Virtual Reality and Artificial Intelligence

A Dual Edged Sword for Advancing Education for the youth with Double Diagnoses

Master Thesis

MED 10

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Abstract

In today's educational settings, youths grappling with dual diagnosis encounter a multitude of challenges when attempting to navigate ordinary educational environments. These obstacles were revealed in an interview with a teacher from a residential school for teenagers with dual diagnoses. The teacher described the difficulties these students confront in their pursuit of education, emphasizing the complexities that come with Cognitive difficulties, low attendance rates, low motivation, mental health issues, and exam anxiety are just a few of the obstacles limiting these youths' educational development. These youths must have a feeling of purpose and something to aim for after finishing therapy.

Therefore, this study aims to provide an immersive learning environment for youths confronting learning issues due to dual diagnosis using Virtual Reality (VR) and Artificial Intelligence (AI). The goal of combining VR and AI is to improve educational experiences and assist youths in English and math topics by encouraging them, fostering knowledge, and preparing them for national examinations. A classroom setting was developed using Unity to create a pleasant familiar environment to provide an engaging learning experience. The purpose of the AI is to replicate teacher-like communication, assist youths in learning English, and establish an authentic and immersive interaction with a teacher in a virtual reality context. The thesis delves into how the experimental environment is designed and the idea behind it, especially the integration of Mimic3 (TTS), which this thesis explains in detailed information. However, before getting into the details of Mimic3 integration, a review of the hardware, software, scripts, and environment is described in Chapter 3. Throughout the testing phase, the youths followed the same structure every day for a week to preserve consistency and simplicity. The testing phase primarily involved the use of a VR Valve Index headset and 2 controllers. These tools connected the youth with the learning exercises within the immersive classroom, designed using software such as Unity, Blender, Fuse, Max 3D, and Photoshop. Furthermore, an important design decision was made regarding the need for an emergency button. Additionally, it was noted that the well-being of the users was a top priority, allowing them to exit the experience if distressed.

Initially, the data sample consisted of 21 youths, and the level of engagement fluctuated. Ultimately, only four individuals completed all the specified steps of the experiment.

The youths were given three math tasks to complete inside the VR learning environment. The first math task was a math triangle puzzle game aimed at improving spatial thinking and geometric knowledge. Following that, the youth engaged in a square-shaping game that focused on improving visual-spatial abilities and geometric knowledge. Finally, a puzzle game involving equations encouraged problem-solving skills and number understanding. To evaluate learning outcomes, pre-and post-tests aligned with the VR learning content were used, along with a questionnaire. The test was designed to assess youths' knowledge and understanding of the VR content for each subject area. To understand the statistical test selection and evaluate the impact of VR and AI on youths' academic achievement, specific statistical tests were chosen to align with the nature of the collected data and the study's objectives. The JASP program was used for Bayesian T-tests, Spearman's rank correlation coefficient, and the Wilcoxon signed-rank test.

Chapter 4.4 revealed a statistically significant difference in Pre and Post score, Math and English scores ($0.049 < 0.05$), supporting the alternative hypotheses ($H1_1$,$H2_1$, $H4_1$). This outcome highlights that the VR learning experience positively impacted youths' performance in both Math and English subjects, leading to improved scores after the 5 days of using the VR experience.

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Chapter 1. Introduction

In today's educational settings, youths grappling with dual diagnosis encounter a multitude of challenges when attempting to navigate ordinary educational environments. These obstacles were revealed in an interview with a teacher from a residential school for youth with dual diagnoses. The teacher described the difficulties these students confront in their pursuit of education, emphasizing the complexities that come with it. Cognitive difficulties, low attendance rates, low motivation, mental health issues, and exam anxiety are just a few of the obstacles limiting these youth' educational development.

Dual diagnosis, as defined by the World Health Organization (WHO), includes the co-occurrence of substance abuse and mental health issues. Accurate data is hard to come by, but 40,000 people in Denmark are believed to suffer from dual diagnosis (Johansen & Schrøder, 2023, p. 5). The increase of such incidents in the mental health care sector highlights the critical need for defined responsibilities, even as support and resources remain insufficient failing to reach required quality standards. The co-occurrence between mental health disorders and drug misuse complicates therapeutic efforts even further providing a barrier to assisting youth who face these challenges (Johansen & Schrøder, 2023, p. 2). Amidst the challenges, artificial intelligence combined with virtual reality may offer a cutting-edge solution.

The combination of VR and AI may have the ability to encourage and empower youth by providing a motivating approach to education. Integrating AI-driven educational resources into immersive VR settings could change their learning experiences.

Youths must have a feeling of purpose and something to aim for after finishing therapy. Education may assist them in seeing a brighter future (Järvinen, 2018). An important component of this journey is education which shapes their goals in addition to providing knowledge. As the social environment has a considerable impact on an individual's trajectory and well-being, a lack of education might potentially lead to relapses. For many people, education is a critical way of attaining upward social mobility (Joye & Falcon, 2014), allowing them to break free from their social inheritance and achieve a greater social position than their parents, therefore reshaping their destinies.

1.1. Objectives, Aims, Design, and Hypothesis

This thesis aims to provide an immersive learning environment for youth encountering learning issues due to dual diagnosis using VR and AI. The goal of combining VR and AI is to improve educational experiences and assist youths in English and math topics by encouraging them, fostering knowledge, and preparing them for national examination.

Due to the unpredictable nature of dual diagnosis, the number of participants may vary during the experiment, which ran over the course of one week in November There may be issues in recruiting youth to participate and ensuring their mental readiness for the experiment. Nonetheless, the primary purpose of the project is to determine how VR and AI applications might improve youths' academic achievement. To evaluate learning outcomes, pre-, and post-tests aligned with the VR learning content will be used, along with a questionnaire. The study will use statistical analysis and tests to detect any significant differences or correlations between hypotheses. To investigate these theories, various methodologies will be used:

Total Score Analysis:

- Null Hypothesis ($H1_0$): No statistically significant difference exists in overall total scores before and after the VR exercise.

- Alternative Hypothesis ($H1_1$): A significant difference is observed in the overall total scores before and after the VR exercise.

Questionnaire Analysis:

- Null Hypothesis ($H2_0$): There is no statistically significant correlation between questionnaire responses and task performance.

- Alternative Hypothesis ($H2_1$): A significant correlation exists between questionnaire responses and task performance.

Math Scores:

- Null Hypothesis ($H3_0$): There is no statistically significant difference in math scores before and after the VR exercise.

- Alternative Hypothesis ($H3_1$): There is a statistically significant difference in math scores before and after VR exercise.

English Scores:

- Null Hypothesis ($H4_0$): There is no statistically significant difference in English scores before and after the VR exercise.

- Alternative Hypothesis ($H4_1$): There is a statistically significant difference in English scores.

Before and after the VR exercise

The experiment's primary design and development are as follows:

- Creating an immersive VR classroom using Unity, Blender, Fuse, and Photoshop for a stimulating learning environment.

- Establishing and optimizing an AI-driven non-Player Character teacher (AI-T) to provide interactive speech and dialogue for a more engaging learning environment.

- Creating a virtual body for the user to provide a more immersive learning environment.

- Design and implement educational components that can help enhance English language proficiency and mathematical problem-solving skills.

1.2. Research Setting and Participants

Participants will be chosen by the study's location. The school chosen was created in 1998, is a non-profit organization that serves as a residential facility focusing on the treatment and education of youths who suffer from dual diagnosis, particularly those who are involved in or influenced by substance abuse. The school strives to provide specialized care and academic assistance that is adapted to the requirements of each youth. The institution's approach is comprehensive, integrating customized tutoring, small-group seminars, and project-based learning to stimulate success and prepare students for the national exam.

Youths at school struggle with a variety of problems which have a substantial influence on the way they learn. Among these difficulties include learning problems, Attention-Deficit/Hyperactivity Disorder (ADHD), and dyslexia. Learning disorders, which interfere with cognitive processes such as reading, writing, and information processing, are frequently recognized in primary school, resulting in academic disparity and low motivation among affected youths (Gibby-Leversuch, Hartwell, & Wright, 2019). Due to the participants' therapy commitments and the unpredictable nature of their circumstances, there were substantial issues with motivation and the VR experiment. Only 7 of the original 21 youths engaged in the VR experience, with only 4 completing all stages of the research successfully. This shift in engagement highlights the complexities and challenges of engaging youths meaningfully in educational settings.

Finally, the purpose of this project is to investigate the impact of AI and VR in educational settings that may improve learning experiences for youths who face obstacles because of double diagnosis. The project attempts to examine how AI-driven tools in immersive VR settings might favorably improve academic and motivational achievement in English and mathematics disciplines, hence solving the educational challenges that these students are faced with.

Thereby, I have arrived at the following final problem statement:

How can the integration of VR and AI into educational environment settings effectively improve the learning and motivation experiences and academic learning of youths with dual diagnosis in English and mathematics?

Chapter 2. Literature Review

2.1. Emotional Support from AI Chatbots

This chapter presents the interaction between technology, emotional support, motivation, cognitive impacts, and education. These studies provide an important foundation for understanding and meeting the diverse educational demands of youths with dual diagnosis.

The study by Meng and Dai (2021) demonstrated the potential of AI-driven chatbots and human interactions in giving emotional support to decrease stress. While human engagement was shown to be more effective in lowering stress than chatbots, the study underlined the important role that AI may play in providing objective and unbiased assistance. Although human partners may have a greater influence, this option may be implemented for youths as they navigate their English language learning path.

To further research the complex relationship between substance abuse, school involvement, and social integration across varied youth groups, a study titled *"Unge, Alkohol og Stoffer"* (Järvinen, 2018) discovers surprising links between education, motivation, and substance addiction across various youth groups. The study consisted of groups A to E and underlines how education and motivation intersect with alcohol usage. It highlights how Group C's and B's academic drive sets them apart from the rest of the groups by having a strong motivation for education. With the highest school motivation of any group, they appear unaffected by alcohol culture or the drinking habits of their friends. This sets them apart from the majority in two ways: they either have an immigrant background or exceptionally strong school motivation. Encouraging higher education and boosting motivation may help reduce substance abuse among youths by providing different opportunities and reducing risky behaviors.

When it comes to the cognitive effects of substance misuse and addiction, the National Institute on Drug Misuse (NIDA) defines addiction as a chronic condition characterized by compulsive drug use despite negative outcomes. It affects brain circuits involved in reward, stress, and self-control, indicating that it has consequences beyond psychological effects (NIDA, 2020). NIDA emphasizes that exposure to substance abuse varies among individuals. As risk factors accumulate, the likelihood of addiction increases. protective factors such as self-efficacy, parental support, positive relationships, academic success, school anti-drug policies, and community resources decrease these risks (NIDA, 2020).

Understanding the significance of protective factors, notably academic success, in developing reward systems offers possibilities to channel motivation toward constructive learning. Integration of technology into education, such as VR, may emerge as a critical tool in combating substance abuse. Immersive experiences in VR considerably improve education by engaging students in more practical and interactive education (Thomsen, 2023). Educational systems may potentially alter brain functions associated with self-control and decision-making by fostering a supportive school atmosphere, promoting academic success, and leveraging immersive technology, consequently lowering the risk of substance abuse among youths.

2.2. Learning disabilities, self-perception, and Open Dyslexic

This section explores the influence of dyslexia on self-perception in educational settings as well as the difficulties in understanding written content in VR. It provides ways for improving readability and understanding with a focus on font selection and text presentation to accommodate people with dyslexia.

Dyslexia, which affects reading and writing skills, can have a substantial influence on a youth's self-perception in areas such as reading, writing, and spelling during elementary education. Interestingly, despite these problems, youths with dyslexia frequently have a favorable self-perception of their mathematics ability and effort (Gibby-Leversuch, Hartwell, & Wright, 2019). Overcoming negative self-perceptions associated with dyslexia requires a supplemented learning method that emphasizes critical thinking, interactive study engagement, and a complete understanding of the subject matter (Murtagh & Lelia, 2015). Similarly, ADHD, which is marked as problems with attention and hyperactivity, has a substantial impact on youths' educational experiences, leading to boredom with uninteresting topics and hyper-focus on areas of interest. When subjects do not hold their interest, these attention-related difficulties hinder their ability to learn. These barriers also have an impact on educational environments and study skills (coach, 2023). As previously said, dyslexia makes it harder to process written information and language. One possible approach for improving readability and understanding is to follow what the Game Accessibility Guidelines promote. To adopt a font made expressly for people with dyslexia, such as Open Dyslexic or FS-ME. These fonts include clean sans-serif typefaces, mixed-case text, 1.5x line spacing, and only a few characters per line (guideline & accessibility, 2023).

Additional considerations include VR and text to support individuals with dyslexia. It may be beneficial to prevent automatically advancing text. This may give those with dyslexia more time to read and understand. It promotes varied reading rates and understanding levels by maintaining the text on-screen until the user actively advances to the next line.

2.3. Multimedia Learning Strategies for Youths with Dual Diagnoses in Education

The combination of VR and education in my thesis has opened the path for multimedia learning, particularly in the context of assisting youths who are dealing with dual diagnoses. This thesis focuses on designing and using VR and AI to enhance the educational journey of these youths. To effectively support their unique learning challenges, integrating diverse sensory learning strategies and adopting a multimedia learning approach becomes crucial. Mayer and Fiorella (2022) emphasize the significance of multimedia learning hypothesis, especially within VR environments, offering effective solutions to diverse learning styles.

The multimedia learning hypothesis proposed by Mayer and Fiorella (2022) asserts that incorporating sound, image, animation, video, and interaction in learning materials fosters deeper understanding than only using words alone. Relying solely on words may hinder their learning abilities, affecting their attendance, motivation, and overall learning experience. This approach proves especially beneficial for youths managing multiple diagnoses like dyslexia and ADHD, aiding their educational journey (Waterford, 2019), including essential exam preparations such as the 9th-grade examination.

> *"Announcement of the Act on Primary Education §14(4): In order to pass the final examination of primary school, the student must have obtained at least the grade of 2.0 on average in the 9th-grade tests mentioned in paragraph 2, and the test in the 8th grade mentioned in paragraph 3."* (Retsinformationen, 2023).
>
> [Bekendtgørelse af lov om folkeskolen §14 Stk.4: For at bestå folkeskolens afgangseksamen skal eleven have opnået mindst karakteren 2,0 i gennemsnit i de 9.-klasseprøver, som er nævnt i stk. 2, og den prøve på 8. klassetrin, som er nævnt i stk. 3. (Retsinformationen, 2023)]

Math and English exams are crucial milestones outlined by the Act on Primary Education, demanding a minimum grade of 02 in both the ninth and eighth-grade exams as a benchmark for academic achievement. Evaluation standards in Mathematics include coherent problem-solving, concept comprehension, and systematic methodologies (Kvalitet, 2022), while English proficiency encompasses language skills, communication, cultural awareness, and source utilization (Kvalitet, 2022).

However, youths managing dual diagnoses face distinct challenges in exam preparation, including cognitive impairments, poor attendance, lack of motivation, mental health issues, and test anxiety. The impact of substance abuse on memory and learning complicates exam readiness necessitating tailored interventions to support academic achievement in this demographic.

Another approach to enhance exam readiness is to use the learner-centered approach that emphasizes the combination of multimedia tools to enhance learning experiences. Unlike technology-centered methods, learner-centered approaches prioritize understanding of how humans think and learn, and how multimedia can be adapted to optimize learning (Mayer & Fiorella, 2022, pp. 6-8).

This framework highlights the connection between the learner's approach, multimedia learning strategies, integrating multimedia techniques tailored to human cognitive processes within VR environments that may serve as a motivational catalyst. By aligning learning approaches with how the human mind comprehends and processes information, VR becomes an engaging and motivating platform for youths navigating dual diagnoses.

Chapter 3. Methodology

3.1.1. Introduction

The purpose of this chapter is to investigate the essential features of the experimental environment with a particular focus on the integration of Mimic3 (TTS) into the environment. The integration of Mimic3(TTS) is a challenging and lengthy procedure which makes this detailed evaluation necessary. Understanding this specific region is critical since it plays a key role in developing the overall structure and operating ability of the AI teacher's complete system. However, before getting into the details of Mimic3 integration, a review of the hardware, software, scripts, and environment is essential.

3.2. Hardware overview

Computer specifications

- i5-9600k CPU
- 16384MB RAM
- Nvidia GeForce RTX 2060
- Operating system: Windows 10 64-bit

Head mount display (HMD) (Valve, 2023)

- The model is a Valve index. The valve index of the microphone and speakers is incorporated into the headset.
- Dual Microphone Array, Sensitivity: -25dBFS/Pa@1kHz, frequency response:20Hz-24kHz
- Speakers: 37.5mm off-ear Balanced Mode Radiators (BMR)
- Frequency Response: 40Hz - 24KHz, Impedance: 6 Ohm, SPL: 98.96 dBSPL at 1cm.
- Two sensors: SteamVR 2.0, compatible with SteamVR 1.0 and 2.0 base stations.

- 2 Valve Controllers: Input Devices Each controller has 87 sensors that capture finger and hand motions.

Figure 1 Image of Valve Index headset, two controllers, and two sensors.

3.3. Software overview

Unity 2022.1.16f1 HDRP

Selected for its versatility in creating the VR environment as well as its easy to integrate with other software.

Visual Studio 2022 (C#)

Due to competency and Unity compatibility, C# will be used as the primary scripting language.

GitHub repository

Gpt4all.unity-master and ggml-alpaca-7b-q4 model (2023):
Localized chatbots compatible with Unity (LLM).

Macoron/whisper.unit and ggml-tiny.bin (2023):
Whisper is a Unity compatible localized speech-to-text (STT) for converting microphone conversation into text.

Mimic 3

A Text-to-Speech (TTS) system that solely runs on Linux.

Windows Subsystem for Linux (WSL)

WSL creates a Linux environment in Windows to solve Mimic 3 and Windows compatibility difficulties.

Ubuntu 22.04

A Linux command prompt similar to the Windows command prompt.

Python 3.11

Python is installed in the WSL environment to help with script creation and communication between Ubuntu and Mimic 3.

Blender 3.3.1

Used largely for 3D modeling, including environment design, 3D body changes, bone construction, lightmap development, and polygon count optimization.

Adobe Photoshop

Used for image editing, including the creation of visual aids and symbol creation for math exercises.

Mixamo

A library for character models that includes choices such as the male body Leonard and numerous animations.

Salsa Lip Sync

A Unity Asset Store tool that controls dynamic animation blend shapes for face emotions depending on audio inputs.

Fuse v1.3

was used to create the AI teacher's body and facial expressions.

Max 3D

This software is used to morph and merge the AI teacher's facial expressions.

HDRP Lighting Box 2 Lit

This element improves the environment's lighting and shadows.

Steam VR

Downloaded from Steam it connects Unity and allows Unity to communicate with the Valve Index head-mounted display.

3.4. Scripts overview

The description of how the code segments interact can be found on Appendix A 1. Flow Chart. A graphic demonstrating the interactions between each part of the script can be seen throughout Appendix A 1. Flow Chart. It is critical to notice that the beginning location and interactions begin at the 'The Player' node at the top of Appendix A 1. Flow Chart. Otherwise, each script is labeled appropriately in the Appendix A 1. Flow Chart.

Llmanager

In charge of the LLAMA chatbot.

MicrophoneDemo

Controls the whisper function for speech-to-text (STT).

Chatsample

Controls the text input received by the chatbot system.

ProcessManager

Handles the transfer of chatbot text to Mimic3Manager for text-to-speech processing.

AudioPlayer

Manages the playback of Mimic 3 sound files to be played.

TeacherAnimationManager

Manages the teacher's character animations, improving realism during conversations and idle moments.

MathGameManager

Manages the environment's different components of math exercises, interactions, and triggers for math exercises.

TriangleTransformer

Handles logic for the shape-sorting task involving triangles.

SquareShapeCreator

Controls the logic for shaping and locking square shapes in place.

TurnManager

Controls the order of math problems and introductions by sequencing events.

MathPuzzle

Manages logic for a math puzzle game, including symbols and the ability to change the difficulty levels.

EmergencyButton

This script controls the red button in the environment, which, in an emergency, allows for a brief escape.

XR Interaction Toolkit

A framework for developing VR experiences that is a built-in asset from Unity.

ButtonActivationArea

Triggers AI teacher animations and random audio when the hand enters the green box area above the character in the VR classroom.

3.5. Classroom Environment

A classroom setting was developed using Blender to create a pleasant familiar environment to provide an engaging learning experience. The atmosphere was designed to resemble the '90s and early 2000s. The first iteration was visually pleasing and detailed, but it encountered technical difficulties such as low frame rates which finally led to system failures. A consistent frame rate is critical for VR to avoid simulation sickness. Simulation sickness occurs when there is a discrepancy between what the eyes and the body perceive. In the case of a low-frame rate, the frames are perceived more as images than as movement, resulting in confusion and nausea (Chang, Kim, & Yoo, 2020). These symptoms can significantly impact the user experience, especially for individuals with dual diagnoses. Therefore, it is essential to address these technical challenges to ensure a seamless VR experience.

To ensure a smooth experience for the youth, a major redesign of the classroom was conducted using Blender. The primary focus was on adopting a low-poly design approach, which meant minimizing the complexity of lighting and shadows while still maintaining an engaging visual environment, Figure 3 shows a screenshot of the vertices in Blender for the classroom environment after the low-poly design approach. Balancing UV mapping and corners in Blender proved to be a challenge, which led to developing optimization strategies such as creating light maps and reducing shader details. Finally, by including the HDRP Lighting Box 2 Lit Free from the asset store, I was able to dramatically improve the frame rate while keeping sufficient shading and lighting. Figure 2 illustrates the effect of light penetrating through corners caused by insufficient lighting maps.

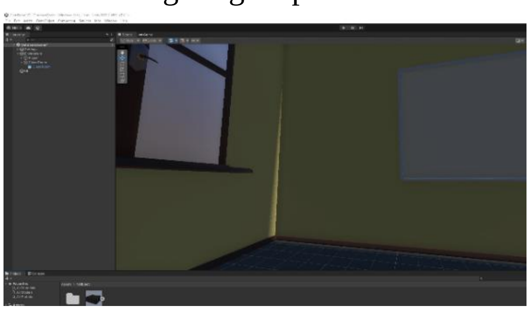


Figure 2 Note. The effect of light penetrating through corners caused by insufficient lighting maps

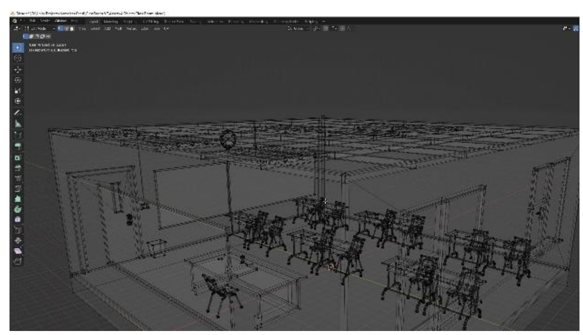


Figure 3 Note. Blender view for the classroom environment after the low-poly design approach

3.6. Emergency button

During an interview with Professor Lise Appendix A (6.Lisa Gjedde interview), an important design decision was made regarding the need for an emergency button for youths with dual diagnoses. It was highlighted that the well-being of the users was a top priority. Therefore, they should be able to exit the experience if they feel distressed. To address this concern, I created a red button mesh in Blender and linked it to a script called "emergencyButton". Figure 4 illustrates the red button in Blender. When the youth's right-hand interacts with the button, the scene darkens shortly and returns to normal after a set amount of time. The purpose of not completely exiting the environment was for the user's convenience, allowing them to resume where they left off if they felt okay.

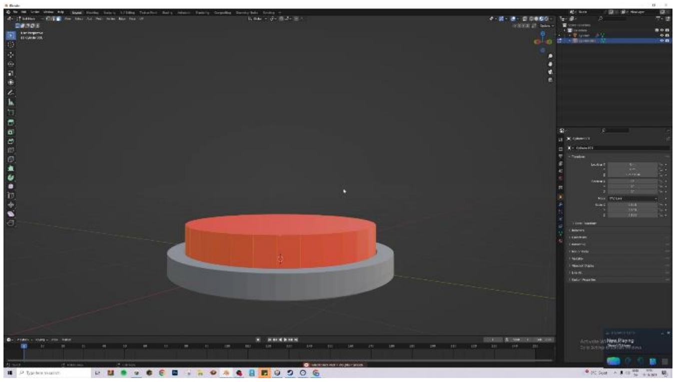


Figure 4Red button mesh in Blender

3.7. The AI teacher

The primary objective of the experience was to use AI to replicate teacher-like communications and assist young people with dual diagnoses in learning English, as well as establish an authentic and immersive interaction with a teacher in a virtual reality context. Three distinct AI components were required to do this. Firstly, a versatile AI language model that can effectively process natural language (LLaMA or chatbot). Secondly a Text-to-Speech (TTS) system that can convert the text into speech, and finally a Speech-to-Text (STT) system that can receive the chatbot's prompts and turn them in verbally. The combination of these components creates an interactive AI teacher capable of understanding spoken commands or questions from youths using STT. It processes this information through the chatbot and responds to the youth in spoken language through TTS. This combination creates a more engaging and interactive experience for the youth to communicate with and learn from the AI teacher effectively. The ultimate goal of this system is to provide an emotionally supportive and unbiased learning environment for English exercises guided by a virtual teacher. Figure 5 illustrates a simplified visual representation of the interactions among each AI system. In order to find a suitable chatbot, I conducted a detailed analysis of Unity's compatibility with different AIs. This phase is crucial because it determines the core of the teaching AI and its level of intelligence. Specifically, I researched the compatibility of Chat GPT, Hugging Face, and Bard AI. However, these various pieces of software made the project face several challenges such as high costs, incompatibility, and lack of functionality. To overcome these challenges, the focus shifted towards localized chatbots compatible with Unity, culminating in the discovery of different GitHub repositories from Gpt4all.unity-master (Macoron, github, 2023)' and the 'ggml-alpaca-7b-q4' model (ga7b) (github, 2023), ensuring a complete cost-free and localized integration into Unity, the main issue with ga7b is that it had a slow response time. For the STT, I incorporated whisper with the ggml-tiny model, enabling communication without text prompts. Yet, the final piece of the puzzle was missing – a TTS system. It had to meet specific criteria: being fast, human-sounding, local, operational during play mode, and free. Eventually, 'Mimic 3' emerged as the ideal choice, despite its limitation of running only on Linux.

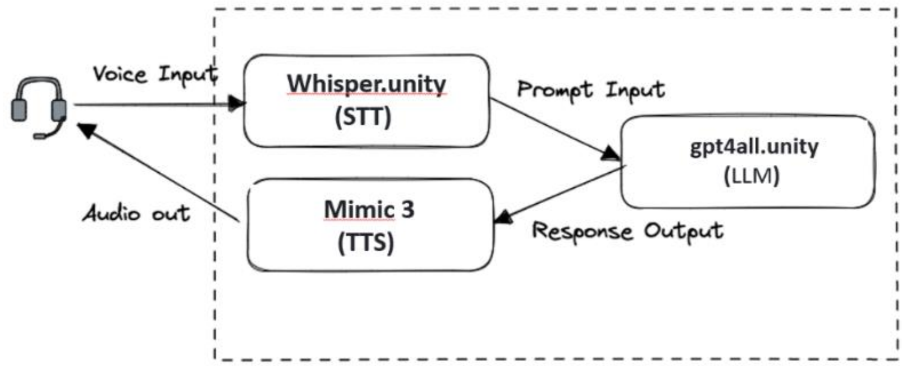


Figure 5Note. Simple overview of the interactions among each AI system

3.7.1. Mimic 3 setup

Despite its limitation of being operational solely on the Linux platform, I remained determined to achieve my goal. To accomplish this task, I installed Windows Subsystem (WSL), WSL stands for Windows Subsystem for Linux. It is a Windows compatibility feature that allows Linux to run within Windows. Eventually, I installed a program called Ubuntu, which acted as a command prompt within WSL. However, upon installation, I encountered the 'WslRegisterDistribution failed 0x80370102' error, which I resolved by Enabling Virtualization in BIOS for AMD CPU. Although this error recurred occasionally due to the BIOS resetting itself upon power disconnection, I managed to resolve it before the first youth attempted the experiment.

Inside the WSL, I installed Mimic 3, pip, pip-23.2.1, and Python. I also installed all available language packs in Mimic 3. Afterward, I created a GameObject called 'Mimic3(Talk)' within the Unity hierarchy. I developed three scripts - Llmanager, MicrophoneDemo, and Chatsample - alongside the ProcessManager script, which controlled the Mimic 3 WSL. The ProcessManager is a critical component that is in charge of creating audio prompts. It works by sending a text prompt to the WSL, which is then processed by Mimic 3 to create a WAV sound file. This allows Unity to communicate with Mimic 3 and generate audio files. The ProcessManager has two primary functions. Firstly, it directs the 'textToSynthesize' inputs that are required to generate the prompt with Mimic 3 within WSL. Secondly, the AudioPlayer script manages changes in the audio folder and plays the Mimic 3 sound file promptly upon receipt.

Example of how mimic 3 works

To provide a detailed insight into the functionality of Mimic3 within the Unity environment, this section explains how the script ProcessManager handles it.

In Figure 5, the illustration provides an overview of how the AIs interact with each other. Notably, the Mimic 3 interaction is the final process. It is crucial to note that the chatbot generates the text output and is prepared to transmit it to Mimic 3. The next step is to examine how Mimic 3 handles the chatbot-generated text.

Let's consider a scenario where the chatbot responds to a user query with the text, *"Yes, what's your question?"* This text is sent to the ProcessManager script, assigned to the 'textToSynthesize' variable. Figure 6 illustrates a code sniper for the CreateMimic3Process() function.

The CreateMimic3Process() function is then called, generating a command string for Mimic 3 and defining the output path. For instance, within this function, the complete command appears as follows:

wsl --shell-type login Mimic3 --voice en_US/m-ailabs_low "Yes, what's your question?" > "C:\Users\nacam\Documents\output.wav"

This command string is constructed to execute Mimic 3 within the Windows Subsystem for Linux (WSL) via the 'System.Diagnostics' namespace. It sets up the process to capture both standard output and standard error, managing relevant events. By triggering Mimic 3's text-to-speech (TTS) functionality from Unity, the script captures the synthesized speech and saves it as a WAV audio file. The specified 'en_US/m-ailabs_low' voice model defines speech characteristics, while the 'C:\Users\nacam\Documents\output.wav' path means the output location for the resulting audio file.

In summary, the script's logic involves receiving text from the chatbot, using Mimic 3 via WSL to convert text to speech, and storing the generated speech as an audio file for further use.

```csharp
public async void CreateMimic3Process()
{
    languageModelSelector.SelectModelByIndex(languageModelSelectorNumber);
    string outputPath = "";

    if (outputPathObject != null)
    {
        outputPath = AssetDatabase.GetAssetPath(outputPathObject);

        if (string.IsNullOrEmpty(outputPath))
        {
            UnityEngine.Debug.LogError("Output folder not selected.");
            return;
        }

        outputPath = outputPath + "/output.wav";
    }
    else
    {
        UnityEngine.Debug.LogError("Output folder not selected.");
        return;
    }

    string command = $"mimic3 --voice {voiceName} \"{textToSynthesize}\" > \"{outputPath}\"";

    Process process = new Process
    {
        StartInfo = new ProcessStartInfo
        {
            FileName = "wsl",
            Arguments = $"--shell-type login {command}",
            UseShellExecute = false,
            RedirectStandardOutput = true,
            RedirectStandardError = true,
            CreateNoWindow = true,
            ErrorDialog = true
        },
        EnableRaisingEvents = true
    };

    process.OutputDataReceived += (sender, args) =>
    {
        if (!string.IsNullOrEmpty(args.Data))
        {
            string ttsOutput = args.Data;

            UnityEngine.Debug.Log("85");

        }
    };

    process.ErrorDataReceived += (sender, args) =>
    {
        // Handle error data here if needed
    };

    process.Exited += async (sender, args) =>
    {

        audioPlayer.GetAudioFileFromMap();
        audioPlayer.SetTheAudioFileToplay();

        await Task.Delay(1);
    };

    process.Start();
    process.BeginOutputReadLine();
    process.BeginErrorReadLine();
    mathGameManager.StopAnimation();
    await Task.Run(() => process.WaitForExit());
}
```

Figure 6 Note. A code sniper for the CreateMimic3Process() function

3.8. The small study case for choosing a voice.

It is necessary to comprehend the selection process and rationale behind the AI's voice. The chosen AI voice significantly influences the type of teacher created. In a scenario where all six English-speaking voices received poor quality scores, it would have led to the design of a robot teacher. Otherwise, if each gender preferred a different voice, I had to create separate teachers based on the participants' gender when trying the experiment. To address this, I designed a simple test case. After successfully integrating a functioning AI system into Unity, I selected six English-speaking voices which were part of Mimic3's downloadable content. Before rating each voice on a scale from 0 to 5, reflecting its human-like quality where 0 is AI and 5 being human, I ensured the collection of age and gender information from the participants.

3.9. Math Exercises

Inspired by Matematikbankens formelsamling (2020, pp. 14-20), three math exercises were created during the construction of the VR environment. Though they served different cognitive functions, the basic goal of all of these exercises was to teach geometry and equations to youths. The XR Interactable script from the XR Interaction Toolkit is used for any exercise items that can be grabbed.

The first exercise was a simple "shape sorting" assignment that focused on triangles. Shape sorting assignments are frequently used in cognitive examinations to evaluate the ability to solve problems, think spatially, and employ fine motor skills. I used Photoshop to extract triangles from the Matematikbankens formelsamling (2020, p. 14), in Photoshop, I removed the shape and standardized the text using the Opendyslexica font and then converted them into a tangible 2D object within Unity, see figure 7 for an illustration. Scripts such as TriangleTransformer and MathGameManager were essential in bringing logic to the function. In addition, a detachable whiteboard was used to hide the original shape beneath, see figure 8 for an illustration. When the youth placed the corresponding triangle onto the whiteboard overlay, the 2D tangible object representing the square disappeared, revealing what lay beneath the whiteboard and what type of triangle it was. Following that, the AI teacher explains what type of triangle it is and its properties. The triangle types that are hidden are the Arbitrary Triangle (Pointed), Equilateral Triangle, Isosceles Triangle, Right Triangle, and Scalene Triangle.

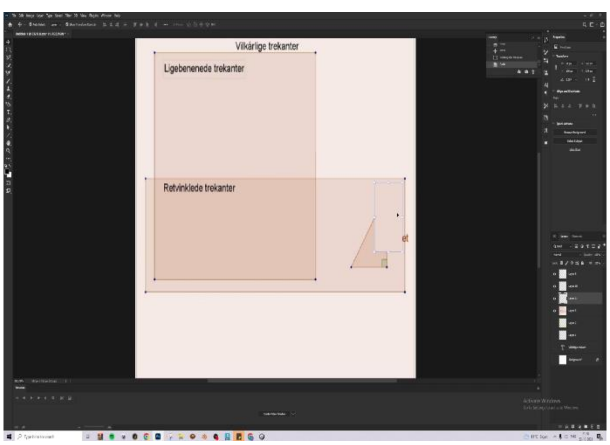


Figure 8The screenshots display the process in Photoshop. Extracting triangles from Matematikbankens formelsamling (2020, p. 14). This involved removing the shape

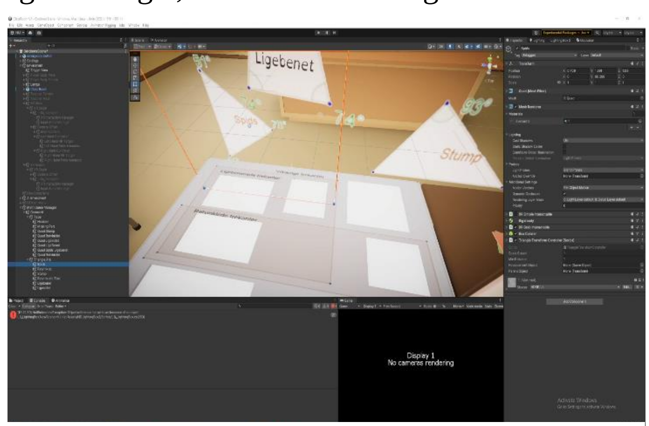


Figure 7 Note: The whiteboard covers the original shape under. The picture shows the whiteboard with removable white square on the table.

In the second exercise, the youths were given the task of "square shaping," requiring manipulating corners to create exact square types. To guide their understanding, a whiteboard was shown to aid in their learning. By using the SquareShapeCreator script and a line renderer connected to four spheres, an interactive system was created, see Figure 10 for visual understanding. The spheres and logic were designed to be interactive, giving youths the ability to manipulate them physically by grabbing and moving the spheres. When the spheres were aligned precisely with each other on the corresponding angles and positions as displayed on the whiteboard, a color change signaled the completion of the task. Throughout this process, the AI teacher explained the properties and distinctions of the different square types - Rectangle, Rhombus, Square, and Trapezoid.

The final math exercise is a math puzzle game which contributes to equation-solving, problem-solving, and number comprehension. This exercise focused on powers, percentages, addition, multiplication, and division. Using Blender for mesh design of cones, and integrating symbols created in Photoshop, the script controlling the logic is MathPuzzle. I added more cones with numbers to allow the difficulty level to be dynamically adjusted in the MathPuzzle script. Essentially, the youth had to grab a triangle cone with a number on it and place it in the correct position, guided only by the mathematical symbols displayed on the table. For instance, the exercise might start with four numbers, e.g., 7, 4, 20, and 11, positioned around the youth, accompanied by a plus symbol on the table. The task was to place the numbers in a way that aligns with the mathematical equation displayed; for instance, arranging 7 + 4 = 11. See figure 9 for visual understanding.

An important factor in the VR experience was the motivation and information provided by the AI teacher. The information is divided into four components —introduction, task overview, motivation by acknowledging their correct actions, and outro—the teacher provided clear and relevant explanations about the shapes involved or what task the AI teacher had to say. The AI teachers' instructions were made outside Unity using the WSL environment and later imported and triggered within Unity through the MathGameManager. For detailed dialogue examples, see Appendix A 2. Sentences of AI for the AI teacher's instructions and explanations.

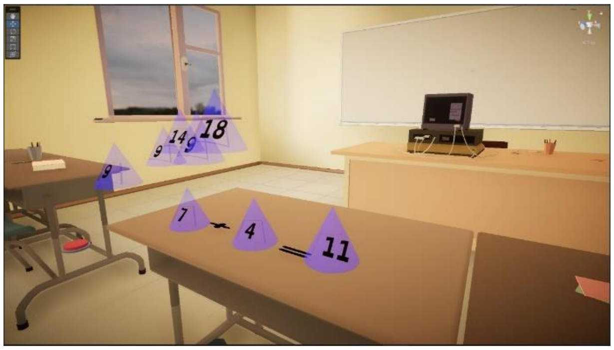


Figure 9 Note. Cones with numbers arranged to solve equations like 7 + 4 = 11.

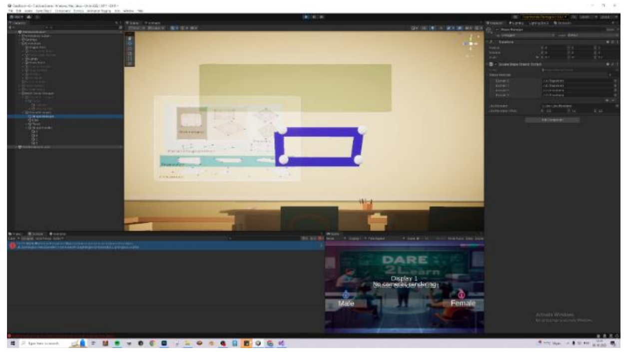


Figure 10 Note. The image shows a line renderer connected with four spheres and a whiteboard shown from front view. The spheres can be moved, and the whiteboard assists in the mental task.

3.10. Ethic

Several significant decisions were made in order to maintain ethical standards. The principal played an important part in the study's ethical requirements by signing a consent form (Appendix A 3.Consent form). Furthermore, both the principals and teachers received a pamphlet Appendix A 4.Pamphlet that conveyed their understanding and approval of the study's objectives. Furthermore, standardized examinations linked with 9th-grade curriculum levels were administered before and after the VR experience; the test is closely related to the VR experience, this method not only offered a consistent metric for evaluating the influence of learning, but it also provided an ethical foundation for measuring the study's findings. To maintain an ethical boundary, the researcher did not administer tests before and after the VR experiment. This approach ensured objectivity, complied with ethical norms, and reduced the possibility of bias in the study. While managing the technical aspects of the VR setup, the researcher prioritized the comfort of the youths. As the test is closely related to 9th grade curriculum levels, it ensured that the youths' time was not wasted and that they continued to follow the 9th grade curriculum. In order to ensure the youths' mental well-being, those who lacked the required energy or mental ability, or had other psychological sections, or those who had psychological challenges on certain days, were excluded from the experiment. Additionally, to assure youths safety, the VR environment included a red emergency button that may be used to exit the experiment if the youths were uncomfortable or distressed. It is worth mentioning that ethical approval is not mandatory for students involved in educational studies at Aalborg University (AAU). This policy at AAU is different from other universities, where other universities may require ethical approval.

3.11. Interview Methodology

Interviews are the foundation of the data collecting method, guided by the updated information, and researching into a sensitive and ethical area, meeting the critical need for up-to-date information about youths with dual diagnoses. The interviews contribute to a better understanding of their needs. Essentially, these interviews were more than conversations; they were crucial in determining the specific demands of the population. The interview with John Appendix A (5.John's Teacher interview), a teacher at Fonden Fraser, is an excellent example. His close work with youths with dual diagnoses, as well as his deep understanding of them and their environment, enables him to understand the unique challenges that these youths experience in education. John has vital insights into the educational challenges that these kids face, as he is deeply familiar with their unique circumstances. Furthermore, this interview essentially aligns with Problem-Based Learning (PBL) principles, allowing cooperation on authentic real-life challenges in a nutshell problem-based learning.

Additionally, the interview with Lisa Gjedde Appendix A (6.Lisa Gjedde interview), a lecturer and expert in education and working with youths, provided crucial insights into the core aspects of designing and conducting experiments in this context.

3.11.1. Types of Interviews

The two interviews were physical interviews, and the conversation was recorded and subsequently transcribed. The collected data from the interviews formed the foundation of the thesis and experiments using the interviews' claims and words to design and build around the youth.

3.11.2. The John Interview

The interview with John was shaped by an unstructured approach allowing for an organic conversation. The interview, conducted while on holiday in Kolding, presented an unexpected opportunity that aligned well with the research focus on youths with dual diagnoses. John's involvement as a teacher working directly with youths with dual diagnoses was crucial to representing the primary target group for the study.

3.11.3. The Lisa Gjedde Interview

The interview with Lisa Gjedde was conducted as a semi-structured approach where specific questions are outlined in Appendix A 7.Lisa Gjedde interview questions. This interview engaged to gather essential insights regarding successful teaching methodologies and their potential integration into a VR-based education environment. Lisa Gjedde's expertise and experience with education and youth psychology provided essential insights relevant to the research. By providing knowledge in education and youth environments, the interview supplemented the possibility of cooperating with Fonden Fraser.

3.11.4. Validity and Reliability

The transcripts of the interviews were not tweaked which ensured an accurate representation of the interviews. This approach was essential in establishing credibility and trustworthiness in the findings. Ultimately, the chosen interview methodology was fundamental in addressing the research objectives, especially in exploring educational strategies for youths with dual diagnoses and contributed considerably to the study's outcomes.

3.12. Research settings

The research setting and participants are critical in understanding the study's aspects. This section dives into the fundamental components that shape the research setting and its setting.
The experiment took place at Fraser School, a residential facility providing treatment and education for youths with dual diagnoses. The school received a prepared pamphlet, Appendix A 4.Pamphlet. The pamphlet informs the principal and teachers about the upcoming experiment.
The experiment was conducted with youths aged 14-21, who had not yet completed the 9th grade and were residents at Fraser. Furthermore, they were undergoing treatment for a diverse range of substance abuse like marijuana, opioids, and amphetamines.
The experimental period spanned a week, beginning on Monday and ending on Friday in November. This time range was selected because of the irregularity of attendance among youths with dual diagnoses in their everyday lives. During this time, youths were assigned one session per day, this distribution was designed for two primary purposes: firstly, the VR experience replaced the math class for that day, and furthermore to ensure the psychological treatments were abided by, and the other academic obligations like English, German, and Danish into their schedules.
The data sample was at first 21 students who participated in the VR experiment. However, the actual engagement was reduced to 7 individuals who actually experienced the VR environment. Due to the inherent unpredictability associated with dual diagnoses and therapeutic obligations, the level of engagement fluctuated. In the end, only four individuals managed to complete all the required steps of the experiment.

3.13. The experiment

Throughout the testing phase, the youths will follow the same structure every day for a week to preserve consistency and simplicity. The testing phase will mainly involve the use of VR Valve index headset and 2 controllers. These tools will connect the youth with learning experiences within the immersive classroom that are designed using software such as Unity, Blender, Fuse, Max 3D, and Photoshop.

For interaction, arm and finger gesture controls are included. There are educational segments in the experience that focus on English language improvement and math problem-solving. The youths were required to take a pre-test on the day before the experiment started, which was managed by their teacher, John. They were then guided to a different room where the computer equipment required for the experiment was set up. The experiment began with the youth being carefully guided in putting on the VR headsets to ensure their comfort before engaging in the experiment. After being equipped with the Valve index and controllers, the students began the experiment by getting an intro from the AI teacher regarding the environment and providing background information for the tasks that followed. The youths were given three math tasks to complete, the first math task was a math triangle puzzle game aimed at improving spatial thinking and geometric knowledge. Following that, youth engaged in a square-shaping game that focused on improving visual-spatial abilities and geometric knowledge. Finally, a puzzle game involving equations encourages problem-solving skills and number understanding.

For interacting with the AI teacher, a green box appears above the youth head indicating their ability to interact, ask questions, or communicate with the AI teacher as required. After the tasks were finished, the AI instructor delivered a closing speech. Following this, the youths were guided in removing the VR headsets and controllers, and the experience concluded for the day. On Friday, the final day of the experiment, the students engaged in the VR experience for the last time and the youth received a post-test and a questionnaire from their teacher, John.

3.14. Statistical Test Selections

To understand the statistical test selection and evaluate the impact of VR and AI on youths' academic achievement, specific statistical tests were chosen to align with the nature of the collected data and the study's objectives. The following programs and methods were used for analyzing the data:

JASP is an open-source statistical analysis program supported by the University of Amsterdam. Bayesian T-tests are employed to assess whether there exists a significant difference in the means of the two groups and are different from the classical T-tests as Bayesian allows for interpretation. The other method is Spearman's rank correlation coefficient, which is ideal for non-parametric data and lower sample sizes; it examines how effectively the relationship between two variables can be stated when the value of one variable grows, so does the value of the other variable. Lastly, the Wilcoxon signed-rank test, a method with minimal assumptions, is used to compare pairs of data especially if the population is small. Each of these methods and programs were purposely picked considering their match with the study's goals and the type of data acquired.

For clarification on why the Wilcoxon signed-rank test and The Spearman's were used, both of them were chosen based on their effectiveness for comparing scores and measures before and after the VR experience, as well as across other different subjects such as math and English scores.

The purpose of comparing the scores and measures before and after the VR exercises is to determine whether the youths learned anything from the VR experience. Additionally, the rationale for evaluating separate subject areas in math and English scores are as following:

The AI teacher's role is linked to the learning outcomes for English scores. The reason for this is due to the fact that the AI teacher explains, informs, and enables interaction with the youths in English which serves to train the language's vocabulary and grammar. Furthermore, the link between math scores and VR exercises is assigned to the learning results for math as the youths are tasked to engage with numbers, geometry, and problem-solving tasks within the VR environment. Additionally, the reason for checking the questionnaire responses and task performance with each other is that it may indicate an increase in youths' motivation.

Furthermore, the Wilcoxon signed-rank test and Bayesian T-tests were chosen as the population size consisted of only four individuals. The purpose for comparing questionnaire responses and task performance is that it may suggest improvements in the motivation of youths. In a nutshell, the hypotheses are as follows:

Total Score Analysis

- Null Hypothesis ($H1_0$): No statistically significant difference exists in overall total scores before and after the VR exercise.

- Alternative Hypothesis ($H1_1$): A significant difference is observed in the overall total scores before and after the VR exercise.

Questionnaire Analysis

- Null Hypothesis ($H2_0$): There is no statistically significant correlation between questionnaire responses and task performance.

- Alternative Hypothesis ($H2_1$): A significant correlation exists between questionnaire responses and task performance.

Math Scores

- Null Hypothesis ($H3_0$): There is no statistically significant difference in math scores before and after the VR exercise.

- Alternative Hypothesis ($H3_1$): There is a statistically significant difference in math scores before and after VR exercise.

English Scores

- Null Hypothesis ($H4_0$): There is no statistically significant difference in English scores before and after the VR exercise.

- Alternative Hypothesis ($H4_1$): There is a statistically significant difference in English scores before and after the VR exercise.

Chapter 4. Results of the data

4.1. Introduction

This chapter will explain the gathered data. It also explains the structure and objectives of the test and the questionnaire. Finally, it will present the data for the paired Samples T-Test, Assumption Checks, Descriptives, and the correlation.

4.2. Description of Test Questions

In Chapter 3.10 the hypotheses are described. Nonetheless, there is not sufficient description about the reasoning behind the test question design. Therefore, this section will provide an overview of their design, which may assist the logic and insight behind the results. However, the hypothesis is divided into these sections:

Total Score Analysis with $H1_0$ *and* $H1_1$

Questionnaire Analysis $H2_0$ *and* $H2_1$

Math Scores $H3_0$ *and* $H3_1$*,*

and finally English $H4_0$ *and* $H4_1$*.*

Each hypothesis correlates with different aspects of the test and experiment, as explained in Chapter 3. Please refer to Appendix A 8.Test for an illustration of the test. The Math and English tests administered before and after the VR experience are designed to assess youths' knowledge and understanding of the VR content for each subject area. The questions numbered 1 to 8 and from 18 to 31 in the test are designed in a multiple-choice format, offering options a, b, c, and d, where only one of these options is the correct answer. Meanwhile, questions numbered 10 to 17 require the student to write numbers in the correct positions rather than choosing from multiple options. The following presents a detailed breakdown of each question's test and how it corresponds to specific parts of the VR exercise.

The Math Part of The Test

Tests Questions 1 to 4:

Test 1 to 4 questions are similar to the 'shape-sorting' assignment within the VR exercise. They cover the different sorts of triangles that match with the first task described in chapter 3.5.

Tests Questions 5 to 8:

The next section of the test is tests 5 to 8, this section of the test is identical to parts 1 and 4. The difference is that this segment is about recognizing squares, which corresponds to the second VR exercise "square shape," in which the youth has to build squares, as mentioned in chapter 3

Tests Questions 10 to 17:

The test ranging from 10 to 17 is the final component of the math test before changing attention to the English test. This part is similar to the VR math puzzle game described in Chapter 3.5. To elaborate on how similar it is, see figure 10 and figure 11. These figures show how identical the exercise and the test are.

1. Du har følgende tal: 4, 3, 8, 7, 6

Udfyld de manglende pladser for at fuldføre ligningen:

__ + __ = __

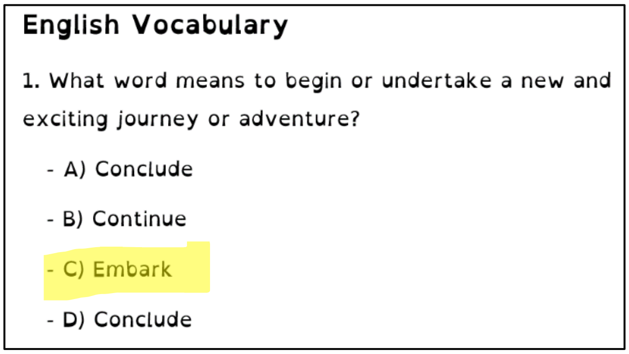
Figure 11 A snipper from the test

The English Part of The Test

The English test is divided into two groups, the understanding of English vocabulary and sentence structure.

Test Questions 18 to 27:

The questions 18 to 27 features a multiple choice approach and focuses on the definitions and synonyms of specific words and sentence structure. These specific words are exactly what the AI teachers say in the VR environment. Figure 12 illustrates these words, with Figure 13 highlighting the correct answers.

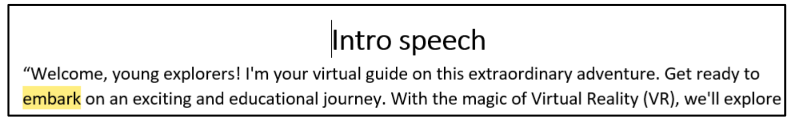


English Vocabulary

1. What word means to begin or undertake a new and exciting journey or adventure?

- A) Conclude
- B) Continue
- C) Embark
- D) Conclude

Figure 12 A snipper from the test for English vocabulary. From Appendix 8.Test



Intro speech

"Welcome, young explorers! I'm your virtual guide on this extraordinary adventure. Get ready to embark on an exciting and educational journey. With the magic of Virtual Reality (VR), we'll explore

Figure 13 A snipper from the intro speech the AI gives from the Appendix 2.Sentences of AI

Test Questions 27 to 31:

The last part of the test, which consists of questions 27 to 31, continues to examine English vocabulary, synonyms, definitions, word meanings, sentence structure, identification of grammatically acceptable phrases, verb usage, sentence creation, and finding the proper sentence form. These specific sentences are exactly what the AI teachers say in the VR environment. Appendix A 2.Sentences illustrates these sentences.

The Questionnaire

As mentioned in Chapter 3.10 the questionnaire test is designed to evaluate the youth's experience in the VR learning environment across 24 questions. Sections 2 to 20 use a scale from 1 to 5, allowing youths to rate their experience while questions 21 to 24 let them write text and express their experiences and perceptions quantitatively. Choosing a score of 5 on every question across all parts of the questionnaire would result in an overall score of 100. The first section is managed by the teacher, John. John provides a random ID number to the paper so it is easy for the researcher to know which Pre and Post scores to measure.

Furthermore, Section 2 aims to understand the general user experience and VR quality. Section 3 examines the effectiveness of the AI teacher, and how well the AI teacher provides assistance, and how natural it is to interact with the AI teacher, as well as the accuracy of the information provided by the AI teacher's information. Additionally, section 3 looks deeper into the AI's impact on the learning process. Section 4 focuses on the physical interaction and the manipulation of tangible objects within the VR exercise. Furthermore, Section 5 examines the youth's cognitive learning, emphasizing the understanding of mathematical and English concepts in the VR environment. Section 6 examines the user-friendliness of the system, exploring the aspects like ease of use and system reliability. Furthermore, Section 7 evaluates educational effectiveness, satisfaction, and motivation. Section 8 returns the scope to the AI teacher, this section examines the content and the impact of the storytelling elements within the VR environment. Section 9 aims to understand the learning progress and assessment of how effectively the VR environment aids in learning and knowledge retention. Finally, the last section allows the youth to express personal emotional and cognitive reactions. Overall, this questionnaire seeks to collect comprehensive feedback about the youth's engagement, learning experience, system usability, and directions for improvements to the VR learning environment.

4.1. Data Presentation

This section will inspect the collected data. Furthermore, descriptions of the collected data will be provided to assist readers in understanding the significance of the findings. Note that all the graphs in this thesis were created using the JASP program, except Figure 14.

Figure 14 is a table of the test and questionnaire outcomes. The first column presents the unique student identification (ID) provided by the teacher (John). The next column displays the pre-test score (pre-score). In addition to that, the columns that follow display the post-test scores (post-score), which indicate the students' performance after engaging with VR for 5 days.

The next columns show the pre-math test score (Pre math score), which is the score from the pre-test without the pre-English test score (Pre English score), which is the complete score minus the English section. The following columns are the pre-test English score (pre English score), which shows the test before the pre-math score showing the test after the VR experience score without the pre-math score, and finally, the question score (Questionnaire Score), which adds the total point or number they provided on the questionnaire.

Student ID	Pre Score	Post Score	Pre Math Score	Post Math Score	Pre English Score	Post English Score	Questionaire Score
1	5	18	1	10	4	8	81
2	10	20	4	10	6	10	70
4	14	17	6	7	8	10	82
7	14	24	11	12	3	12	82

Figure 14 Note-The test and questionnaire outcomes

4.1.1. Symbols Described

Before analyzing Figure 14, it is useful to understand what each of the symbols represent in the figure.

Figure 15 compares the means of the Pre score with the Post score. It does that by measuring the difference between the two means divided by the standard error of the difference. Furthermore, the first symbol ‘W’ indicates the strength of the relationship between the two variables. Additionally, it makes no assumptions regarding the data's normality. The ‘W’ statistic has a range of 0 to 1, where 0 represents no association and 1 indicates a perfect relationship. The next symbol ‘Z’ is a standardized version of the ‘W’ and ranges from -1 to 1. where it compares the strength between different pairs of variables. The ‘df’ stands for degrees of freedom, as seen in all the t-test graphs the symbol is not calculated as the analysis is based on a non-parametric test in other words the Wilcoxon signed-rank test. The next symbol is the P-value. The P-value is the factor that indicates if the null hypothesis can be rejected. If the p-value is less than 0.05 it indicates that the null hypothesis can be rejected. What this means is that the observed differences seem unlikely to have happened by chance. The Rank-Biserial Correlation is a correlation coefficient that measures the relation of a variable that is a boolean or a continuous variable like height and weight. The final measure is the SE Rank-Biserial Correlation, which stands for the standard error of the rank-biserial. It is used to indicate the standard error of the Rank-Biserial Correlation. Figure 16 shows the assumption checks and the Shapiro-Wilk test. The Shapiro-Wilk test is a statistical test that is used to estimate whether a dataset is normally distributed or not. A normally distributed dataset is a dataset that is bell-shaped and symmetrical, while the opposite is not bell-shaped. But if it is normally distributed the data can be used for parametric statistical tests, such as the paired samples t-test, to compare two groups (Goss-Sampson, 2018, pp. 8-19-38-45).

4.2. Total Score Analysis

T-Test

As every measure and symbol has been defined, we can start analyzing Figure 15. The P value in Figure 15 is 0.049 and the Z is -1.826. This assumption indicates that there is a difference between the mean pre-scores and post-scores. In a nutshell, since the p-value is less than the significance level of 0.05, we can reject the null hypothesis and conclude that there is a statistically significant difference between the mean pre-scores and post-scores. Put otherwise, the graph indicates that there is a significant improvement in the test scores of youths.

Paired Samples T-Test

Measure 1		Measure 2	W	z	df	p	Rank-Biserial Correlation	SE Rank-Biserial Correlation
Pre Score	-	Post score	0.000	−1.826		0.049	−1.000	0.499

Note. For all tests, the alternative hypothesis specifies that Pre Score is less than Post score.
Note. Wilcoxon signed-rank test.

Figure 15 Paired samples T-Test That measure pre Score - Post score

Assumption checks

Similar to Figure 15, the Shapiro-Wilk test findings in Figure 16 show that the variation in pre- and post-scores follows a normal distribution. Hence, the Shapiro-Wilk test's p-value is 0.316 as this is higher than the significance level of 0.05, which explains the normal distribution. If the p-value is more than 0.05, it indicates that there is not enough proof to rule out the null hypothesis, which states that the data are bell-shaped. What this means is that the data may be normally distributed. Nonetheless, it can use parametric statistical tests, such as the paired samples t-test, to compare the Pre score and the Post score.

Assumption Checks

Test of Normality (Shapiro-Wilk)

			W	p
Pre Score	-	Post score	0.875	0.316

Note. Significant results suggest a deviation from normality.

Figure 16 The Test of Normality of Pre score - Post score

Descriptive plot and descriptive Graph

Figure 18 and Figure 17 show the distribution of scores for the Pre score and Post score. The plot in Figure 17 confirms the assumption from Figure 16 that the pre-scores and post-scores are both approximately normally distributed with a Mean of 10.75 for the pre-scores and 19.75 for the post-scores. Additionally, the SD indicates the standard deviation. Furthermore, the plot indicates that the standard deviation was higher for the pre-scores at 4.272 than for the post-scores at 3.096. These differences indicate that the VR experience was effective at increasing youths' learning. The SD differences indicate the VR experience seemed successful in improving the youths' learning. Furthermore, graph Figure 18 indicates that the post-scores are clustered more tightly around the mean than the pre-scores, which further supports what Figure 15, Figure 16, Figure 17, and Figure 18 indicate, that the VR experience was effective in increasing the learning of the students' academic achievement.

Descriptives

Descriptives

	N	Mean	SD	SE	Coefficient of variation
Pre Score	4	10.750	4.272	2.136	0.397
Post score	4	19.750	3.096	1.548	0.157

Figure 17 Descriptives of Pre Score and Post score

Descriptives Plots

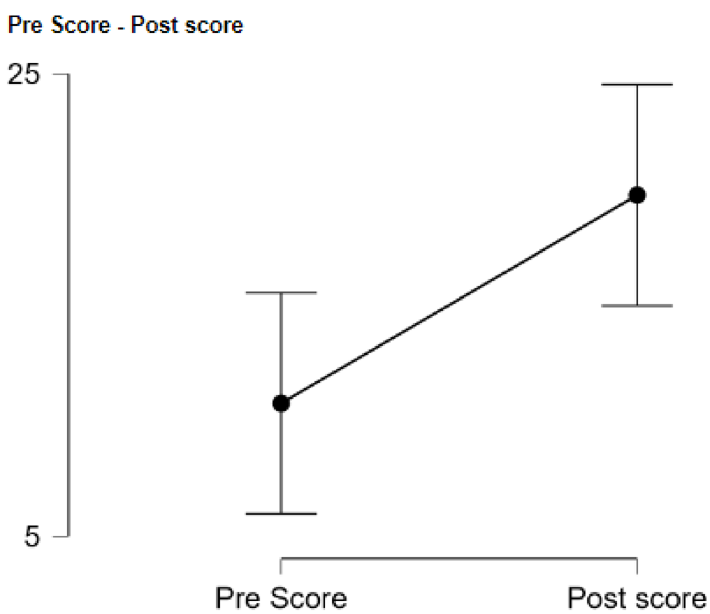


Figure 18 Descriptives plot pf Pre Score and Post score

4.3. Data analysis of Math score and English score

T-Test

Figure 19 is a sample t-test table for pre- and post-test scores for math and English. The P value in Figure 19 for all the tests is 0.049, which is less than the significance level of 0.05. If it is less than 0.05 it indicates that the null hypothesis may be rejected and indicates that there is a significant difference between the pre- and post-test scores for math and English. The other interesting measure is the rank-biserial correlation. This correlation is -1.000 for all tests. When the rank-biserial correlation is negative it means that there exists a perfect negative correlation between the two measures. This negative correlation justifies that the higher the pre-test score, the lower the post-test score. In summary, Figure 19 indicates that there is a statistically significant difference between the math and English pre- and post-test scores, with the post-test scores being lower than the pre-test results.

Paired Samples T-Test

Measure 1		Measure 2	W	z	df	p	Rank-Biserial Correlation	SE Rank-Biserial Correlation
Pre Math Score	-	Post Math Score	0.000	−1.826		0.049	−1.000	0.499
Pre English Score	-	Post English Score	0.000	−1.826		0.049	−1.000	0.499

Note. For all tests, the alternative hypothesis specifies that Measure 1 is less than Measure 2. For example, Pre Math Score is less than Post Math Score.
Note. Wilcoxon signed-rank test.

Figure 19 A sample t-test table for pre- and post-test scores for math and English

Assumption checks

Figure 20 shows the Shapiro-Wilk test for the pre- and post-test scores for math and English. As mentioned earlier, the Shapiro-Wilk examines the data and specifies if the data is normally distributed. The W for all four of the data is less than 0.95, which indicates that the data is not normally distributed. The p-values for all four data sets are also less than 0.05, which means that the null hypothesis can be rejected as the data is normally distributed. In other words, the dataset is not bell-shaped.

Assumption Checks ▼

Test of Normality (Shapiro-Wilk)

			W	p
Pre Math Score	-	Post Math Score	0.857	0.250
Pre English Score	-	Post English Score	0.865	0.279

Note. Significant results suggest a deviation from normality.

Figure 20 Shapiro-Wilk test for the pre- and post-test scores for math and English

Descriptive plot and descriptive Graph

The graph in Figure 22 and the box plot in Figure 21 show the distribution of scores for pre- and post-test scores for math and English. The box plot in Figure 22 confirms the assumption from Figure 20 that the pre-scores and post-scores are both approximately normally distributed with a mean of 5.5 and 9.75, respectively, for math and 5.25 and 10.0 for English. Additionally, the SD indicates the standard deviation. Furthermore, the plot indicates that the standard deviation was higher for the pre-scores at 4.203 and 2.217, respectively, for math and English, than for the post-scores at 2.062 and 1.633, respectively. These differences suggest that the VR experience was effective at increasing the learning of youths in both math and English. The SD differences provide evidence that the VR experience has improved the youths' learning. Furthermore, Figure 21 indicates that the post-scores are clustered more tightly around the mean than the pre-scores, which further supports the findings of Figure 20, Figure 21, Figure 22, and Figure 21 that the VR experience was effective in increasing the learning of youths in both math and English.

Descriptives

Descriptives

	N	Mean	SD	SE	Coefficient of variation
Pre Math Score	4	5.500	4.203	2.102	0.764
Post Math Score	4	9.750	2.062	1.031	0.211
Pre English Score	4	5.250	2.217	1.109	0.422
Post English Score	4	10.000	1.633	0.816	0.163

Figure 21 Descriptives of the pre- and post-test scores for math and English

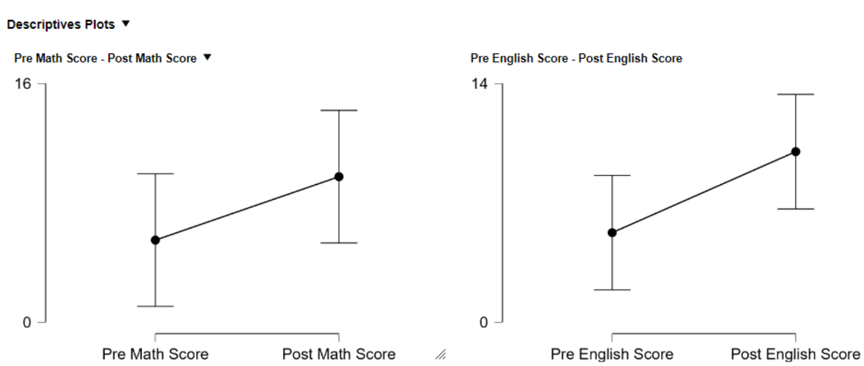


Figure 22 Descriptives plot of the pre- and post-test scores for math and English

Post score vs questionnaire score, spearman's correlation measures

This section will analyze and explain what Figure 23 shows.

The figures show a table of Spearman's correlation where the Post score is measured with the questionnaire score. As mentioned in chapter 3.10, Spearman's correlation measures the strength and direction of association between the Post score and Questionnaire score. In Figure 23, the Spearman's rho is -0.105, while the p-value is 0.553.

What this suggests is that the post score and questionnaire score have a slight negative association. A negative association means that as the post score increases, so does the questionnaire score. However, the correlation is modest, indicating that the association between the two variables is not significant.

Correlation ▼

Spearman's Correlations

			Spearman's rho	p
Post score	-	Questionaire Score	−0.105	0.553

Note. All tests one-tailed, for positive correlation.
* p < .05, ** p < .01, *** p < .001, one-tailed

Figure 23 Spearman's correlation for the Post score - Questionnaire Score

4.4. The small case study

Before doing the experiment and integrating TTS/Mimic 3 into Unity, I needed to choose the AI teacher's voice as I aimed for an AI that minimized the uncanny valley effect. To accomplish this, I conducted a small survey at Aalborg University in Sydhavn to decide the preferred voice among youths. I ensured to collect age and gender information before allowing participants to rate each voice on a scale from 0 to 5, reflecting its human-like quality. To ensure a proper examination, I shuffled the order of voices given to each participant to bypass bias. The survey involved 22 participants, with 12 females and 10 males, averaging 24 years of age.

Figure 24 illustrates the voices presented to the participants during the survey, which articulated a specific sentence, this added a consistent comparison base, the sentence is:

"In the 13th century, an Italian mathematician named Fibonacci introduced a sequence of numbers that would later be named after him. This sequence, known as the Fibonacci sequence, starts with zero and 1. And each subsequent number is the sum of the two preceding ones."

Figures 25 and 26, illustrate that there is a significant difference in voice preference between male and female participants. Necessitating the creation of two distinct teachers and player bodies. Figures 25 and 26, illustrate the preferred voices are: Voice 8 en_US for males and Voice 9 en_US for females.

Figure 26 The name of the English-speaking Mimic 3 Voices

ID	
6	en_UK/apope_low
7	en_US/cmu-arctic_low
8	en_US/hifi-tts_low
9	en_US/ljspeech_low
10	nice en_US/m-ailabs_low
11	better en_US/vctk_low

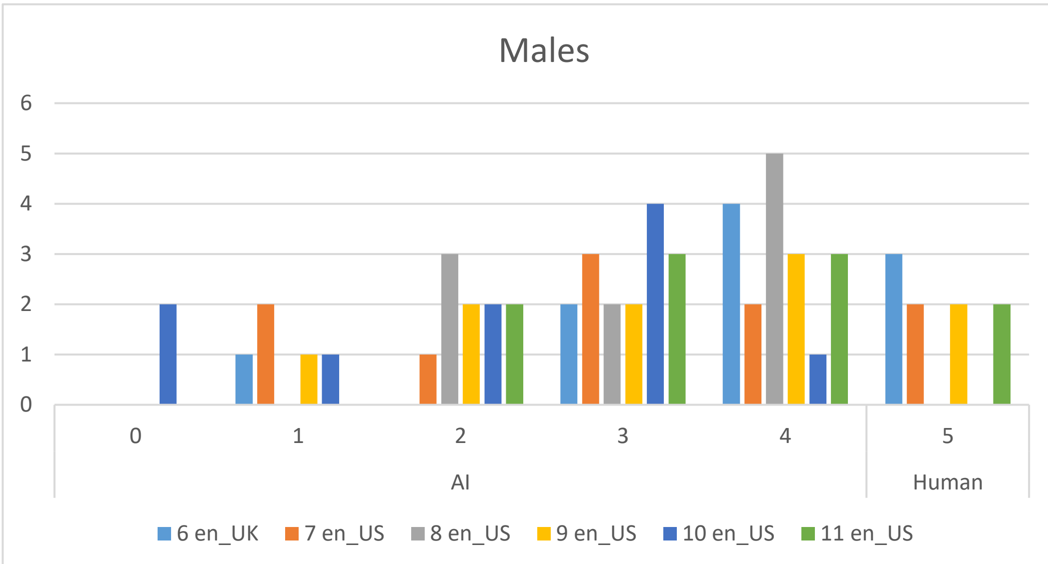


Figure 25 The overall male preference in the small case study

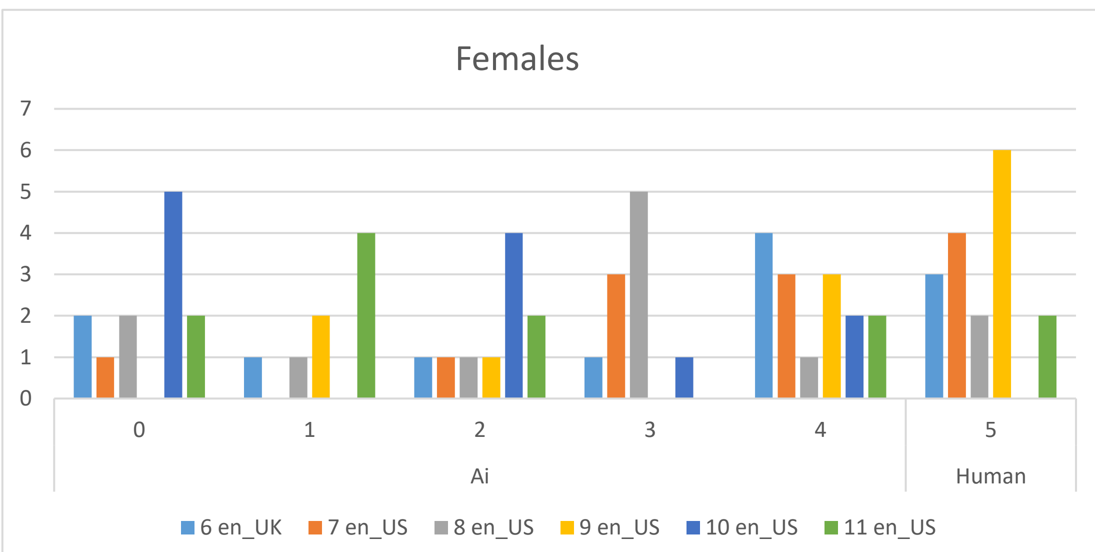


Figure 24 The overall female preference in the small case study

Chapter 5. Discussion

5.1. Key Discoveries Overview

The result shown in Chapter 4 suggests that the VR learning environment was effective in improving the academic achievement of youths with dual diagnoses, indicating the potential of VR and AI to significantly impact education and motivation. Chapter 2 showcased the need for a comprehensive understanding of the complex interplay between technology, emotional support, motivation, cognitive effects, and education to fully understand the effectiveness of VR and AI in assisting youths with dual diagnoses. Chapter 3 illustrates the detailed relationship between TTS, STT, Lama, math exercises, and the learning environment, emphasizing the requirement for specialized design to effectively engage and support youths with dual diagnoses in their pursuit of education.

The alternative hypothesis ($H1_1$) for the overall total score with the pre and post-score was supported by Chapter 4.4. Furthermore, Chapter 4.4 demonstrates a statistically significant difference in total scores (0.049 0.05). This finding highlights the impact of the VR experience on the youth overall academic performance, demonstrating an improvement after 5 days of VR experience.

5.1.1. Math and English Scores Analysis

The hypotheses for the Math ($H3_0$ and $H3_1$) and the English scores ($H4_0$ and $H4_1$) Chapter 4.4 revealed a statistically significant difference in both Math and English scores ($0.049 < 0.05$), supporting the alternative hypotheses ($H3_1$ and $H4_1$). This outcome highlights that the VR learning experience positively impacted youths' performance in both Math and English subjects, leading to improved scores after the 5 days of using the VR experience.

English scores and emotional support from AI

The statistically significant English scores ($H4_1$) may be linked to the immersion in the English language provided by the AI teacher. The AI teacher's part in providing explanations, information, motivation, and interaction with youths in English may have helped to create an immersive learning environment. This immersion may have contributed to improved vocabulary and grammar understanding which may lead to better English scores.

Another possible factor that may have contributed to the positive outcome for the English scores is the objective and unbiased assistance nature of the VR learning environment. Youths could ask any question without feeling any pressure which may have encouraged them to engage more actively in the learning process. Additionally, the motivational sentences provided by the AI teacher, as illustrated in Appendix A 2.Sentences of AI, may have further improved the youth engagement and motivation. This claim is further supported by Meng and Dai (2021).

Finally, the reason for the favorable results for the English scores ($H4_1$) could have been the VR learning environment's open and judgment-free atmosphere, the motivational sentences provided by the AI teacher, the immersive learning environment, and the possible increase in motivation that comes with using a different teaching approach.

5.1.2. Math Scores and Multimedia Learning Strategies

The statistically significant math scores ($H3_1$) align with the multimedia learning hypothesis proposed by Mayer and Fiorella (2022). This hypothesis claims that incorporating sound, image, animation, video, and interaction in learning materials fosters deeper understanding than only using words alone.

The learner-centered approach used in this thesis focuses on the combination of multimedia tools to enhance learning experiences. The learner-centered approach prioritizes the understanding of how humans think and learn, and how multimedia can be adapted to optimize learning. This approach is reflected in the design choices made for the VR experience, which were tailored to and for the needs of the youth and their learning styles. This personalized approach is likely to have contributed to the favorable results for the math scores ($H3_1$).

Some of the design choices that have had an impact on the learning to increase math scores were specifically tailored to address the challenges faced by youths with double diagnosis, dyslexia, and ADHD – frustration, anxiety, boredom, difficulty focusing, and negative self-perception (Gibby-Leversuch, Hartwell, & Wright, 2019). Furthermore, one of the approaches to improving readability and understanding in the VR exercise for youths with dyslexia was the use of a font specifically designed for dyslexia. The font used is the Open Dyslexic (guideline & accessibility, 2023). Another approach that may have helped to reduce boredom and improve focus was the inclusion of hands-on math exercises like "shape sorting," "square shaping," and "MathPuzzle". These exercises allowed youths to apply their math skills to real-world problems, making the subject more engaging and relevant, this active learning approach may have contributed to the statistically significant improvement in math scores ($H3_1$).

Overall, the VR exercise demonstrated its potential as an effective tool for improving math skills in youths with dual diagnoses. The combination of immersive technology, personalized teaching, and hands-on activities can effectively address the challenges faced by youths and promote academic success.

5.1.1. Questionnaire Responses and Task Performance of Self-perception

The statistically significant correlation between questionnaire scores and task performance ($H4_1$) suggests that the VR experience was effective in improving both motivation and math skills.

The implementation of OpenDyslexic fonts for every aspect of the VR environment is likely to have contributed to the high questionnaire scores. These fonts can enhance readability and comprehension (guideline & accessibility, 2023), making the reading of the test, questionnaire, and VR environment feel easier to understand. This could have boosted the students' motivation and engagement leading to improved task performance. Another factor for the significant correlation between questionnaire scores and task performance ($H4_1$) may be the association with learning through VR has increased motivation. When the youths find the educational approach enjoyable, they tend to invest more effort and attention which can lead to better learning outcomes. Additionally, the study duration of five days using the VR experience might have provided a sufficient amount of time for the youths to familiarize themselves with the environment, adapt to the learning tools, and enhance their math skills while 5 days make it unique and new. Yet, the correlation between the post score and questionnaire score was weak and statistically insignificant (rho = -0.105, p = 0.553) Chapter 4.3.3. This weak correlation may suggest that there is a slight negative relationship between youths' performance on the math test and the VR experience. This might be because of the length of time that youths spend using the VR experience, their motivation to learn, or their prior knowledge of math. Overall, the weak correlation between the post-score and questionnaire score is small and may not be meaningful.

5.1.1. Limitations and Recommendations for Future Research

Even though the study produced some encouraging results, there are several issues that need to be resolved with further research:

Firstly, the predictability of the results may have been affected by the sample size, which was quite small.

Secondly, it is possible that the experiment was too brief to fully assess the long-term advantages of AI and VR on academic outcomes.

Thirdly, the research did not investigate the influence of VR on subjects other than math and English.

Future research should address these limitations in order to provide a more complete understanding of AI and VR's possibilities.

Chapter 6. Conclusion

The purpose of the study was to investigate and develop strategies for combining AI and VR to improve the English and math learning and motivation experiences of young people with dual diagnoses. With the research and design concerns in mind, the following final problem statement was proposed:

> *How can the integration of VR and AI into educational environment settings effectively improve the learning and motivation experiences and academic learning of youths with dual diagnosis in English and mathematics?*

The primary objective was to provide an immersive learning environment that included a VR classroom with an AI teacher which included a virtual body and engaging educational exercises. The following are the study's hypotheses:

Total Score Analysis:

- Null Hypothesis ($H1_0$): No statistically significant difference exists in overall total scores before and after the VR exercise.

- Alternative Hypothesis ($H1_1$): A significant difference is observed in the overall total scores before and after the VR exercise.

Questionnaire Analysis:

- Null Hypothesis ($H2_0$): There is no statistically significant correlation between questionnaire responses and task performance.

- Alternative Hypothesis ($H2_1$): A significant correlation exists between questionnaire responses and task performance.

Math Scores:

- Null Hypothesis ($H3_0$): There is no statistically significant difference in math scores before and after the VR exercise.

- Alternative Hypothesis ($H3_1$): There is a statistically significant difference in math scores before and after VR exercise.

English Scores:

- Null Hypothesis ($H4_0$): There is no statistically significant difference in English scores before and after the VR exercise.

- Alternative Hypothesis ($H4_1$): There is a statistically significant difference in English scores

A pre and post test matched with the 9th-grade curriculum, as well as a questionnaire, were used to test the hypothesis. The VR experience was designed with a learner-centered approach in mind, highlighting the integration of multimedia elements to enhance learning experiences. Furthermore, the VR experience was specifically tailored to address the challenges faced by youth with dual diagnoses, such as dyslexia, ADHD, frustration, anxiety, boredom, difficulty focusing, and negative self-perception.

The AI teacher is designed to recognize speech, respond to it, and provide natural language feedback. The AI teacher also supports and motivates the youth as they interact with the environment. The AI teacher is tailored to the learning experience and can address the unique needs of youth with dual diagnosis. The goal is for the AI teacher to provide safe and supportive learning spaces for young students without the distractions and anxieties associated with traditional educational settings.

6.1. Key Findings Overview

The research unveiled significant findings related to math and English learning pre and post score, the impact of the AI teacher, the questionnaire, and motivation. In the Total Score Analysis, the T-Test displayed a noteworthy discovery with a P-value of 0.049 (referenced in Figure 15, Chapter 4.2), indicating a statistical difference between pre and post-scores. This aligns with the main research objective. In simpler terms, the T-test demonstrated significant differences between pre-and post-test scores ($H1_1$). Assumption checks confirmed a normal distribution for both pre and post-scores. Additionally, descriptive plots and box plots indicated improvements in post-test scores compared to pre-test scores.

For hypotheses $H2_0$ and $H2_1$, comparing Post Scores with Questionnaire Scores via Spearman's Correlation revealed a slight negative association. This modest correlation suggests several potential factors such as the duration of VR usage, motivation to learn, or prior math knowledge influencing this relationship. However, the weak correlation between post-scores and questionnaire scores may not hold much significance.

Regarding hypotheses $H3_0$ and $H3_1$, the T-test displayed a p-value of 0.049, indicating statistical significance below the 0.05 threshold. This result strongly supports $H3_1$, emphasizing the VR's positive impact on youths' math performance. After five days of exposure to VR learning, there was a notable improvement in math scores, highlighting the effectiveness of this learning approach.

The impact of the AI teacher and educational content, particularly the AI teacher's involvement in offering English language support, yielded notably positive results. Customized exercises and the interactive AI teacher played a significant role in improving youths' vocabulary, grammar comprehension, and mathematical skills. Hypotheses $H4_0$ and $H4_1$ are directly associated with the AI teacher's contribution to enhancing English scores. The AI teacher's role in explaining concepts, providing information, and facilitating interaction in English substantially contributed to the improvement of language vocabulary and grammar skills among the youths.

Some technical challenges and enhancements in the VR environment design were linked to ensuring a stable frame rate within the VR classroom and integrating the TTS Mimic 3. To overcome these challenges, strategies involved the redesign of the environment and Mimic 3 integration, the adoption of low-poly designs, WSL installation, lighting and shadow optimization, the inclusion of facial expressions, and the implementation of an emergency exit. These measures significantly improved the environment and ensured ethical considerations for youths with dual diagnoses.

The study identified several limitations.

Firstly, the limited sample size might have affected the generalizability of the findings.

Secondly, the short duration of the experiment (5 days) might not fully capture the long-term benefits of AI and VR on academic outcomes. Lastly, the focus on Math and English subjects in the study could limit the broader understanding of AI and VR's impact on various educational aspects.

In conclusion, the immersive VR learning environment demonstrated considerable efficacy in enhancing academic performance among youths with dual diagnoses. The study showcased a statistically significant improvement in overall academic scores, particularly in Math and English subjects, following a 5-day immersive VR experience. Furthermore, this research offers valuable insights into how integrating VR and AI can improve educational practices for youths with dual diagnoses in English and mathematics. Despite promising results, further comprehensive studies and technological advancements are crucial to fully understand the potential of VR and AI in cultivating effective learning environments.

I believe that the integration of VR and AI into educational environments holds the potential to revolutionize the way we teach and support youth with dual diagnosis. By creating personalized and engaging learning experiences, we can help these students reach their full potential and achieve academic success.

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Chapter 8. Appendix

Appendix A added to the Project folder

Code added to the Project folder

Unity project added to the Project folder