. 16 Average Marks of Pre-test and Posttest



The hardware requirement for the user testing is any laptop or PC with GPU: NVIDIA GTX 970 / AMD R9 290 equivalent or greater and CPU: Intel i5-4590 equivalent or greater.

The pre-posttest is used to test the effectiveness of the developed VR; thus, the set of questions and answers is similar for both tests. Then, the UAT (Table II) is used to evaluate the learning material or content of the developed VR, and it is based on the Likert scale of 1 to 4.

There are 4 components that will be evaluated by the end user: content, interface design, functionality, and learnability. Based on Table II, the scale 1 refer to Strongly Disagree (SD), scale 2 for Disagree (D), scale 3 for Agree (A), and scale 4 for Strongly Agree (SA). Besides, we also ask for the user's comments or suggestion after experiencing our VR.

Results and Discussion

Fig. 15 and 16 show the results for pre-test and posttest. Each test consists of ten questions, and the marks are calculated based on the number of correct answers. From Fig. 15, the lowest mark for the pre-test is 20% and the highest is 70%. Consequently, for the post-test, the highest mark is 100% and the lowest is 80%. In overall, all respondents get higher marks in the post-test compared to the pre-test. Accordingly, these can also be seen in Fig. 16, where the average mark of the post-test is higher (67%) than the average mark of the pre-test (25%).

Moreover, Table II and Fig. 17 shows the obtained results for the UAT. The acceptance interval for UAT is measured as follows: Strongly Disagree (0-25%), Disagree (26-50%), Agree (51-75%), Strongly Agree (above 75%).

The percentage of acceptance for each question is calculated based on the Likert scale (refer Table II). The calculation formula is as follows, where *n* is the number of respondents, *t* is the total score, *max* is the maximum score of each questions and *p* is the acceptance percentage:

$$t = 1(n) + 2(n) + 3(n) + 4(n) \quad (1)$$

$$\max = 1(0) + 2(0) + 3(0) + 4(20) = 80 \quad (2)$$

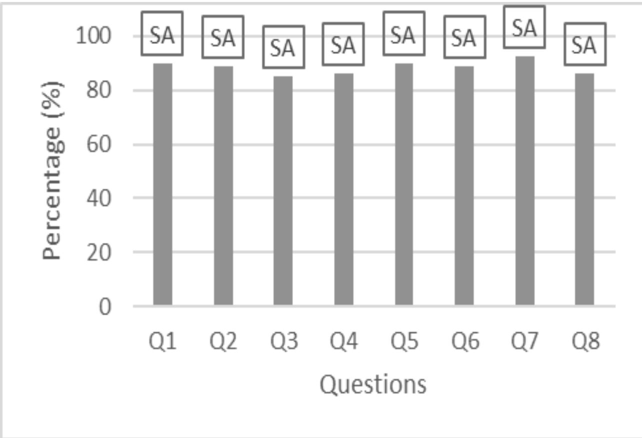
$$p = (t / \max) * 100 \quad (3)$$

From Fig. 17, it shows that in average most of the respondents strongly agree with our VR as all of the obtained percentage of acceptance is above 80%.

Table II Test Data of UAT

Questions	SD (1)	D (2)	A (3)	SA (4)
Q1. Users able to understand the infographic easily.	0	0	8	12
Q2. The infographic able the user to attract the audience.	0	0	9	11
Q3. Interactive multimedia elements attract me and suitable for kids.	0	0	12	8
Q4. The VR is simple and satisfy users experience in exploring it.	0	0	11	9
Q5. The content management is easy to navigate with the instruction given.	0	0	8	12
Q6. The user able to grasp the information on the sign language easily.	0	0	9	11
Q7. VR is a new way for effective and interactive learning method?	0	0	6	14
Q8. It is much easier to learn simple Malaysian Sign Language based on the video.	0	0	11	9

Fig. 17 UAT Percentage of Acceptance



Conclusion

The pre-test and posttest proved the effectiveness of learning with VR compared to the conventional method, as it is easier to comprehend the MSL and improve the communication skills. Accordingly, the UAT results indicate that the respondents are satisfied and gave an assessment of being very accepting of our VR.

On the other hand, there are several limitations in the developed VR. As the configuration settings for this project are WebGL rather than Android, this VR is only supported on the PC or laptop and is not compatible with mobile devices. Hence, this VR is a low-immersion type that only relies on the computer and not any haptic devices.

From the feedback from end users, the number of tutorial videos should be increased, and the interactions in this VR should be improved. Moreover, the UAT questionnaires should be more specific about VR and MSL, as the given questions are quite general. Therefore, in the future, several improvements should be made to strengthen this VR so that it can be further implemented in practice.

In conclusion, the development of VR for MSL will be able to contribute to MSL education, particularly for deaf-mute children and their parents. Besides, this VR application is able to attract people to learn MSL, thus reducing the communication gap between deaf-mutes and the community.

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