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A NOVEL METAVERSE-BASED PERSUASIVE SYSTEM FOR RAISING AWARENESS OF DRUG ADDICTION

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ABSTRACT

Drug addiction is one of the most serious problems facing the societies today, despite the significant efforts made to address drug abuse, the problem is on the rise leading to serious health crisis, an increase in crime rates, family disruption, and a significant rise in homelessness. This paper introduces a novel metaverse-based system as a persuasive technology that simulates the potential future physical effects of drug addiction using personalized avatars in real-world contexts. The goal is to evoke emotional responses to raise awareness and deter drug use. The proposed system consists of two main stages. The first stage involves developing a mobile application to capture a selfie of the individual. This image is then processed to simulate the physical deterioration typically associated with long-term drug use. The second stage involves creating a digital avatar of the person from the previous stage and embedding it into the user's actual environment. The aim of this utilization is to allow the person to see their future after addiction presented before them in the present moment, thereby reinforcing emotional impact and awareness. Ethical approvals were obtained from the relevant research ethics committees. There are many obstacles in recruiting the participants due to the sensitivity of the topic, the reluctance of many to witness manifestations of addiction, and the relatively long time required testing the simulator and collecting pre- and post-test feedback presented major obstacles to obtaining consent from a large number of actual users to participate in the simulator experiment. Despite these obstacles, we were able to convince volunteers to participate in the experiment after completing the required consent form and being informed of the instructions and procedures in accordance with the research ethics protocol. The experiments were conducted after training the participants and preparing them to overcome any effects especially for those using metaverse for the first time. The results were analyzed according to four metrics of System Usability Scale (SUS) and Presence Validation (IPQ) to validate the usability and persuasiveness of the virtual digital environment. Both descriptive statistical methods and data analysis were used to evaluate the results, which demonstrated an increase in participants' awareness of drug risks. The results showed that the immersion feature of the metaverse and users' personal experience of the risk of addiction supports the applicability of our proposed system.

KEYWORDS: Metaverse Simulation, Persuasive Technology, Virtual Reality.

1. INTRODUCTION

Drug addiction is a persistent condition marked by recurrent relapses, defined by the persistent consumption of addictive substances despite negative repercussions for both the individual and society. The dependence on drugs is progressively emerging as a global phenomenon in behavior that is observed in affluent and impoverished nations alike. Hence, drug addiction is a complex and serious problem that can have severe consequences for individuals and society [1]. Drug use disorder is maladaptive pattern characterized by distress, clinically significant impairment including progressive tolerance and withdrawal symptoms [2]. According the World Health Organization there are thirty-six million people diagnosed with drug use disorders in 2019, the most commonly encountered drugs are amphetamines, opioids, cannabis, and cocaine [3, 4]. I the Kingdom of Saudi Arabia, the prevalence of drug use disorders jumped from 329.28, (95% uncertainty interval, 265.82, 406.95) to 433.74 (95% uncertainty interval,359.14, 523.44) in the years 1990 and the year 2019 respectively [5]. In recent times, there has been a surge in severe drug abuse, leading to a multitude of societal issues such as a health crisis, an increase in crime rates, family disruption, and a significant rise in homelessness. Despite the significant efforts made to address drug abuse, the world continues to grapple with this pressing challenge. This situation prompts researchers from various disciplines to engage in interdisciplinary research with the goal of developing innovative solutions to combat the drug abuse problem. Following the same concept, in this paper, a Metaverse application based on persuasive technology has been implemented to provide a novel solution for enhancing awareness of drug addiction.

Persuasive technology (PT) is the use of modern technologies to design an interactive experience with the user to modify his behavior or lifestyle, for example, without deception or coercion [6]. Many studies have found that the use of persuasive techniques is one of the most effective methods for lifestyle modification in various life sectors such as education improvement [7] or providing a new way for governments and health organizations to motivate the public to respond appropriately to pandemics [8]. In the health field, studies have found that the use of persuasive technologies, which are usually directed and designed to suit everyone, may not suit specific individuals, indicating that persuasive technologies must be designed specifically for the individual and adaptable to that person and his/her variables. Studies have also indicated that a person's impact on the experience of persuasive technology may be affected by factors and characteristics specific to him/her (such age, and gender) and contextual factors (such as environment and location) [9]. One of the most important examples of persuasive technologies is smart technologies in social media. In contrast, the metaverse works to create virtual worlds that merge with the real world and enhance the digital content in it. This makes the metaverse to be capable of modifying what people believe to be reality [10], making it the appropriate environment for persuasion without interference or force. Following the advice from [9], we have developed a framework that considers placing a person's avatar in a metaverse environment that simulates their current real-world surroundings, effectively creating a real-time simulation of their environment.

The metaverse is a digitally connected virtual world where users engage in real-time activities such as socializing, working, playing, and interacting via avatars. It integrates technologies like virtual reality (VR), augmented reality (AR), block chain, artificial intelligence (AI), and the internet to deliver immersive experiences. Recently, the metaverse has been utilized as a novel tool in the fight against drug addiction. Yayak in his study[11] highlighted the potential of the metaverse in addiction treatment. Christofi et al. [12] demonstrated through experiments the metaverse's impact on enhancing awareness of the daily realities faced by drug users. The proposed metaverse application visualizes the appearance of a person after a specific duration of drug use. For instance, it shows how a 20-year-old might look after one year of drug use. The generated image is then transformed into a personalized avatar and integrated into the user's real-world environment. Seeing this digitally altered version of themselves depicting the harsh effects of drug use triggers fear and deepens personal awareness of the associated risks.

According to Noar and colleagues [13], Pictorial warnings also led to an increase in skipping a cigarette, intentions to quit smoking, negative emotional responses, awareness of smoking's dangers, and discussions about quitting. In this paper, a similar concept is followed by generating images of individuals after simulated drug use. Awareness of these visual changes may serve as a psychological driver to help individuals break harmful habits.

This paper is structured as follows: Section 2 presents, discusses, and analyzes related works. Section 3 illustrates the proposed methodology.

Section 4 details the implementation, demonstrating the applicability of the proposed metaverse simulation. Section 5 discusses and presents the results. Finally, Section 6 concludes and outlines future work.

2. RELATED WORKS

The study in [14] performed experiments showing that following Virtual Reality (VR) treatment, there was a notable decrease in both the average and standard deviation of patients' heart rates. This substantial reduction serves as strong evidence that patients' reactions to drug stimuli are significantly diminished after VR treatments. The authors in [15] developed an augmented reality (AR) board game intended for incorporation into formal anti-drug curricula. The objective is to render anti-drug educational courses engaging and appealing, rather than tedious. The findings indicate that the AR board game focused on drug prevention is successful in improving learning outcomes effectively. The study in [16] created a system that combines Brain-Computer Interface (BCI) and Virtual Reality (VR) technologies to assist individuals struggling with drug addiction in overcoming their dependencies mentally. The central concept of the developed system, aimed at enhancing the focus of individuals battling drug addiction, is facilitated through real-time management using BCI technology. The primary goal of this system is to enhance drug addicts' self-regulation abilities through repetitive training sessions.

The study in [17] created a virtual reality closed-loop program for sports imaging and rehabilitation to enhance self-regulation training among individuals struggling with substance abuse. The authors in [18] conducted experiments that prove the ability of VR to make greater improvements in the levels of alcohol craving. The study in [19] demonstrated that serious VR games have the potential to improve adolescents' ability to regulate emotions, serving as a preventive measure against drug abuse. The authors in [20] demonstrate the importance of VR simulations for alcohol prevention, and the results suggest that studies should be extended to encompass more domains. The study in [21] created educational games utilizing three-dimensional virtual reality technology to enhance the potential of these games in encouraging motivation to refrain from smoking. The findings suggest integrating these games into teaching materials for smoking prevention education. The authors in [22] illustrate that the VR method consistently produced effects in triggering and decreasing cravings for various substances. The outcomes indicate that virtual reality holds promise as an effective tool for evaluating and addressing cravings in individuals with substance use disorders. The study in [23] conducted a survey investigating the recent implementations of VR in psychotherapy, clinical rehabilitation, and in the treatment of substance addiction. The results indicate that the increasing use of VR applications in combating drug use is effective and offers numerous advantages, including low cost and versatility.

The study in [24] performed studies to assess how well users accept an immersive three-dimensional VR system aimed at deterring illegal drug use. They also pinpoint elements linked to the sustained interest in three-dimensional VR education among high school students. The findings suggest incorporating the program into the curriculum for teaching about preventing illegal drug use. The authors in [25] carried out experiments with 60 participants who are undergoing detoxification for substance abuse disorder. Physiological stress levels were evaluated by monitoring respiratory rate, skin conductance, and heart rate recordings during the VR session. The results indicate that VR relaxation might serve as a potentially beneficial intervention for alleviating stress in patients undergoing detoxification. The study in [26] conducted a study to explore individuals' viewpoints on using VR for overdose prevention. This research showcased strong acceptance and reduced heart rate responses to VR among individuals with a history of drug use. The study in [27] conducted a study that demonstrated VR exposure as a promising approach to dissuade cocaine cravings. The study in [28] conducted a review of related work that demonstrates the utility of using VR applications in addiction treatment.

The authors in [29] employed a novel behavioral intervention program, Cognitive Behavioral Immersion (CBI), delivered through metaverse VR. The program aims to prevent relapses among individuals recovering from substance use disorders using educational, social, community, and technological approaches. The study in [30] discusses using the metaverse within a medical-psychological paradigm called 'Cue Exposure Stimulation' to help reduce an addict's desire to use or revert to problematic behaviors, such as drug addiction. This psychological model has proven effective in monitoring and detecting potential addictions. This study focuses on combining what is called memory retrieval-extinction with virtual reality to reduce cravings for drugs (methamphetamine). The study in

[31] combines memory retrieval-extinction with virtual reality to reduce cravings for drugs (methamphetamine). Similarly, the authors in [32] incorporated virtual reality's effectiveness into a counterconditioning procedure called the virtual reality counterconditioning procedure. This model has been shown to reduce cravings for drugs such as methamphetamine. The study in [33] demonstrates and reinforces the effectiveness of virtual reality in not only reducing addiction cravings but also in treating addiction. Table 1 shows the significance of each discussed related work in this section.

Table 1: Significance of the Related Works.

No.	Ref. No	Significance
1	[14]	Provide evidence that patients' reactions to drug stimuli are significantly diminished following VR treatments. This evidence proves that VR could be utilized in drug treatment
2	[15]	Incorporating an AR board game into a formal anti-drug curriculum enhances learning outcomes
3	[16]	Improve the self-regulation skills of individuals struggling with substance abuse through training sessions that utilize VR applications.
4	[17]	Enhance self-regulation training among individuals struggling with substance abuse
5	[18]	Utilize VR applications to reduce levels of alcohol craving
6	[19]	Demonstrate that VR games serve as a preventive measure against drug abuse
7	[20]	Show the significance of VR simulations in alcohol prevention
8	[21]	Utilize VR games to encourage motivation to abstain from smoking
9	[22]	Utilize VR applications in decreasing cravings for various substances
10	[23]	Demonstrate the significance of VR applications in combating drug use by reviewing related research
11	[24]	Enhance VR system that designed deterring illegal drug use
12	[25]	Demonstrate the potential of VR applications for intervention for alleviating stress in patients undergoing detoxification
13	[26]	Show the acceptance of VR applications among people with a history of drug use
14	[27]	Demonstrated VR exposure as a promising approach to dissuade cocaine cravings.
15	[28]	Prove the effectiveness of VR in addiction treatment
16	[29]	Demonstrating the potential of VR to influence addict behavior and prevent relapse.
17	[30]	Using the metaverse in a medical-psychological model called 'Cue Exposure Stimulation' to influence a person's psychological response to addiction or relapse.
18	[31]	Combining Memory retrieval-extinction with virtual reality to reduce cravings for methamphetamine.
19	[32]	Employing VR in a counterconditioning procedure to reduce cravings for drugs.
20	[33]	A virtual reality-based therapeutic and preventive program to reduce cravings for addiction and treat addiction.

In the previously reviewed literature, numerous studies have demonstrated the potential of virtual reality (VR) in raising awareness and influencing behavioral change, particularly in combating smoking and alcohol addiction. These studies have shown that VR can be effective in supporting detoxification and increasing emotional engagement, especially within immersive educational environments. However, a key limitation of traditional VR applications is their confinement to synthetic, generic environments that do not reflect the user's actual context which has been a gap in previous studies that this study will attempt to fill. Therefore, this paper addresses this limitation by introducing a metaverse-based system that merges personalized avatars with the user's real-world surroundings, thereby creating an emotionally compelling, immersive experience tailored to the individual. This approach enables users to visualize the potential impact of drug addiction on themselves in a familiar environment, enhancing both realism and awareness through personalized learning experiences enabled by digital transformation.

3. METHODOLOGY

Methodology focuses on addressing a key deficiency we found in previous studies and research, which is personalization of a real person. By this, we mean that instead of a person observing the experiences of others, this system emphasizes a person witnessing the effects and dangers they may encounter if tempted into drug addiction. In the proposed system, two essential worlds will be merged: the real world and the virtual world to form mixed reality. The utilization of this proposed system involves a combination of following two steps: generating 3D model, Simulate Drugs Addiction Effects.

In addition to enhancing awareness of drug use, this study aims to evaluate the usability of metaverse technology in creating an immersive virtual environment that visually demonstrates the effects of addiction on the human body. In this proposed system, the user captures a photo of themselves using the mobile application, which is then uploaded to a server designed to process images. The image is converted into a 3D model (avatar) and integrated into the metaverse environment using the Unity engine. The user then wears mixed-reality glasses to immerse themselves in the metaverse experience, where they can see their avatar and body in a parallel digital world. This environment visually depicts the effects of drug use, allowing the user to perceive and sense its dangers firsthand. In the following section, the aforementioned steps are collectively implemented and described as in the Figure 1.

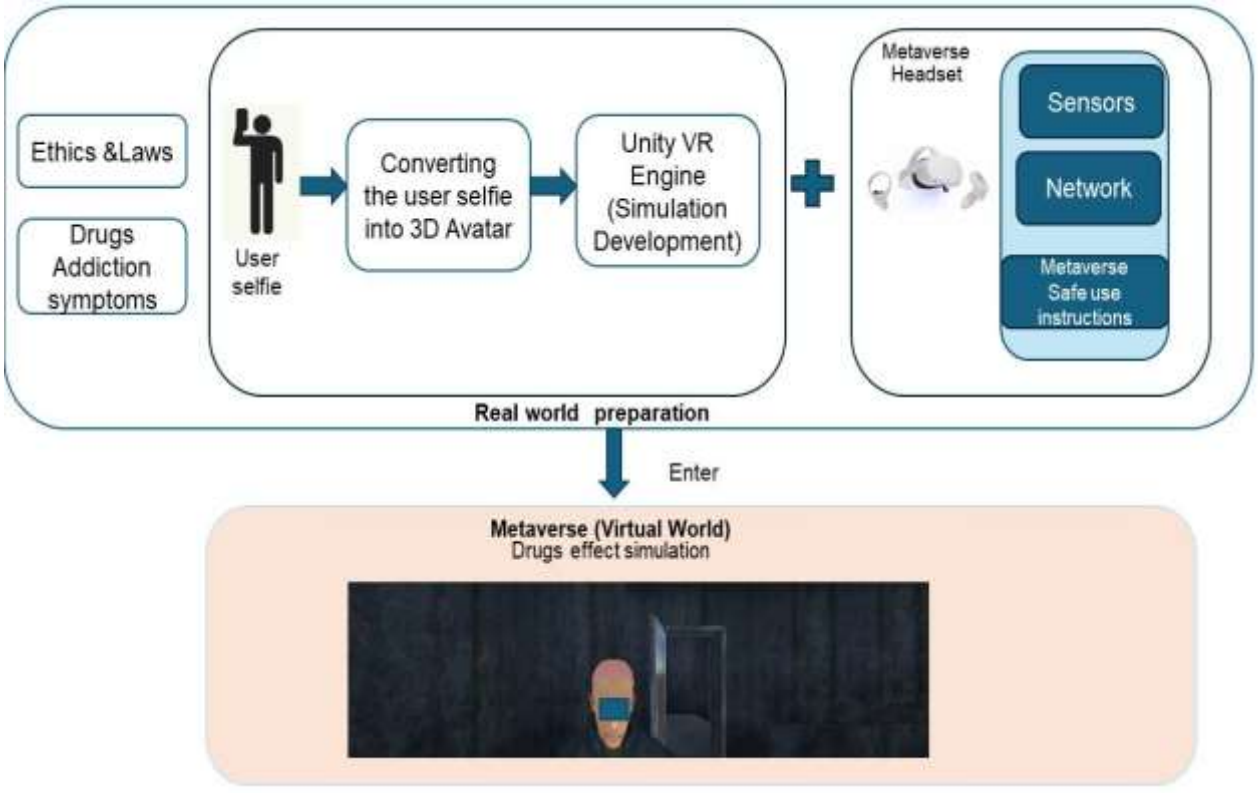

Figure 1: Components of the Proposed Metaverse Simulation.

3.1. Generating the 3D Modelling for Participant

Stage 1: In the first phase, an individual will capture a selfie. As mentioned earlier, before allowing participants to do that and conduct experiments on the simulator, we had to meet the requirements for obtaining ethical approval from research ethics committee to support the research. In addition, informed consent forms and procedures were obtained from all participants prior to using the system or processing their images for the simulation process. This image will then be processed in the Unity engine to convert the person's image into a 3D model using a Unity plugin that creates a 3D avatar from a single character image, preparing it to serve as their avatar in the metaverse environment. Subsequently, these images are placed within the virtual environment component of the system. This virtual world can be experienced using Meta Oculus Quest headsets. Generated avatars can be used to simulate a real person. It is worth noting that this avatar can be programmed to track head movements and facial expressions to adapt to the virtual environment and embody movement within it.

To protect privacy and comply with the ethical principles and guidelines of the Medical Research Ethics Committee—which prohibit the publication of personal data or any information that could identify participants, as agreed upon in the signed consent form—real participant images have not been included in this article. However, to illustrate the process to the readers, we used a simulated avatar as shown in Figure 1 and finally the symptoms on his face after a period of addiction, represented by sunken eyes and pale face.

Stage 2: In this phase, metaverse Oculus Quest 3 glasses are outfitted with sensors to monitor the movements and interactions of an individual in both the real and virtual worlds. One crucial consideration is that the simulation should occur in a spacious room and environment where the individual can move freely in a designated space without encountering obstacles, as they will be immersed in the virtual world and dis-connected from the real world. Before users can engage with the simulation through Oculus glasses, they must undergo preliminary training to instruct them on how to wear and operate the metaverse glasses to transition into the virtual world of the drug addiction simulation. This training aims to enable them to witness their progression through the stages of addiction. The instructions should stress the initial use of the glasses for a limited period to gauge any potential discomfort such as headaches or dizziness. Following the training, individuals can proceed to utilize the simulation, experiencing firsthand the dramatic and rapid deterioration of their appearance over time.

3.2. Simulate Drugs Addiction Effects on Face

This subsection describes the process of simulating the effects of drug addiction on a person's avatar. The avatar is created based on an image that reflects the symptoms of addiction, meaning it represents the person after these symptoms have clearly affected their appearance. The goal of creating this avatar was to integrate it into the virtual simulation environment. Algorithm 1 illustrates the avatar generation process.

Algorithm 1: Illustrates the Steps Involved in Creating the Avatar.

```
graph TD
  A[Start: Upload Selfie] --> B[Pre-processing & Feature Detection]
  B --> C[Facial Landmark Detection]
  C --> D[Feature Extraction: Face Shape, Eye Color, etc.]
  D --> E{Avatar Generation Method?}
  E -- A: Hybrid Approach --> F[Rule-Based Asset Matching]
  F --> G[Present to User for Fine-Tuning]
  E -- B: Deep Learning --> H[Input to Trained GAN/Diffusion Model]
  H --> I[Generate New, Stylized Avatar]
  G --> J[Output: Avatar Image]
  I --> J
  J --> K[Post-processing & Finalization]
  K --> L[End: Avatar Saved/Displayed]
```

3.3. Placing an Avatar in a Person's Environment

In this subsection, we describe the process of placing an avatar into a person's environment. The environment simulates the individual's real-world surroundings, making the avatar's presence more realistic and impactful. This enhances immersive experience and supports the goal of raising awareness. Algorithm 2 outlines the steps for placing the avatar into its appropriate environment.

Algorithm 2: The Steps for Placing an Avatar in its Appropriate Environment.

```
<Purpose > ::= Create Simulation
Type(output) ::= Virtual Reality environment << name (metaverse-device)
<source > ::= read<< input (metaverse-device) & self(picture)
type (source) ::= algorithm 1(avatar << name (input_picture))
Features ::= { gender-preferred-environment, comfortable }
Apply (features, input avatar) ::= metaverse simulation
Check simulation convenience (input_avatar, output_ metaverse -Simulation) < 70% << go 3
Return ::= metaverse-simulation
```

The following section will provide details of the experimental setup, volunteer preparation, and the appropriate environment to verify the effectiveness of the metaverse simulator for awareness.

4. EXPERIMENTAL SETUP

The paper presents a timely and innovative solution to a global problem—drug addiction—by combining metaverse and persuasive technology to achieve an inspiring goal. It helps users to envision a future in which they experience the destructive consequences of drug use on themselves. The use of personalized avatars based on a user's own image is a powerful emotional and psychological approach. This serves as a powerful awareness tool that can be leveraged by relevant authorities, especially because each individual views their own personalized avatar—rather than a generic model—within the simulation. This level of personalization enhances emotional engagement and may function as both a deterrent and a motivating factor to avoid drug use. Figure 2 illustrates the sequential steps involved in the experimental setup to verify the effectiveness of the proposed system and is described below:

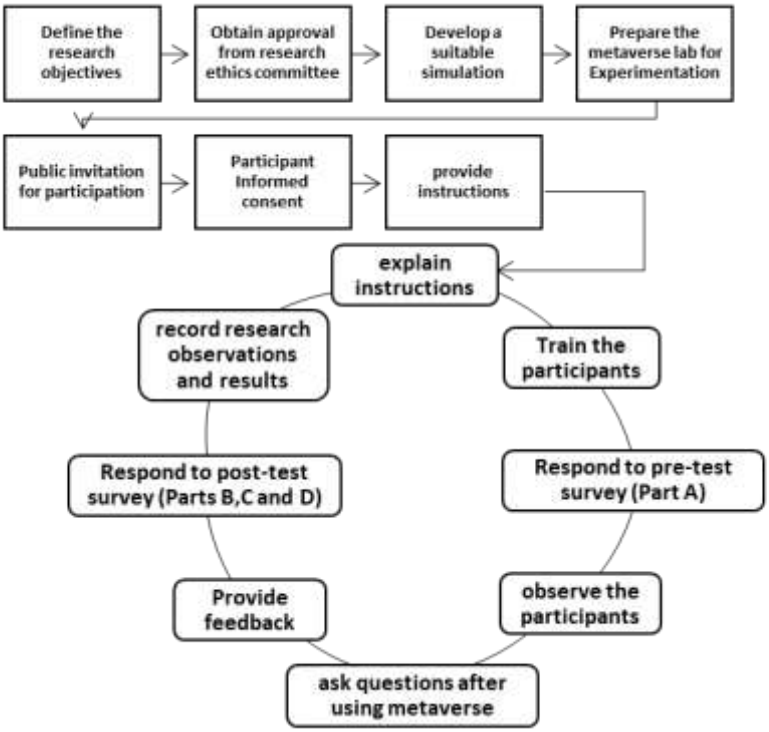

Figure 2: The Experimental Setup.

1. Define the research objective: Identify the central concept and primary goal, which is to enhance awareness of drug addiction. A secondary objective is to highlight the importance and potential of leveraging Metaverse technology in combating drug abuse.
2. Obtain research ethics approval: Since the study will include human participants, approval was obtained from the Local Research Ethics Committee (LREC) at Tabuk University to ensure adherence to ethical standards and participant safety.
3. Develop a suitable simulation: A Metaverse simulation environment was developed using the Unity game engine. This simulation can be deployed to the Meta Oculus Quest 3 headset, as illustrated in Figure 3.
4. Prepare the Metaverse lab for experimentations: The Metaverse lab is equipped with the necessary research facilities and equipment to implement the proposed system. This includes:

- Meta Oculus Quest 2 & 3 headsets: Essential devices that deliver high-quality, immersive experiences.
- High-Performance computer hardware (8 PCs): Each PC is equipped with an Intel i9 processor, 32GB RAM, and a powerful graphics card.
- Metaverse development tools: Used to accurately model user environments and

effectively convey conceptual ideas.

- Laboratory Room: A spacious lab area is designated for safe and interactive experiences, allowing up to two participants to move freely while wearing Metaverse headsets in accordance with safety protocols.

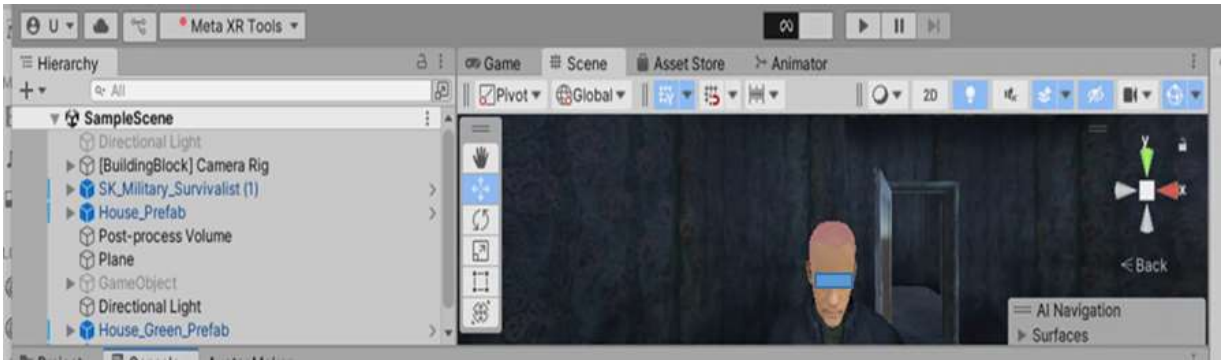

Figure 3: Snapshot of the Generating 3D Avatars and placing it in the Developed Simulation.

5. Public invitation for participation: An open call was announced to allow interested individuals to register and take part in the experiment.
6. Participant informed consent: this process of obtaining voluntary permission from individuals before they participate in a research study. This consent ensures that participants:

- Understand the study – They receive clear and complete information about the purpose, procedures, risks, benefits, and their rights.
- Have the freedom to choose – They agree to participate voluntarily, without pressure or coercion.
- Can withdraw anytime – They have the right to stop participating at any point without consequences.

7. Pre-Experiment Assessment: Before participants interact with the metaverse simulation, participants are asked questions to evaluate their grasp of fundamental concepts and research objectives.
8. Give guidance: Prior to launching the metaverse simulation, we offer guidelines to the participants on safely using the Oculus Quest 3 headset.
9. Participation Monitoring: As participants interact with the metaverse simulation, we examine their interactions and identify any misunderstandings or areas that require further clarification.
10. Conduct post-experiment questioning: After the participants complete the metaverse replication, we provide inquiries to evaluate their grasp of fundamental concepts and research goals.
11. Providing Feedback: By leveraging participants' feedback and reactions, we provide insights to improve their understanding of the material.
12. Reiterate the process: To enhance the experience for participants who have questions and want to repeat the simulation, we may repeat and evaluate the metaverse again.
13. Draw decisions and analyze research findings.

5. RESULTS

This section outlines the experimental procedures and presents the analysis of the results obtained.

5.1. Experiments

The method for gathering data from various audience groups is outlined below. First, a drug addiction simulation based on the Metaverse was developed. Second, pre- and post-simulation surveys were designed to collect audience perspectives on the use of Metaverse technology for drug awareness.

A detailed survey consisting of four sections (A, B, C, and D) was utilized. The training sessions and experiments were conducted in the Metaverse laboratory. Voluntary participation was announced for students interested in taking part in the simulator experiment. Due to the sensitivity of the topic, gathering a large number of participants was challenging. Consequently, 35 volunteers in the audience engaged and provided responses, with no personal data being collected. Section A assesses volunteers' general understanding of the dangers of drug addiction prior to utilizing the Metaverse simulation. Upon completing 10 multiple-choice questions in section A, participants receive training on using the Metaverse simulation. They then interact with the simulation for 10 minutes before responding to six questions in section B. Section B explores volunteers' feelings about the drug

addiction environment and how it influences their perception of themselves within the Metaverse simulation.

Section C (10 questions) employed the System Usability Scale (SUS) [34] to evaluate the simulation's effectiveness in enhancing drug awareness. Part D (13 questions) employs the Igroup Presence Questionnaire (IPQ) [35] to evaluate participants' perceived presence and level of immersion within the virtual environment.

5.2. Analysis

The study adhered to the bioethics committee's guidelines, ensuring that each participant received a briefing and signed a consent form before participation. No personal data was collected, and participants did not receive any compensation. They were also informed that they could withdraw from the study at any time without obligation. None of the 35 participants had prior experience with simulation. Among them, 7% were familiar with Metaverse and had used it more than three times, 28.2% had used it fewer than three times, and 64.7% had never used it before. The following sections present the results from the pre and post-tests of the Metaverse simulation, along with findings from the System Usability Scale (SUS) and the sense of presence assessment.

5.2.1. Analysis of the Effectiveness of Metaverse in Raising Awareness of Drug Addiction

This study employs both descriptive statistics and data analysis techniques to evaluate the results. The analysis involves summarizing the data collected from the Metaverse simulation using measures such as the mean and standard deviation. The goal is to assess participants' perceptions of how effective Metaverse can be in enhancing awareness of the dangers of drug addiction.

In the Part A questionnaire, all participants reported that they had never previously used a Metaverse-based drug addiction simulation. This indicates a consistent baseline of prior experience among all participants.

As shown in Figure 4, after experiencing the simulation, most participants reported a positive impact on their understanding of the dangers of drug addiction (SD = 0.595, N = 35). Furthermore, as illustrated in Figure 5, participants recommended using the simulation for educational purposes (SD = 0.339, N = 35). In Figures 5 and 6: a score of 3 represents "Agree", a score of 2 represents "Somewhat Agree", a score of 1 represents "Do Not Agree". The abbreviation SD refers to standard deviation, a measure of how spread out the responses are around the mean. A lower standard deviation indicates that responses were closely clustered around the mean, while a higher value suggests greater variability in participant responses [36].

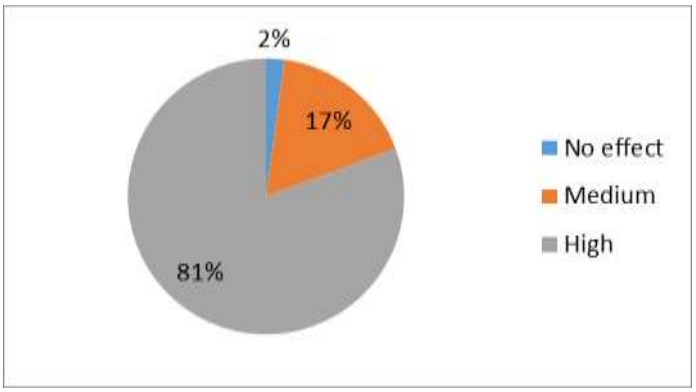

Figure 4: Volunteer's Response to the Effect of Metaverse Technology on your Understanding of Drugs Addiction Dangers.

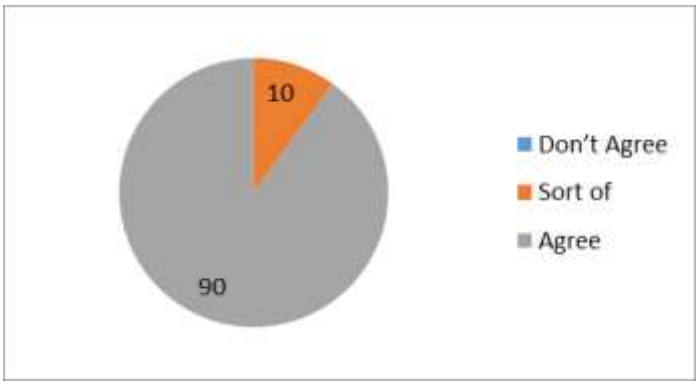

Figure 5: Volunteers' Response to B4 Do You Recommend Including the Metaverse in the Methodology of Drugs Dangers Awareness?

5.2.2. Evaluation of the Effectiveness of the Metaverse Simulation for Drug Addiction Awareness

The second sub-objective of this study is to evaluate the effectiveness of the developed metaverse-based drug addiction simulation as a tool for raising awareness and serving as a resource for community education. Participants' responses before the simulation experience indicate that none of the participants had any prior knowledge of using metaverse to raise awareness of the harms of drug usage. The results also indicated that all participants were impressed by the ability of the metaverse to embody a personal awareness experience about the potential effects of drug abuse on their appearance and bodies. Table 2 displays the mean and standard deviation of the participants' responses before and

after interacting with the drug addiction simulation.

Table 2: Pre- and Post-Test Response to Predict the Importance of Using Drug Addiction Simulation to Raise Awareness.

Test	Test Topic	SD	Mean	N
Pre-Drugs Addict simulation	the effects of drugs on human	0.649	2.48	35
Post- Drugs Addict simulation	the effects of drugs on human	0.506	2.82	35

In addition, to evaluate whether using the metaverse influences awareness of drug addiction, we conducted a paired-samples t-test at $\alpha = 0.05$. The t-test is appropriate for hypothesis testing when comparing two related samples, especially with a small sample size, to determine whether the observed difference is statistically significant. We used responses from the same group of volunteers before and after experiencing the metaverse simulation. The p-value for the paired-samples t-test was 0.00603, which is less than 0.05, indicating a statistically significant difference in awareness after the metaverse experience. The test used was a paired-samples t-test, comparing responses to the question "How much do you know about the effects of drugs on humans?" before the simulation with responses to "After experiencing the metaverse simulation, do you know the effects of drugs on humans?" afterward. Figure 6 shows the results of the t-test.

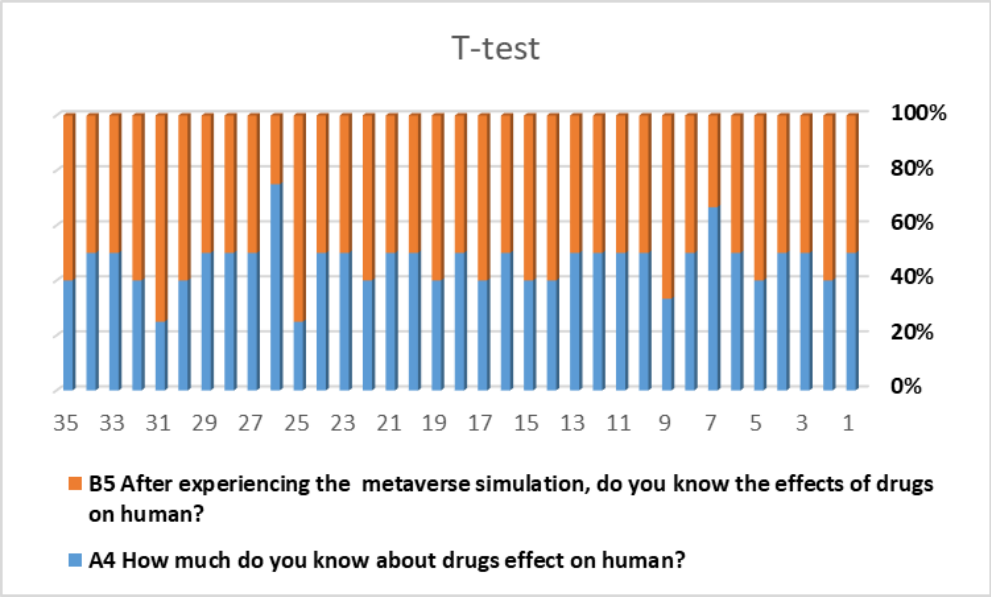

Figure 6: The Results of the t-Test.

5.2.3. Evaluation of SUS and Sense of Presence Metrics

Participants in the drug addiction Metaverse simulation also filled out section C of the questionnaire, which assessed the System Usability Scale (SUS) along with their sense of presence and immersion in the metaverse. This survey was conducted after a metaverse simulation, with all 35 participants successfully completing it. The System Usability Scale (SUS) was utilized to assess the usability of an application, or environment being studied. The survey consists of a 10-item questionnaire with a five-point response scale, ranging from strongly agree to strongly disagree [37]. The SUS measures the impact of the ten elements and calculates a single number that represents an overall measure of the usability of the system being tested. It is important to note that the scores of the individual elements comprising the scale are not independently significant. The value entered by the person testing the system for each element ranges from 0 to 4. For elements 1, 3, 5, 7, and 9 of the scale, the contribution of the scores is equal to the scale position minus 1. For elements 2, 4, 6, 8, and 10, the contribution is equal to 5 minus the scale position. To explain how the SUS overall score is calculated, the contributions of each element to the scores are first added together. Finally, the resulting total score is multiplied by 2.5 to obtain the overall SUS value.

After collecting participant responses, the scores must be normalized to a 0-100 scale. The calculated SUS score for the 35 participants was 81.92, which exceeds the average SUS score of 68. On the adjective grading scale, this score corresponds to "Good." This

finding suggests that the drug addiction VR simulation is considered suitable for practical use.

The IPQ questionnaire evaluates four key presence metrics. The first is general presence (G), which assesses the overall sense of being present in the metaverse environment. The second is spatial presence (SP), which reflects the sensation of physical existing within the metaverse world. Spatial presence is defined as "the dimension of presence that describes the user's feeling of being physically in the metaverse environment and the ability to interact with that environment and the objects in it as if it were real" [38]. The third metric, participation (INV), measures both engagement and involvement. The fourth is experiential realism, which evaluates the subjective perception of the virtual world's realism [39].

As shown in Table 3 and Figure 7, general presence (G) achieved the highest score (mean = 2.60, SD = 0.69). Figure 8 further supports this by analyzing students' responses regarding their sense of immersion in the drug addiction experience while using the simulation. Spatial presence ranked second, with a score of 2.39 (SD = 0.64).

Table 3: Results of the Presence Feeling Test.

IPQ	Avg Result	SD
G (General presence)	2.60	0.69
SP (Spatial presence)	2.39	0.64
INV (Involvement)	2.23	0.73
Real (experience of realism)	2.09	1.02

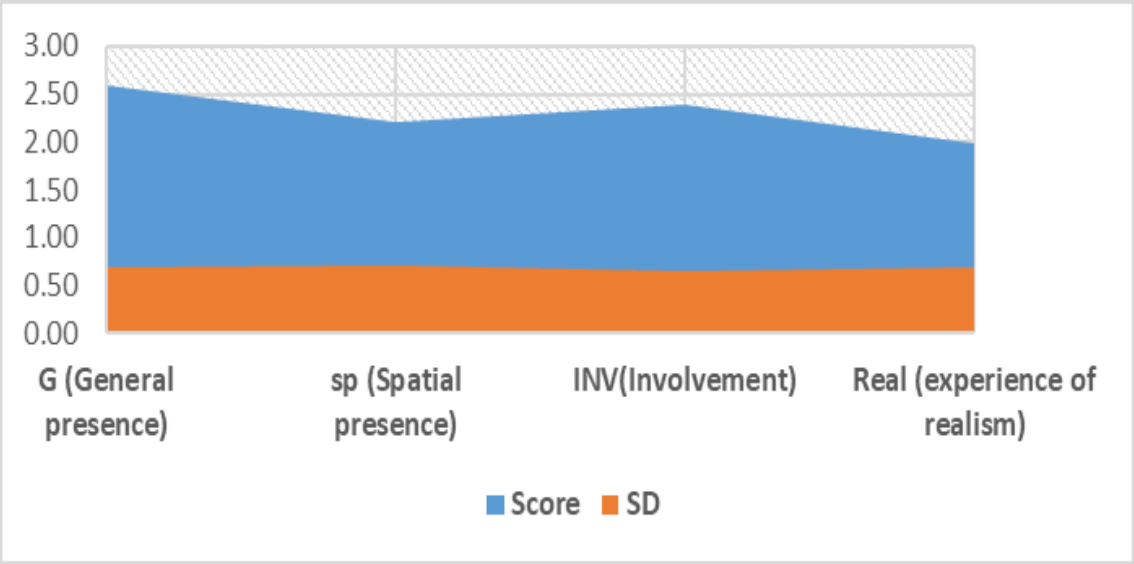

Figure 7: Average Response Scores for the Four-Presence Metrics (IPQ).

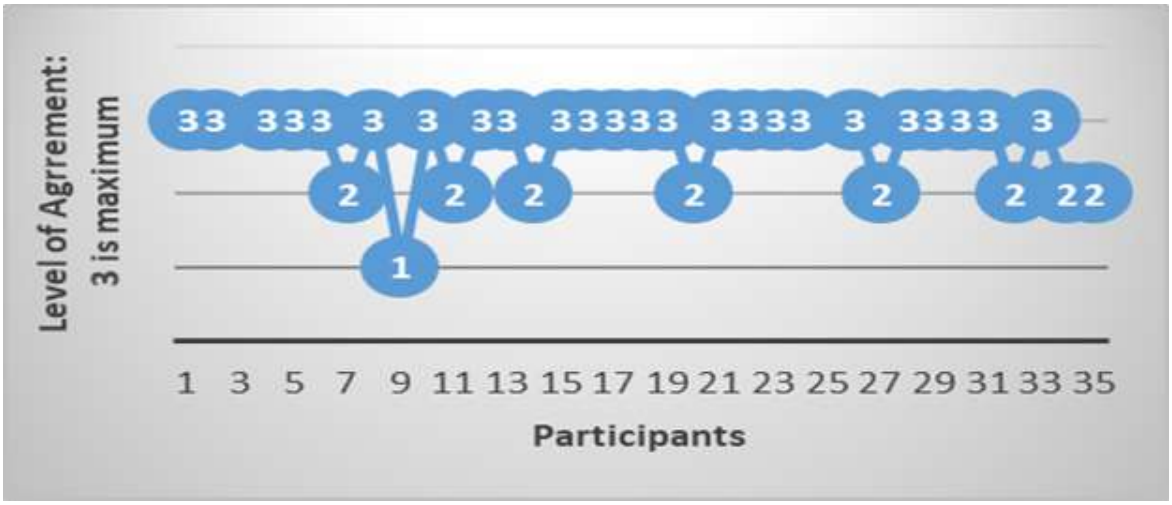

Figure 8: O Overall Sense of Immersion in the Drug Addiction Metaverse Simulation.

6. CONCLUSION AND DISCUSSION

The use of technology, particularly immersive and persuasive tools, can significantly influence behavioral change and enhance awareness of critical issues. By leveraging the Metaverse, it is possible to evoke powerful emotions such as fear and empathy. Within this virtual environment, users can experience a simulated version of themselves affected by addiction, which triggers strong emotional reactions. This experience not only highlights the dangers of substance use but also encourages individuals to reflect deeply on their choices in a technology-enhanced awareness setting.

In this paper, the integration of the Metaverse and users' personalized avatar experiences is introduced as a new approach to combating drug addiction by enhancing awareness. The authors in [19] demonstrated that serious games have the potential to enhance adolescents' emotional regulation skills, acting as a preventive measure against drug addiction. Therefore, addressing emotions is a proven method to combat drug usage. Following this concept, in this paper, we intend to utilize fear, as an emotion, which could be utilized in the fight against drug addiction.

In this paper, we aim to raise awareness of the harms of drug use by illustrating the potential changes that may occur, instilling a sense of fear in individuals. The element of personalization adds realism, enabling individuals to vividly experience the harsh reality and physical changes they may undergo as they fall into drug addiction. It is akin to taking a journey into the future to witness oneself. Such an experience can serve two main purposes: 1) raising awareness among non-addicted individuals, and 2) serving as a stark warning for those struggling with addiction, prompting them to recognize the potential consequences and bolstering their resolve to quit at an early stage or as promptly as possible.

There are many obstacles in recruiting the participants due to the sensitivity of the topic, the reluctance of many to witness manifestations of addiction, and the relatively long time required testing the simulator and collecting pre- and post-test feedback presented major obstacles to obtaining consent from a large number of actual users to participate in the simulator experiment. Despite these obstacles, we were able to convince volunteers to participate in the experiment after completing the required consent form and being informed of the instructions and procedures in accordance with the research ethics protocol. The experiments were conducted after training the participants and preparing them to overcome any effects, especially for those using metaverse for the first time.

According to the Central Limit Theorem (CLT), the distribution of sample means will approximate a normal distribution as the sample size becomes larger, regardless of the original population's distribution. The number 30 is a common rule of thumb where this approximation begins to be useful for many statistical tests[40]. Based on this principle, a sample size of 30 is generally considered a minimum requirement to satisfy the assumptions of many parametric statistical tests.

The study in [41] generated a dataset on drug abuse using lifelike synthetic images of faces (by using image processing techniques) to substitute authentic ones in deep learning tasks, safeguarding privacy. In addition, we have included a section on considering ethics and laws in our proposed framework to protect the identity of individuals who use our framework. As this system has the potential to function as an automated system, addressing ethical concerns is essential.

The proposed system comprises two main components. The first component demonstrates how drug addiction can progressively alter a person’s appearance, evoking a sense of fear about their potential future. The second component connects this projected future state with the individual’s present-day reality, thereby instilling a more immediate, personal fear based on their current circumstances.

In the implementation phase, to address privacy concerns, a mobile application was used to capture a selfie of the individual. This image is then processed to simulate the physical deterioration typically associated with long-term drug use, fulfilling the first part of the system. For the second component, an avatar-generation tool was employed to integrate the simulated image into the individual’s present environment, effectively implementing the research concept in a digitally transformed educational setting.

The developed metaverse simulation was tested and piloted through a public call for participation, conducted in accordance with the guidelines and regulations of the Ethical Research Committee. Participants voluntarily experienced the simulation and responded to several questions regarding their sense of immersion and physical presence in the virtual environment. This evaluation aimed to ensure that the developed environment realistically simulated a real-world experience. The participants’ responses supported the hypothesis that the metaverse can serve as an effective platform for raising awareness about the dangers of drug addiction.

Our primary concern is proving that a metaverse-based persuasive system is a suitable tool for raising awareness of drug addiction. We are not focused on measuring awareness among a specific group or in a particular demographic area.

Although the experiments were conducted on students at the Faculty of Computers and Information Technology, the findings can be generalized to this geographical area. This is because all students, regardless of gender, share a similar lifestyle, educational.

In future work, collaboration with relevant authorities is planned to develop a fully automated system based on the proposed system and deploy it in real-world settings with scalable implementation.

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