"Fun2Write": Portable Immersive Environment Application

Man-Ching Yuen[1*], Chi-Wai Yung[1], Ze-Kin Chung[1], Ruitao Huang[1] and Zetao Lou[1]

[1] Department of Applied Data Science, Hong Kong Shue Yan University, Hong Kong, China
`mcyuen@hksyu.edu`

Abstract. Nowadays, mobile games are commonly used for children's training and therapy. Literature shows that multisensory activities help raise the children's interest in their learning, raise their concentration and reinforce their memories. Portable multi-sensory games can provide an immersive training environment for children anywhere. In this paper, we design and develop a portable multisensory educational game, *Fun2Write*, to help children to learn and recognize Traditional Chinese words. It could also help to evaluate how effective it is on encouraging children to learn and effectiveness of game-based interactive teaching methods. The game mechanism is based on whack-a-mole game, each mole holds a card with a Chinese character, players have to whack the correct mole in order to gain points, which is the metric to assess how well does the player recognize Chinese characters. Unlike conventional controls such as mouse, keyboard or screen tapping, *Fun2Write* utilizes a controller that has an in-built gyro system (Such as Nintendo's Joycon) to simulate real life mole-whacking experience. The controller's mechanism is similar to laser-pointer, which allows pointer movement in 3D space, and accurately tracks the movement of the player's hand and adjusts the pointer's position accordingly. When the pointer hovers above the mole. Upon locking onto the target, the player can then perform swinging gestures to simulate swinging a hammer. This design is intuitive and helps reduce cognitive load on re-learning controls. The game can be accessed on most hardware such as smart phones and computers. To extend the portability, we design and develop a low-cost portable cave by using projectors. The output results demonstrate the effectiveness of a portable immersive environment application.

Keywords: Immersive experience, VR technology, Interactivity.

1   Introduction

1.1   Overview

Background of Traditional Chinese Dyslexia. According to the Department of Health of Hong Kong [1], 9.7 to 12.6 percent of children suffer from dyslexia, which could be devastating during their phase of development, such as hindering their ability to learn properly, or unable to socialize and fit into the society. Therefore, it is crucial to develop a system to assist children in Traditional Chinese learning.

Game-based Learning. Game-based learning method (Tobias et al., 2014) has been proven to be an effective way to help children to learn more effectively (Prensky, 2003), as it is more engaging, has a higher level of acceptance from children, and to cater to children that have no access to additional learning resources (Chen et al., 2017). There is an absence of games about learning Traditional Chinese on the market, therefore, we created a web-based training and gaming platform named Fun 2 Write, that features several games that can be accessed by computers and mobile devices (Yuen et al., 2023).

Immersive environments. Although Fun 2 Write games provide multisensory learning which could potentially improve visual and auditory skills, its conventional interaction method with computer or smart devices such as tapping and clicking is limited in a 2D space, which reduces some factors such as dynamic controls and degrees of movement that could potentially improve the interaction level of the game, or kinesthetics level.

To extend the space to 3D, we set up a Cave Automatic Virtual Environment (CAVE) with the purpose of simulating a virtual environment without the need of VR headsets or goggles, then we use it to host the one of the games in Fun 2 Write , which is whack-a-mole game to test on how to simulate 3D navigation and select appropriate viewing angle and input device. The CAVE is assembled with portable projectors and screens, which means it can be deployed in different places.

The portable CAVE has a few characteristics that can enhance the game-based learning experience, such as providing an immersive and interactive environment, which enhance multisensory learning experiences, making children to actively involved/focused on the learning process, becoming more willing to study and make better learning experiences.

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[1] Department of Health Child Assessment Service. (2022, March 31). *Dyslexia.* https://www.dhcas.gov.hk/en/dyslexia.html

1.2   Our Contribution

In this project, we have several contributions as shown in the following.

- Using an immersive environment to enhance existing game-based learning methods.
- Collect data about how engaged the players are.
- Data about how players feel about the level of enhancement.
- Potential improvements for better immersion

2   Related Work

Taiko-no-Tatsujin is a popular rhythm arcade game, it is famous for its highly interactive gaming experience where players are actively engaged with it when playing. The arcade machine features drums, flashy screens and uplifting music, which players could pick up and follow the game instructions easily. In the game, the player needs to follow the screen, listen to the rhythm and incorporate their body in order to hit the correct note, which trains their visual, auditory and kinesthetic skills, making them actively involve in the game and fully immersed in it.

   Below are several examples of games or tools designed specifically for dyslexic students.

- *HOPE*[2] (Chinese part-of-speech and sentence game) - This game app was developed by YWCA Hong Kong, and it is especially designed for children with dyslexia. It provides children with interactive games that tell Chinese tales so as to help the children practice Chinese words and sentences. Since the game is designed for children with certain prior language skills, some kindergarten and early primary school Chinese learners may find it difficult to play, which could possibly result in frustration.

- *C.A.R.D.*[3] (AR toys for dyslexia early screening) – This game was developed by a group of secondary school students who were seeking to provide a tool utilizing AR technology for dyslexia early screening through toys with some certain colors and shapes. The development team designing the game without words so as to try to avoid labeling children as dyslexic simply due to their unfamiliarity with certain words. However, the lack of complexity and function richness limit the game's ability to detect or screen potential dyslexic children.

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[2] Hong Kong Young Women's Christian Association (2023). *HOPE 中文詞類及句子遊戲* (Version 6.0) [Mobile app]. Google Play.
   https://play.google.com/store/apps/details?id=hk.org.ywca.hope2&hl=zh_HK&gl=US

[3] Wong, T., Cheung, I., & Fong, M. (n.d.). *C.A.R.D. - Augmented reality game for identifying early-age school kids with dyslexia*. C.A.R.D.
   https://www.ardyslexiatoy.com/en/index.html

- *Read and Write Trooper* [4] - HEEP HONG Society has developed a series of games in an effort to motivate children to learn at home at ease. Among these, the 'Read and Write Trooper' offers the most comprehensive training and materials for learning traditional Chinese. This app also adopts the multi-sensory learning method, and this is the best app we could find on the market that realizes this approach, having an abundant number of areas to be touched by children. However, the drawing is realized solely by writing on a glass display with a single finger, while in the real case pencil and paper are used. Thus, the obtained experience will be relatively less practical, since single finger writing is not the same as writing with a pencil.

- *TraceIt* (An Air Tracing Reading Tool for Children with Dyslexia) (Teh et al., 2015) - A group of Malaysian researchers took advantage of assistive technology to create an interactive tool called TraceIt that adopts multi-sensory methods. Instead of having students use traditional paper and pen or the newly developed finger-writing on a glass screen, they used a wireless computer mouse to involve kinaesthetic movement along with visual and auditory effects. The results were also inspiring, as over half (about 55%) of the dyslexic participants were able to learn a set of new words within 10 minutes of practice. The project proved that with the assistance of external input sources, learners can be encouraged to be more engaged in the learning process, so this can be a supplement to the traditional way of guiding dyslexic children. We aim to achieve an extension of this project's concept on a larger scale, and we hope that our platform can actually be used by local dyslexia associations to train children.

- *ARToolKit-based Interactive Writing Board (IWB)* - This project presented an easy and low-cost interactive solution (Khan et al., 2019) that uses an ARToolKit-based Interactive Writing Board (IWB) to teach Arabic and Urdu characters to primary school students. We applied the concept of this project to our project, since the marker-based AR library (AR.js) that we used in our project makes use of jsartoolkit5, a JavaScript version of ARToolKit, for marker tracking.

3   Latest Technology

3.1   Multisensory Learning

Multisensory learning is the approach of utilizing multiple perception such as auditory, visual, kinesthetic, in the process of learning. Multisensory learning is proven to be a more optimal learning approach as human brain is prone to learn with multisensory activities (Shams & Seitz, 2008).

- advantage in daily application
- example results to show how it is related to our project

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[4] Heep Hong Society (2021). *聽說讀寫小奇兵* (Version 1.7) [Mobile app]. Google Play. https://play.google.com/store/apps/details?id=org.heephong.lsrw&hl=zh_HK&gl=US

3.2   Cave Automatic Virtual Environment (CAVE)

The CAVE is an immersive virtual reality environment that is created by projectors and flat walls / screens that surround the user, the number of screens is variable depending on the user requirements. It creates a sense of 3D perception and real-life simulation, where users can then interact in the virtual environment and object like it is real life. The CAVE has multiple applications such as creating virtual scenarios for employee training or simulating dangerous environments, for instance: a virtual archaeological cave sites map for safety training and discovery without causing harm to the actual cave sites (Trimmis, 2018). In our case, the cave could potentially create a more relaxing environment for children, in order to lower the intimidation level of the learning environment and heighten their willingness to learn.

4 Our Work

4.1   Game

The Whack-a-Mole game is chosen from the Fun 2 Write games platform as a testing game, which is made by the Phaser 3 game framework. Phaser game framework is used for light-weight web-based games, which makes the game accessible to anyone that has a smart device or computer. Other than that, most of the game designs are family friendly and could promote positive interactions (Yuen et al., 2023).

In the Whack-a-mole game (as shown in Fig. 1), some animations are applied to simulate the effect of moles jumping up from the holes and going back to the holes. The player has to interact with the correct moles to earn marks.
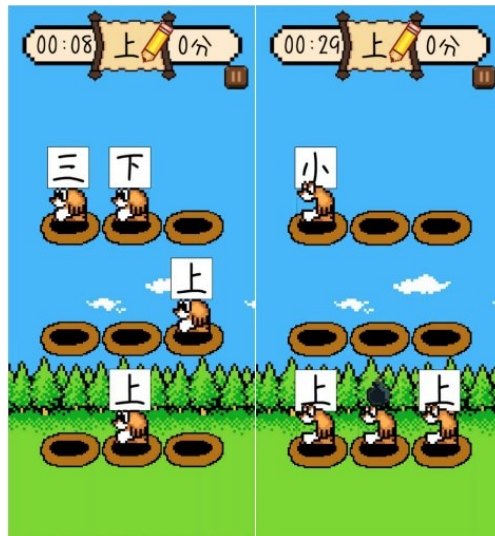

Fig. 1. Whack-a-mole game

4.2   CAVE environment

Information and Communication Technology Innovation and Creativity. Cave's innovation lies in the use of panoramic VR technology, which expands the virtual environment beyond the limitations of head-mounted displays and places it in the environment. It uses a projector to project the image and a controller to enhance the interaction between the user and the display environment. It provides a unique immersive experience when used for multi-user displays.

Functionality. It can display any image that can be displayed on a computer as a panoramic display technology that can interact with the image. As a system that can be controlled with a controller, its control is also very simple, and users can control the system with intuitive and effective actions. Subsequent development can also be carried out to create some physical games.

Market potential/performance, internal or public acceptance. Currently, there are no well-established solutions for small-scale virtual environment display systems. Our competitors are traditional VR devices and some large projection virtual environments, which are generally expensive. As a large virtual reality Cave, its maintenance and mobile costs in the future are incalculable. As a system that creates virtual environments for small spaces, our customers can showcase their ideas anywhere. Although the level of expression of virtual environments is not as high as that of traditional virtual reality and head-mounted VR devices, our system is low-cost and can be quickly deployed when our customers want to create some light interactive displays.

Benefits and impacts. Our system is low-cost, flexible in design, and has a low threshold. Users do not need to buy special equipment to play similar projects. With a home computer, projector, and controller, they can have a Cave system, so the budget will be adjusted according to the situation, and the final cost will be much lower than buying VR equipment. And because it is projected, multiple people can visit together, feel the virtual atmosphere, and be more immersive.

4.3   Control

For the game controller, we chose the controller that has in-built gyro systems and Bluetooth connections, easy to handle and control for children, Nintendo's JoyCon controller is the best option in this case as it is well-known in Hong Kong and could potentially have higher acceptance rate from parents.

To make the control more intuitive and simpler, only the left Joy-Con controller has been used. By integrating all the controls into one controller, players can pretend the controller is a hammer, which reduces learning time and increases the immersion of the game.

4.4   Control Software

In order for the game controller to interface properly with the computer, we used a tool called JoyShockMapper to access additional features in the controller such as

gyro programming and gesture setting, in order for the computer to register sudden movements such as swinging the controller like a hammer and set the hammering motion as hitting action to hit the appearing moles. This enhances the game's interactivity as players are no longer confined in 2D space, able to access 3D space movements and have immersive experience and more intuitive control.

4.5   Our Immersive Whack-a-Mole Game

Fig. 2 shows our immersive whack-a-Mole Game. The Immersive Writing Fun digital game has the following advantages:

- Specifically for children with Chinese language dyslexia.
- Immersive mode of interaction(3D).
- Portable equipment design.
- Low cost.
- Easy to start for children.
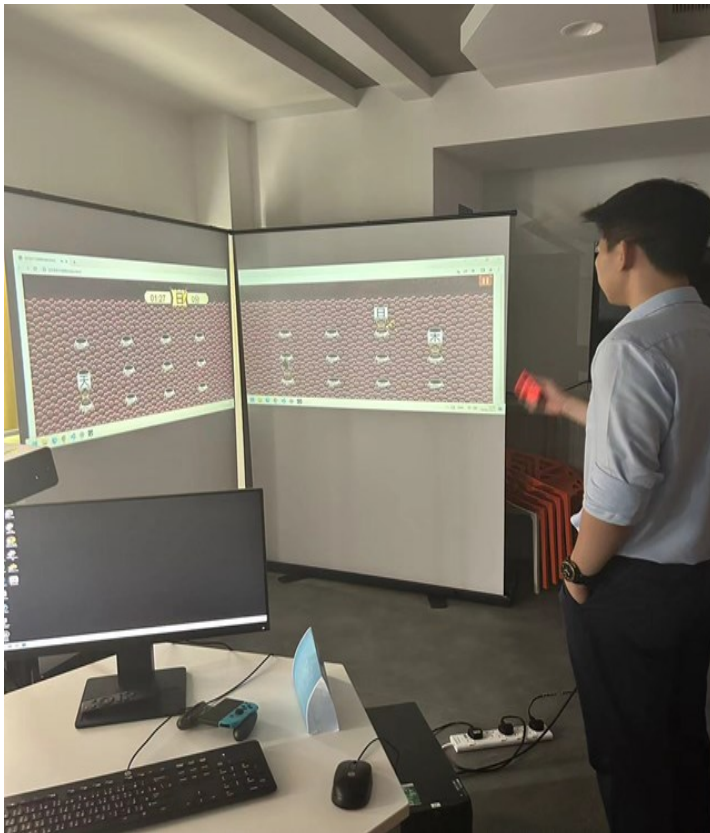
Fig. 2. Our immersive whack-a-Mole Game
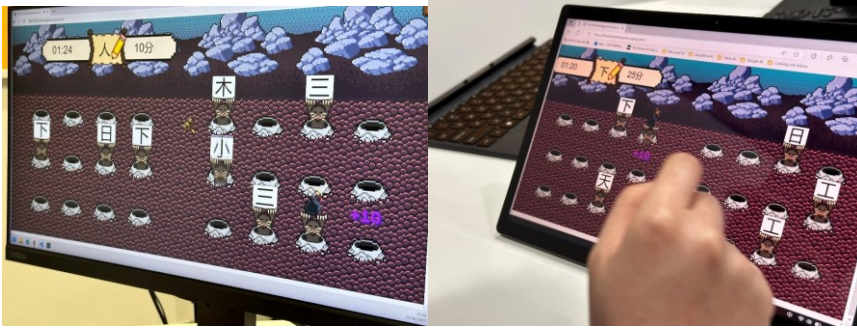
Fig. 3. PC version of our game

Compared with the PC version of our game (shown in Fig. 3), our portable immersive game can enhance multisensory activities because

- Increase interactivity (kinesthetic)
- By using surrounding screen depends on user requirement
- By using surrounding sound
- Children learn while playing games.

5   Performance Evaluation and Data

We have designed a few questions to measure the performance of the portable CAVE. The survey data was collected from surveys after they have tested our system. The survey used the rating scale of 1 to 5, where 1 is the lowest score and 5 is the highest score. Fig. 4 shows the plot of 2 survey questions. The first question in the survey is to find the level of engagement under the CAVE environment of the testers. The second question is to rate how much the CAVE enhances the gaming experience.
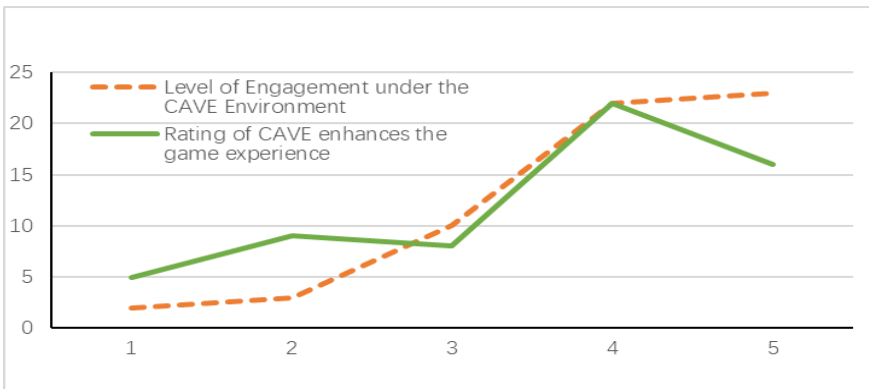
Fig. 4. Data collected demonstrates inclination towards higher ratings

Fig. 5 shows testers' opinion on elements that could potentially improve the immersion of the CAVE.
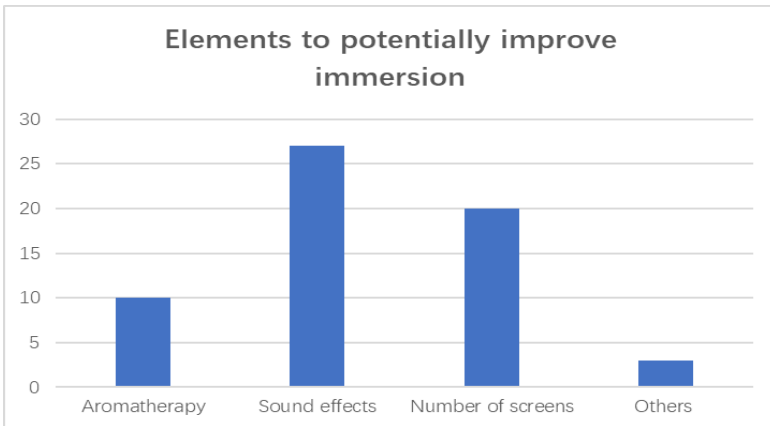

Fig. 5. Higher inclination on sound effects

6   Limitations / Future plan

The future expectations and plans are shown as follows.

1) Child Applicability
    During the game development process, we had a tight schedule and needed help finding a suitable opportunity to expand the scope of testing. We have been designing for children but still need testing and analysis of children playing in the field. Therefore, in the future, we will visit schools and kindergartens to conduct offline testing, collect feedback from children playing, and make modifications for the next step.

2) Unity of Hardware and Software
    During testing, some testers reported that our project had a feeling of inconsistency between software and hardware ecosystems, which caused a fragmented experience. Specifically, there are several issues:
    - Selecting the cursor in the game feels rigid. We can change the cursor selection to move an auxiliary judgment box instead, which will reduce operational errors and improve the game's playability.
    - The gap between the screens still affects the gaming experience. It is best to solve the separation problem from a physical perspective.
    - The use of Bluetooth connection for the controller occasionally causes operational delays and mis-touches. We suggest using more suitable receivers or control software.

7   Conclusion

Multisensory learning can be an effective way to help children with dyslexia to learn properly. Game-based learning is one of the ways that can provide multisensory learning, and a relaxing and engaging learning environment that enhances the learning experience by developing their visual, auditory and kinesthetics. We have designed a game for dyslexic children training. Our game can be accessed on most hardware such as smart phones and computers. However, the games are typically displayed on a 2D screen / tablet, which has a lower effect on their kinesthetics development. To allow children to interact with virtual environments with 3D movement controls, CAVE is built with sense of kinesthetic, visual and auditory. To extend the portability, we have designed and developed a low-cost portable cave by using projectors. The portability of the system can make it deployable anywhere. The output results demonstrate the effectiveness of a portable immersive environment application.

Acknowledgements

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