

Virtual Reality in Training: A Case Study on Investigating Immersive Training for Prisoners

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Abstract—This study addresses the pressing issue of prison rehabilitation by comparing traditional and Virtual Reality (VR) based training services offered by the General Directorate of Prisons in Saudi Arabia. Utilising Technology Acceptance Model (TAM) metrics such as perceived usefulness, ease of use, and enjoyment, the study evaluates the acceptance of VR technologies across two different headset platforms. Findings reveal that VR-based training services received significantly higher acceptance ratings than traditional methods. Both VR platforms were highly rated in terms of perceived usefulness, ease of use, and enjoyment but showed no significant differences between the headsets. These results indicate that VR-based methods could be more effective, engaging, and safer alternatives in correctional rehabilitation programs. Importantly, this research contributes to the field of Human-Computer Interaction (HCI) by suggesting design frameworks tailored for effective interventions in training and rehabilitative contexts where safety and psychological health are of high concern.

Keywords—Component; virtual reality; correctional services; technology acceptance; rehabilitation

I. INTRODUCTION

Prison rehabilitation has been a growing concern in recent years, as the recidivism rate remains high and the need for effective rehabilitation programs continues to grow. There are more than 60 thousand prisoners in Saudi Arabia [1] and more than 11 million globally [2]. Prisoners are a vulnerable group with mental disorders and infectious diseases compared to the general population [3]. They may show reluctance or lack interest in rehabilitation services and programs. In addition, the reluctance and lack of interest may result from the lack of interest in the traditional methods often used in prisons, including old, ineffective motivation techniques for rehabilitation.

In Saudi Arabia, prisoners are offered numerous rehabilitation services by Trahum (The National Committee for the Welfare of Prisoners and Released Prisoners and their Families in Saudi Arabia). Due to limited resources, safety, and individual mental status, not all services can be offered to them. Many prisoners struggle with substance abuse, mental health problems, and trauma, which can interfere with their rehabilitation and reintegration into society [4]. Nellis [5] added that the prison environment could be detrimental to rehabilitation efforts, with overcrowding, violence, and poor living conditions affecting prisoners' physical and psychological health.

Recently, interest in using VR technology in prisons has grown as a potential way to improve the outcomes of prisoner

rehabilitation. VR technology can place users in safe learning environments by immersing them in realistic, regulated environments. Prisoners can engage in various rehabilitative, educational, and training activities in a safe, controlled, and immersive setting using VR [6]. VR technology can improve the delivery of social problem-solving treatment and successfully enhance psychological disorders [7]. Studies have investigated the use of VR in forensic mental health treatment [8]. According to a systematic review, VR can be utilised as a tool for assessment and treatment in forensic psychiatric settings. Exposure therapy, for example, is one potential application.

In addition, VR is an effective tool for teaching coping skills to users with disabilities [9]. In this study, participants with disabilities were trained in coping skills through VR simulations, and the results showed improved coping skills and increased self-efficacy. VR simulations can provide job training, cognitive behavioural therapy, and exposure therapy for Field individuals with mental health conditions [10]. VR can also address substance abuse and other high-risk behaviours through guided simulations that allow prisoners to experience the consequences of their actions [11]. VR technology in prisons has been shown to impact prisoners' well-being positively, behavioural change, and overall rehabilitation outcomes [11], [12].

VR has been used for crime prevention and rehabilitation [13]. In this study, the author explores the potential of VR as a rehabilitation tool to reduce recidivism and promote pro-social behaviour in criminal justice settings. According to a systematic review by [14], VR has shown potential as a tool for addressing various issues in criminal justice and rehabilitation, including anxiety disorders, post-traumatic stress disorder (PTSD), and teaching coping skills to people with disabilities. However, implementing and using VR in prisons requires careful consideration of ethics, security, and inmate acceptance.

VR acceptance depends on several factors, including perceived ease of use, usefulness, and enjoyment. Perceived ease of use refers to the ease with which a user can learn and use VR technology. In contrast, perceived usefulness refers to the extent to which VR technology is perceived as helpful and valuable [15]. Perceived enjoyment refers to the extent to which VR technology is experienced as a fun and enjoyable experience [16]. These three factors positively affect user adoption and acceptance of VR technology, and they are more likely to engage with and benefit from rehabilitation programs.

This study evaluates prisoners' acceptance of VR-based rehabilitation systems as an alternative to traditional methods. By leveraging the Technology Acceptance Model [15], it seeks to assess the perceived ease of use, usefulness, and enjoyment of VR in rehabilitation settings for two VR headsets. Our study's findings could have far-reaching implications for policymaking and prison management strategies, revolutionising how we approach rehabilitation and reintegration of prisoners into society. We hypothesised that 1) VR-based training and rehabilitation have a higher level of perceived ease of use, 2) VR-based training and rehabilitation have a higher level of usefulness, 3) VR-based training and rehabilitation have a higher level of enjoyment, and 4) VR-based training and rehabilitation have a higher level of prisoner acceptance compared to traditional training and rehabilitation services.

Following the introduction, Section II will delve into the 'Material and Methods' used in the research, providing insight into the study's methodology and data collection procedures. Section III will then present the findings of our study, followed by Section IV which deals with 'Discussion,' where the result is analysed and interpreted in the context of existing literature. Finally, the paper concludes in Section V by outlining potential directions for future work.

II. MATERIAL AND METHODS

A. Participants

The study comprised a group of 46 male inmates from Makkah prison in coordination with Tarahm. The age range of the participants was 18 to 41 years, with an average age of 23. Most participants were either single or divorced. Educational levels varied among the participants: three had completed primary education, eight had intermediate education, 28 had graduated high school, and few held university degrees. All participants were unemployed. On average, the duration of their incarceration was 3.6 years. The following figure shows the experiment setup (see Fig. 1).



Fig. 1. Experiment setup where prisoners take turns to participate.

In preparation for the forthcoming experiments, participants were asked to evaluate their computer skills, experience, and weekly usage of computers using a rating scale ranging from 1 to 5, with 5 indicating the highest level of proficiency. The outcomes of this assessment were as follows: Participants provided an average rating of 3.04 out of 5 for their computer skills, indicating a moderate level of competence. Regarding weekly computer usage, participants demonstrated an average

rating of 2.66 out of 5, suggesting a moderate frequency of interaction with computers. Moreover, participants show a notable interest in computer games, as evidenced by an average rating of 3.68 out of 5 for their level of engagement. Importantly, it's noteworthy that none of the participants had prior exposure to VR tools. These initial assessments aimed to provide insights into participants' familiarity with computer-related activities, informing their readiness to interact with the VR system during the experimental sessions.

B. Apparatus

In this study, both software and hardware components were integrated. Through deliberations with the prison administration, a consensus emerged on employing a VR scenario that centred around mechanical training. Consequently, a VR environment was built, specifically designed for engine assembly. Within this immersive setting, participants were tasked with reassembling engine components, employing a VR controller as their interface. To facilitate this process, the system provided visual cues in the form of distinct colours, strategically guiding participants on the appropriate sequence of assembly steps (see Fig. 2)

In terms of hardware, the computational demands were adeptly met by an HP OMEN Gaming Laptop to power the VR headsets. For the immersive experience, two headsets were selected: the HTC Vive and the Oculus Rift. These cutting-edge devices were chosen to deliver a level of visual fidelity and interactivity, thus enhancing the realism and engagement of the participants within the virtual environment.

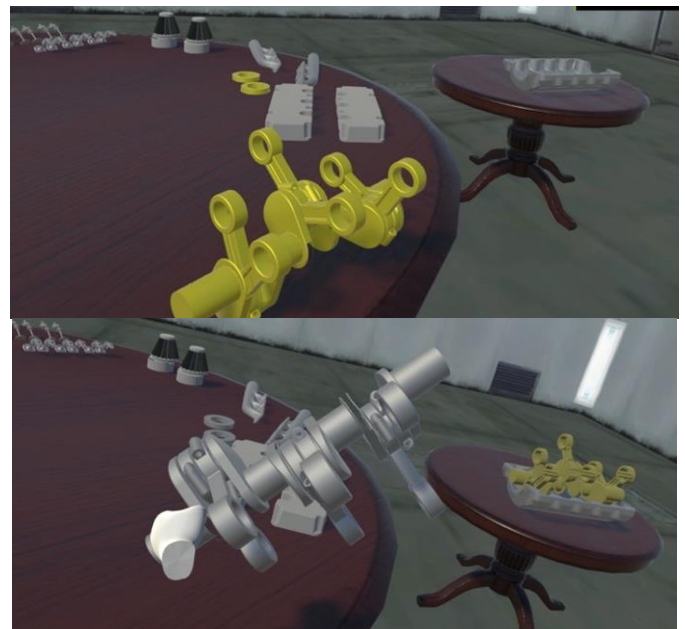


Fig. 2. The top picture shows the engine components to be installed next. The bottom picture shows picked-up components to be placed on the engine base.

C. Data Collection

The research methodology entails the employment of a structured questionnaire as the primary data collection tool. This method uses various dimensions such as demographic information, proficiency in general skills, computer aptitude,

the acceptance model comprising perceived ease of use, perceived usefulness, and perceived enjoyment, along with an evaluation of preference. Additionally, insights into the utilisation of traditional rehabilitation services offered by Tarahm were obtained. The data amassed through the questionnaire was analysed through the Statistical Package for the Social Sciences (SPSS) software.

D. Design and Procedure

In a within-subject experiment design, each participant was asked to perform the same task in each of the headsets (HTC Vive and the Oculus Rift) in a randomised and counterbalanced order, where across all participants, each headset was exactly 23 times the first and second. The task was to reassemble the whole engine.

Upon arrival, participants were welcomed and asked to sit down comfortably. After the introduction and provided written consent, participants were asked to complete a general demographic questionnaire. The information provided in the demographic questionnaire was then used to educate participants about using the headset and controllers. The participant started with a training session to get used to using the headset, followed by the actual experiment conditions. After each condition, participants were asked to complete a post-condition questionnaire. A self-report sheet was filled out by the researcher while the participant performed all three conditions. The report was then finished with the participants' verbal feedback gathered at the end of the experiment to help with future studies. The experiment was concluded by asking the participants to complete a preference questionnaire, and the participant was thanked for their participation.

III. RESULTS

A. Services Provided by the Prison and Tarahm

The prisoner receives their education and training from either the correctional service department in the prison or a third-party institution (Tarahm). This study compares the services provided by those two to compare that later to our proposed VR-based training. Three questions were asked for both as follows: 1) How do you evaluate the correctional services provided to you by the Prisons/Tarahm in general? 2) How do you evaluate the practical educational and training services provided to you by the Prisons/Tarahm? and 3) How is your interest in the educational and training services provided to you by the Prisons/Tarahm? The results of these metrics offer a general idea of how well these services are perceived, as well as their variability among the respondents. The following graphs represent subjects' responses to questions 1, 2, and 3 (see Fig. 3).

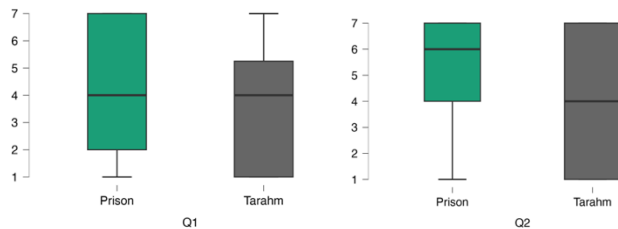


Fig. 3. Boxplots of all 3 questions: Q1: general service, Q2: training and education service, Q3: interest.

The means and standard deviation are reported in Table I. For the Evaluation of Correctional Services in General, the higher mean for the Prison (4.304) compared to Tarahm (3.722) suggests that, on average, respondents evaluate the services provided by the General Directorate of Prisons more favourably. There was no significant difference between the two groups. A paired-sample t-test revealed a t-statistic of 1.127, with $df=45$ ($p < .263$). The effect size was small, with a Cohen's d of 0.251.

Regarding the Evaluation of Practical Educational and Training Services, the Prison services (5.043) scored higher on average than Tarahm (4.083), indicating a preference for the educational and training services offered by the Prisons. There was no significant difference between the two groups. A paired-sample t-test revealed a t-statistic of 1.739, with $df=45$ ($p < .086$). The Cohen's d value of 0.387 suggests a small-to-medium effect size.

Prisoners' interest in Educational and Training Services shows similar results. The mean score for the Prison (4.696) is higher than for Tarahm (4.111), indicating that respondents are generally more interested in the educational and training services provided by the Prison. There was no significant difference between the two groups. A paired-sample t-test revealed a t-statistic of 1.041, with $df=45$ ($p < .301$). The Cohen's d value of 0.232 indicates a small effect size.

TABLE I. MEANS AND STANDARD DEVIATION FOR THE SERVICES PROVIDED BY THE PRISON AND TARAHM

	Q1		Q2		Q3	
	Prison	Tarahm	Prison	Tarahm	Prison	Tarahm
Mean	4.304	3.722	5.043	4.083	4.696	4.111
SD	2.346	2.288	2.394	2.590	2.439	2.627

B. Perceived Usefulness

Certainly, in the realm of Human-Computer Interaction (HCI), the perceived usefulness of a technology is a critical factor in its adoption and sustained usage [15]. Our study sought to assess the perceived usefulness of two prominent VR platforms, HTC Vive and Oculus, across three dimensions: general benefit (Using VR technology is good for me), efficiency and effectiveness (The use of VR technology makes me more efficient and effective), and ease of life (Using VR technology makes my life easier).

Employing a paired samples t-test, no statistically significant differences were found between the two platforms

for all three dimensions (p-values ranging from 0.816 to 0.897), as reported in Table II. The effect sizes, represented by Cohen's d, were negligible, ranging from 0.019 to 0.035, suggesting that any observed differences are not meaningful.

Participants consistently rated both platforms highly, with mean values ranging from 6.298 to 6.596 on a seven-point scale and standard deviations between 1.228 and 1.841. This suggests a strong and consistent perception among participants that both HTC Vive and Oculus are beneficial, efficient, and make life easier. Moreover, the uniformly high perception of usefulness across platforms provides strong empirical support for the integration of VR technologies in educational and training contexts.

TABLE II. PAIRED SAMPLE T-TEST FOR PERCEIVED USEFULNESS QUESTIONS

Oculus	HTC Vive	t	df	p	Cohen's d	SE Cohen's d	
Q1	-	Q1	0.130	45	0.897	0.019	0.219
Q2	-	Q2	0.218	45	0.828	0.032	0.220
Q3	-	Q3	0.234	45	0.816	0.035	0.213

C. Perceived Ease of Use

In extending the investigation into the user experience of VR platforms, perceived ease of use was analyzed, a construct known to be highly correlated with technology adoption and sustained use in Human-Computer Interaction (HCI) research [15]. Three questions, in the form of a seven-point scale, assessed ease of use: 1) Using VR technology is easy, 2) Learning to use VR technology is easy, and 3) It's easy to use VR technology to complete tasks. A paired samples t-test revealed no statistically significant differences between the two platforms across these questions, with p-values ranging from 0.613 to 0.799. Furthermore, the effect sizes, as calculated by Cohen's d, were minimal and ranged from -0.051 to 0.075 as shown in Table III.

The means for all questions were exceedingly high (ranging from 6.596 to 6.761 on a seven-point scale) and exhibited low standard deviations (ranging from 0.705 to 1.258). This suggests not only a high perceived ease of use for both platforms but also a consistency in this perception among respondents.

TABLE III. PAIRED SAMPLE T-TEST FOR PERCEIVED EASE OF USE QUESTIONS

Oculus	HTC Vive	t	df	p	Cohen's d	SE Cohen's d	
Q1	-	Q1	0.256	45	0.799	0.038	0.201
Q2	-	Q2	0.509	45	0.613	0.075	0.207
Q3	-	Q3	-0.345	45	0.732	-0.051	0.214

D. Perceived Enjoyment

The perceived enjoyment of technology is increasingly recognized as a key variable affecting its adoption and

sustained use, particularly within immersive platforms [17], [18]. This experiment aimed to explore the perceived enjoyment of HTC Vive and Oculus across four different dimensions, encompassing aspects of fun, enjoyment, impressiveness, and willingness to use VR technology for services and rehabilitation programs. The questions are as follows: 1) Using VR technology is fun, 2) Using VR technology is enjoyable, 3) Using VR technology is impressive, and 4) I am ready to use VR to benefit from the services program offered by the prison.

A paired samples t-test revealed that the perceived enjoyment does not significantly differ between the two platforms, ranging from 0.581 to 0.914. The effect sizes were marginal, with Cohen's d ranging from 0.016 to 0.082, indicating that any observed differences are practically insignificant, as shown in Table IV.

The mean scores for all the questions were remarkably high, ranging from 6.435 to 6.804 on a 7-point scale, with relatively low standard deviations (0.886 to 1.628). The consistency in these scores across dimensions and platforms suggests a high level of perceived enjoyment for VR technologies, regardless of the specific hardware.

TABLE IV. PAIRED SAMPLE T-TEST FOR PERCEIVED ENJOYMENT QUESTIONS

Oculus	HTC Vive	t	df	p	Cohen's d	SE Cohen's d	
Q1	-	Q1	0.139	45	0.890	0.020	0.218
Q3	-	Q3	0.556	45	0.581	0.082	0.219
Q4	-	Q4	0.187	45	0.853	0.028	0.219
Q5	-	Q5	0.109	45	0.914	0.016	0.211

E. Hardware Preference

Understanding users' preferences towards different VR headsets is pivotal in the HCI domain, particularly for tailoring experiences that are both engaging and comfortable [19], [20]. To this end, participants' preferences were evaluated based on four dimensions: comfort, presence, dizziness, and visual perception in the virtual world. Paired samples t-test indicated that there are no statistically significant differences in users' preferences between HTC Vive and Oculus for these dimensions, with p-values ranging from 0.587 to 0.916. This is corroborated by minimal effect sizes, where Cohen's d values varied between -0.081 and 0.069. See Table V for more details.

TABLE V. PAIRED SAMPLE T-TEST FOR PREFERENCE QUESTIONS

Oculus	HTC Vive	t	df	p	Cohen's d	SE Cohen's d	
Q1	-	Q1	-0.548	45	0.587	-0.081	0.222
Q2	-	Q2	0.467	45	0.643	0.069	0.218
Q3	-	Q3	0.106	45	0.916	0.016	0.226
Q4	-	Q4	-0.183	45	0.856	-0.027	0.224

The descriptive statistics provided additional insights into the subjective experiences with the headsets. For instance, both

headsets scored high for comfort and presence (mean scores ranged from 6.213 to 6.426), suggesting that users generally felt comfortable and immersed while using VR. Interestingly, dizziness, a potential downside of VR experiences known as VR sickness [21], had a lower mean score (ranging from 3.298 to 3.596), which is a positive indication of the usability and acceptance of these platforms.

In sum, the data suggest that both HTC Vive and Oculus provide similarly positive experiences across multiple dimensions. As such, the choice between these two platforms may depend less on inherent qualities like comfort or immersion and more on other factors like cost, available software, or specific use cases, such as educational or therapeutic interventions.

F. Comparison

Comparative analysis's most salient finding lies in the acceptance ratings, which represent a synthesis of perceived usefulness, ease of use, and enjoyment. The average acceptance rating for traditional services was 4.709 (SD = 2.148), significantly lower than the VR-based approach, with a mean rating of 6.601 (SD = 0.629). The paired samples t-test confirmed this difference as statistically significant ($t = -5.516$, $df = 46$, $p < .001$, Cohen's $d = -0.805$, $SE = 0.259$). Fig. 4 shows a graphical comparison between the two factors.

The stark disparity in ratings substantiates the compelling advantage of VR-based interventions over traditional methods in the context of correctional and rehabilitation services at the prison. The effect size is not just statistically significant but also practically meaningful.

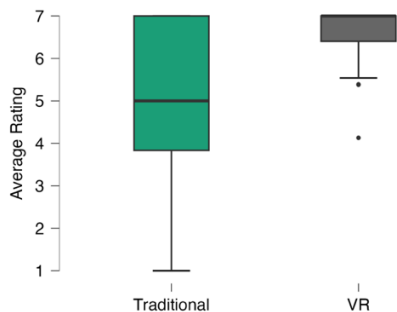


Fig. 4. Boxplots of participants' average rating for traditional services compared to VR-based training.

IV. DISCUSSION

The integration of VR into various sectors, including training and rehabilitation, is gaining traction as a transformative technology. This study sought to evaluate and compare traditional methods of training and education by the Prisons and Tarahm, with a VR-based approach. Users' experiences were evaluated, comparing two major VR platforms, HTC Vive and Oculus, across several dimensions: perceived usefulness, perceived ease of use, perceived enjoyment, and headset preference.

Findings revealed that traditional services provided by the General Directorate of Prisons scored slightly better on average than those offered by Tarahm, though not to a level of statistical significance. This could be attributed to various

factors such as service quality, accessibility, or even inmate familiarity with the correctional service department.

On the front of VR, data paints an optimistic picture of the perceived usefulness, perceived ease of use, and perceived enjoyment of using VR technology, regardless of the platform. Across all these dimensions, the scores were statistically indistinguishable between HTC Vive and Oculus. Interestingly, the perceived enjoyment scores were particularly high, aligning with extant literature that posits enjoyment as a crucial factor for the adoption and sustained use of technology [17], [18].

Importantly, both VR platforms scored highly on comfort and presence while scoring lower on inducing dizziness, a common VR issue. These findings imply that modern VR headsets have improved to the point where comfort and dizziness are less of a concern, thus potentially boosting their viability in applications like training and rehabilitation services. The lack of significant differences between the two platforms suggests that choices could be made based on other criteria, such as cost or specific features, rather than user experience [19], [20].

The VR-based approach demonstrated a significantly higher acceptance average rating when compared to traditional services. These results echo the comparative analysis presented in the results section and provide compelling evidence for VR's potential to be more favourably received than traditional methods and a safer option to adopt for prisoners. Findings support the notion that VR-based training could be an alternative to traditional correctional services in some cases or scenarios, given the high levels of perceived usefulness, ease of use, and enjoyment. Second, the platform-agnostic nature of these experiences points to the greater importance of content and application design in achieving successful outcomes. Third, for decision-makers in correctional services, it serves as a compelling argument for investment in VR technologies. Furthermore, it presents a new avenue for HCI researchers focused on rehabilitation and correctional technology, underscoring the need for a design framework that leverages VR's strengths in delivering effective interventions. Limitations of this study include the focused task scenario and the limited number of platforms evaluated.

V. CONCLUSION AND FUTURE WORKS

This study represents a comprehensive evaluation of the role of VR technologies, specifically HTC Vive and Oculus, in comparison to traditional educational and training methods provided by prison facilities and third-party institution (Tarahm). It was found that while traditional services had no statistically significant advantages over one another, both HTC Vive and Oculus demonstrated exceptional performance in perceived usefulness, ease of use, and enjoyment among users.

Significantly, when comparing VR-based training to traditional methods, the VR-based approach exhibited considerably higher levels of user acceptance. This finding not only supports the potential of VR as a viable alternative but also presents compelling empirical evidence for its integration into training and rehabilitation services. Given that there was little to no difference in the perceived quality of experience between HTC Vive and Oculus.

These results serve as a roadmap for decision-makers in correctional services contemplating investment in VR technologies. They also highlight the necessity for further research in this area, especially for understanding long-term outcomes and expanding the number of platforms evaluated.

This study opens new doors for HCI researchers, particularly those focusing on technology design in training and rehabilitative contexts. It underscores the imperative to establish a design framework that exploits VR's unique strengths, leading to more effective interventions in training and education settings.

Future research should expand on these variables and consider long-term impacts and outcomes. For example, future studies could evaluate learning outcomes and extend to other fields of study, such as therapy. One potential area to investigate is the use of VR to allow participants to live situations outside the prison wall, for instance, visiting family or walking on a beach. This would serve as an adaptation method for prisoners before they are released into society.

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