

The Pedagogy of Play: Establishing UX Benchmarks for Efficacy and Learning Outcomes in VR Serious Games**¹Mr. Mohit Bhardwaj*, ²Dr. Promil Pande**¹PhD Scholar, ²Dean and Professor^{1,2}Affiliation Address: GD Goenka University, G D Goenka Education City, Sohna Gurgaon Road, Sohna, Haryana 122103¹Email: mohit.bhardwaj2302@gmail.com, ²Email: promil@uid.edu.in

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Abstracts

Pedagogy of play and user experience (UX) design have a joint effect on the learning effectivity and performance in the VR serious games. Despite a growing popularity of using VR serious games in the educational process because of their ability to engage students in the educational process and offer a highly experiential learning experience, there is no consistent evidence of their beneficial use, and the standard of their UX is yet to be established. Its goal is to put empirical benchmarks of UX that can be related to play-based elements of pedagogies and learning outcomes. Mixed-method design is used with descriptive-analytical design. Structured questionnaires made in the Delhi NCR area were used to gather primary data on 200 users of VR serious game, and secondary data are used to provide its theoretical foundation. The SPSS is used to carry out statistical analyses of the data, including the descriptive statistics, correlation, regression, and ANOVA. Results indicate that UX design is a significant predictor of learning outcome (practically more than half of the variance) and play-based pedagogical factors exhibit a high positive correlation with UX design factors. The findings show that successful learning in VR settings is the product of their interaction between pedagogical intent and user-friendly UX and not technology itself. The study reaches the conclusion that the combination of play-based teaching strategy and an optimized user experience positively influence the engagement, cognitive learning, and development of skills. The results can provide effective recommendations to educators, designers and policymakers to embrace evidence-based VR learning solutions. The study has drawbacks associated with the regionality of study, cross-sectionality, and use of self-reported data. The future study must consider longitudinal, cross-disciplinary, and adaptive UX methodology to enhance the generalizability and long-term learning findings.

Keywords: *Virtual Reality, Serious Games, User Experience (UX), Play-Based Pedagogy, Learning Outcomes.***1. Introduction**

Digital educational games are one of the rapidly researched areas of educational technology over the last decade. (Dub'e & Wen, 2022). Educational games can be effective in learning (although, overall evidence of their efficacy has been mixed) because they can provide such affordances as quick feedback, interactive problem solving, and learner control. They were also identified to enhance motivation and engagement (Ryan and Rigby, 2020). Nevertheless, educational games have not been embraced in the classroom because of a number of obstacles. These are the absence of technological infrastructures, insufficient training of the teachers, administrative controls and the social stigma of the modern digital game (Kaimara et al., 2021). The way of adoption of the use of digital games in the learning process is significant in the role of teachers, yet the adoption of educational games by teachers has been low (Vazquez-Cano et al., 2023). This has been mostly explained by four aspects; insufficient curricular resources to instructors, mismatch with curricular goals, insufficient knowledge of game based learning by teachers and time and efforts needed to incorporate digital games in lessons. One possible solution that could help to have a positive impact on the acceptance of games among the teachers could be availability and access to curricular material designed to facilitate the process of integrating a game into the classroom. In this respect, curriculum guides have been developed to assist teachers on the adoption of commercial-off-the-shelf (COTS) games (Game Guides, 2024; Sharma & Dub'e, 2021).

These manuals give a set of guidelines to educators to adapt digital commercial games to learning purposes. As an illustration, the United Nations, which is an international organization established curriculum guides to help teachers adapt to the use of educational games. These manuals give lesson plans and teaching tools to teachers to incorporate serious games in their classes. Games for Change also prepared various guides and resources to facilitate the use of digital games in learning by teachers (Games for Change, 2024). Nevertheless, the efficacy of these guides and how they affect teachers has not been researched. The attitude of teachers on the content of the curriculum, the utility of the given materials, and their role in enriching their knowledge of the game and the skills they develop during the process of learning game-based learning (GBL) may become the major attributes affecting their decision to implement the game in their classes (Nousiainen et al., 2018).

1.1. Educational 3D Virtual Worlds

Game-based learning (GBL) facilitates new types of learning that alter the learning process with simulated (real-life) activities in primary and secondary (K-12) education (Pellas, & Vosinakis, 2018). In designing and developing digital GBL interventions, instructional designers consider, at the same time, several instructional methods intended to enhance cognitive and practical skills of learners with the help of problem-solving (Liaw, et al., 2018).

A novel technique of developing prototypes of games is linked with the application of simulated realistic representational fidelity of visual objects/elements created using three-dimensional (3D) computer graphics. Specifically, the application of 3D virtual worlds (3DVWs) presented the opportunities to sophisticated (and not so sophisticated) programmers to develop and create simulation games. A 3DVW is a virtual world of computer programs, where users have an opportunity to find the solutions to simulated problems and watch how their mistakes happen in real time visually and acoustically to realize what they do (Pellas, & Vosinakis, 2018). Examples of 3DVWs used to indicate some of them, like social Quest Atlantis, Second Life, and open source, like Open Simulator or Open Wonderland (Pellas, & Mystakidis, 2020). Every user is physically present in the form of an avatar (i.e. a representation in a digital form that has human or inanimate qualities) to communicate in real-time and explore its functionality through visual objects and engage in a great variety of simulated activities or tasks. There are asynchronous methods and tools that allow users to communicate with other peers and synchronous ones, through gestures, VoIP calls to (co)-design and/or program visual objects with geometric figures by using the scripting language of 3DVWs or by using the visual palette of Scratch4SL (Fokides, & Chachlaki, 2020).

A rich amount of study has presented much written evidence regarding the effect of 3DVWs on different education practices and activities (Dede, et al., 2017). Indicative examples are the behavior of gamified collaborative and cooperative learning and lesser financial expenditure of the behavior of simulations otherwise including hands-on experimentation with costly/special apparatus. When the latter is considered, other advantages are known under the terms of the alleviation of the environmental issues (e.g., the decrease in the production of hazardous waste) as well as the eradication of the laboratory injuries determining the branches of education related to Science, Technology, Engineering and Mathematics (STEM) (Liaw, et al., 2018).

1.2. UX Metrics and Benchmarks for Learning Efficacy

User experience (UX) measures are essential in assessing the learning effectiveness of VR serious games because they incorporate the perception and interaction of immersive environments, as well as cognitive processing of the learning environment by the learner. Usability, learnability, accessibility, and satisfaction are frequently used as normal recent UX measures, which can be quantified with the help of

standardized tools like the System Usability Scale (SUS) or task-specific performance metrics (Hamilton, et al., 2021). These measurements take the form of interface efficiency within education VR to perceived control, feedback understandability, and user-friendliness in simulated situations. Researchers can use benchmarks based on these metrics to compare learning interventions to contrast various VR applications and pedagogical designs. A knowledge application with low cognitive friction and intuitivity can be used to divert more mental resources towards problem solving and knowledge building, which in turn increases the learning efficacy and facilitates the pedagogical intentions of serious games (Alabbas, & Alomar, 2025). In addition to usability, immersive-specific UX criteria like presence, engagement and flow are fundamental indicators of measuring the learning outcomes of VR serious games. Presence indicates the learner the feeling of being there in the virtual environment, whereas the engagement and flow imply the maintenance of attention and intrinsic motivation in the game. The measurement of these constructs is usually done via self-report, behavioral data (e.g., time-on-task), and interaction logs (Hakkinen, 2020). The presence and engagement have been linked to a greater understanding of the concept and demonstrated better skill transfer especially in simulation-based learning activities. Setting standards of these immersive measures allows the effective assessment of the effectiveness of VR experience in the context of experiential learning. These benchmarks also help designers in the process of balancing realism and interactivity so as not to overburden the cognitive system and make immersion oriented to the learning goal rather than to distractions of it (Maslov, & Nikou, 2020, June).

The benchmarks of learning efficacy metrics in VR serious games are progressively based on both UX metrics and direct educational performance metrics including knowledge acquisition, skill acquisition, and retention. This approach is combined to enable researchers see significant relationships between user experience quality and learning performance. As an example, benchmarks can be associated between optimum usability and engaging scores with statistically relevant enhancement in the post-test outcome or accuracy in the task. Besides, adaptive analytics and learning dashboards can also give real-time UX data which can be used to redesign in an iterative way (Ntoa, et al., 2021). The standardization of UX standards among studies aids in being comparatively and reproducibly, which are key to evidence-based educational design. Finally, clear UX measures and benchmarks serve as an interface between pedagogy and technology, so that VR serious games do not only look interesting but can actually be proved to be effective tools of learning (Marques, et al., 2021).

The study is important as it connects the play-based pedagogy to the user experience (UX) design, to improve learning in VR serious games. It provides useful advice to teachers and developers who should create immersive, engaging, and effective learning environments by setting UX benchmarks. The study proves the ability of pedagogical factors to enhance cognitive abilities, motivation, and knowledge retention in the presence of a well-designed UX. It can also be used to assess the efficacy of VR games using measurable criteria, which underlies evidence-based design choices. Altogether, the study helps to optimize the use of VR serious games that can be a strong educational device to balance the levels of engagement and usability with meaningful learning outcomes.

The study is organized in the following way: the Introduction provides the background, significance, and research gap of play-based pedagogy and UX in VR serious games. This is then accompanied by a Review of Literature which talks about theoretical underpinnings, empirical research, and gaps that have been identified. The section on Research Methodology describes the research design, sampling, data collection and data analysis tools. The Results section contains hypothesis test and statistical results. Discussion finds the interpretation of results as per the existing literature. Lastly, the Conclusion is a summation of important findings, then the implications, limitations and the future study directions are provided.

2. Literature Review

2.1. Pedagogical Foundations of Play in VR Serious Games

Constructivist and experiential learning theories were highly influential pedagogical perspectives of VR serious games since they focused on building knowledge by actively engaging the environment (Fernandez-Sanchez, et al., 2023). As previous studies pointed out, VR serious games allowed learners to participate in situational problem-solving tasks in which knowledge was created by exploring, experimenting, and reflecting (Fanenshtil, et al., 2020). VR enabled experiential learning because of its immersiveness: e.g. to handle virtual objects, view the effects of the actions, and repeat the solution in safe, simulated environments (Tan, & Nurul-Asna, 2023). According to systematic reviews of the scientific material on educational technology, such play-based environments enhanced a deeper conceptual and procedural knowledge, especially in STEM-related fields (Carrión-Toro, et al., 2020). The pedagogical principles were operationalized through the means of embedding a learning objective into the mechanics of VR serious games, which made play align with an intentional instructional design (Ullah, et al., 2022).

VR serious games were also supported by problem-based learning and inquiry-based pedagogies (Caserman, et al., 2020). There was reliable empirical evidence that game scenarios based on real-world, real-life challenges led to critical thinking, decision-making, and learning transfer (Dimitriadou, et al., 2021). In VR settings, the learners were put in the role of a participant, which required them to examine the situation, evaluate hypotheses, and react to the dynamically changing feedback of a system (Roedavan, et al., 2021). Another aspect of the study was the use of narrative and role-play to improve the engagement and motivation of learners because these activities placed tasks in contexts of meaningful stories (Mittal, et al., 2021). The systematic reviews showed that pedagogical scaffolding, including hints, adaptive feedback, and progressive difficulty, could be introduced as part of a VR game to ensure, among other things, a higher level of task performance and a longer duration of engagement in the game (Lamrani, & Abdelwahed, 2020). The conclusions made in the study explained the need to support play mechanics and instructive approaches to learning (Teichmann, et al., 2020).

Social constructivist views also added to the pedagogical premises of play in VR serious games, as they focused on collaboration, communication, and meaning making (Cozza, et al., 2021). The study on the use of multi-user VR environments demonstrated that cooperative gaming encouraged peer learning, as participants engaged in dialogue, negotiated, and solved problems together (Tsita, & Satratzemi, 2018). The study contained in the recent systematic reviews suggested that avatar-based communication and common virtual environments could support social presence and collaborative knowledge-building (Teichmann, et al., 2020). Also, debriefing and in-game feedback were listed as significant pedagogical elements that bridged the gap between play experiences and learning outcomes (Petri, & von Wangenheim, 2017). All of the studies taken together proved that successful VR serious games were based on the model of pedagogy integrating individual exploration, guided inquiry, and social interaction. These principles secured the fact that play was not just an engagement, but a guided learning process (Mittal, et al., 2021).

2.2. User Experience (UX) Design and Learning Efficacy Benchmarks in VR

VR-based learning environments were systematically reviewed in which the perspective on user experience (UX) design was always among the key determinants of successful learning (Gorantla, & Devineni, 2023). The analysis was based on the synthesis of the results concerning usability tests, experimental research, and design-based research, and immersion, presence, interaction fidelity, and cognitive load were identified as the key UX dimensions (Alomari, et al., 2020). Studies stated that intuitive navigation, low-latency feedback, and ergonomic interaction methods greatly decreased any excess mental activity, allowing the learners to concentrate on learning material (Karimi, & Salavatian, 2018). Multisensory feedback and visual realism were often associated with enhanced engagement, but the reviews warned of overfidelity that could distract the learners (Alomari, et al., 2020). Such tools of evaluation were typically standardized UX tools, task-performance measures, and qualitative user feedback (Fokides, & Chachlaki, 2020). In multiple fields, the data indicated that user-oriented UX design, which aligned with pedagogical objectives, enhanced satisfaction, motivation, and attention, which created a precondition for a quantifiable learning outcome in VR settings (Liaw, et al., 2018).

The learning efficacy benchmarks in VR was a study that synthesized the results on knowledge retention, skill transfer, and higher-order cognitive development (Mustafa and Karimi, 2021). VR-based instruction was compared with traditional and screen-based modes in systematic reviews, which often reported moderate to high effectiveness in improving procedural learning, spatial conceptualization, and experiences (Pei, et al., 2023). Benchmarks were commonly operationalized by means of pre-after the fact testing, delayed retention measurement, performance accuracy, and transfer activity in real-life or simulated situations (Hakkinen, 2020). According to meta-analysis findings, VR experiences were scaffolded, goal-focused, and assessment-aligned in order to achieve the highest learning efficacy (Schott, & Marshall, 2021). However, inconsistent benchmarking criteria and brief intervention lengths were also found to bring variability in the effect sizes based on the reviews (Fanenshtil, et al., 2020). Recent reports demanded longitudinal references, learning standards, and more direct correlations between UX variables and learning outcomes in order to enhance the empirical premise of VR-based learning (Gorantla, & Devineni, 2023).

Though the idea of the pedagogical basis, play-based learning, UX design, and learning efficacy in VR serious games have been explored in previous studies, there is a critical gap in the study to comprehend their combined influence on the learning outcome. The available study mostly views pedagogical strategies, dimensions of UX, and efficacy benchmarks as independent constructs, and provides little information on the role of UX design as a mediator or moderator of the effectiveness of play-based pedagogies. Also, the discrepancy between benchmarks of learning efficacy, and absence of longitudinal and standardized evaluation constructs prevents meaningful comparisons across studies. The active role of adaptive UX and pedagogical scaffolding in the process of sustaining varying learner profiles between the short term and the long term is also under researched. The future studies need to take holistic and empirical methods that methodically match UX design measures with pedagogical intent and strong learning effectiveness levels in VR-based learning contexts.

3. Research Methodology

The research design is a mixed-method one it combines both quantitative and qualitative research methods to thoroughly study the pedagogy of play and the UX standards in VR serious games. The study is conducted in the area of the Delhi NCR, where the target study population are VR serious game learners. Purposive sampling is used with a stratified random sampling to make sure that the relevant and diverse groups of participants are included. The study adheres to a descriptive and analytical research design, which allows not only systematizing the description but also analysing the relationships between variables. Information has been gathered through a structured questionnaire which has been given to the respondents of a sample of 200 respondents whose data were collected using primary and secondary sources. The independent variables are user experience dimensions and play-based pedagogical factors, whereas the dependent variables are learning outcomes and UX design factors. The analysis of the data is conducted with the help of the MS Excel and SPSS 27 based on the application of mean, standard deviation, regression, and correlation. According to the picture below on the left hand there is independent variable on other where H1 of both are correlated similarly H2 of both are correlated to each other.

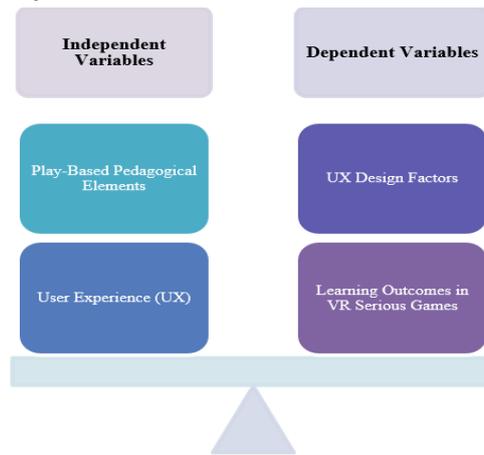


Figure 1: Conceptual framework, Source: Authors own compilation

Figure 1: Conceptual framework
Source: Authors own compilation

4. Results based on hypothesis

Table 1: Demographic characteristics

S.NO	Demographic characteristics	N	%	
1	Age	Below 18 years	69	34.5
		18-22 years	46	23
		23-27 years	42	21
		Above 27 years	43	21.5
2	Gender	Male	113	56.5
		Female	87	43.5
3	Education level	Higher secondary	49	24.5
		Undergraduate	47	23.5
		Postgraduate	50	25
		Doctoral	54	27
4	Field of study	Arts & humanities	40	20
		Engineering	46	23
		Management	62	31
		Science & technology	52	26
5	Experience with VR technologies	Less than 1 year	52	26
		1-3 year	47	23.5
		No prior experience	51	25.5
		More than 3 years	50	25
6	Purpose of VR serious game use	Academic learning	39	19.5
		Professional development	66	33
		Recreational learning	48	24
		Skill development	47	23.5

The demographic grouping of the participants suggests the existence of a diversified sample about age, gender, education, area of study, VR experience, and mission of VR serious games application. Most of the participants are under the age of 18 years (34.5%), and the other older groups are fairly represented. There were a slight majority males (56.5) and females 43.5%. Doctoral and postgraduate students were the most educated types (27 percent and 25 percent, respectively) and represented the largest groups of the study population. The subjects represented diverse professions, the most of them being management (31%) and science and technology (26%). The data of VR technologies experience is quite balanced as there were no more than 50 percent and 50 percent not having experience, not more than one year, one to three years, and more than three years. Professional development (33%), recreational learning (24%), skill development (23.5%), and academic learning (19.5%), were the main topics of playing VR games.

H1: User experience (UX) design dimensions significantly predict learning efficacy and learning outcomes in VR serious games.

Table 2: Model summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.719 ^a	.517	.514	2.65076

a. Predictors: (Constant), User Experience (UX)

According to the model summary, the relationship between the User Experience (UX) and the dependent variable under study is a strong positive association. The correlation coefficient (R) of 0.719 indicates that there is strong relationship, and Rand square is 0.517, and this implies that UX can explain a large part of the variance in the dependent variable (0.517). Its excellent Adjusted R Square of 0.514 found to be propagated by the sample size and the number of predictors is a confirmation of the strength of the model. The average distance between the observed and predicted values is given by the standard error of the estimate, 2.65076, which indicates fairly accurate predictions. On the whole, UX is an influential forecast in this scheme.

Table 3: ANOVA

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1487.945	1	1487.945	211.761	.000 ^b
	Residual	1391.250	198	7.027		
	Total	2879.195	199			

a. Dependent Variable: Learning Outcomes in VR Serious Games

b. Predictors: (Constant), User Experience (UX)

The results of ANOVA show that the regression equation of predicting Learning Outcomes in VR Serious Games with User Experience (UX) is significant. The regression sum of squares (1487.945) in comparison to residual sum of squares (1391.250) indicates that a significant amount of the variance in learning outcome is attributed to UX. The F-value of 211.761 calculated with the significance of.000 indicates that the predictive power of the model is very strong, which is far from much below the traditional 0.05. It implies that the differences in UX have a close connection with differences in learning outcomes. On the whole, the model shows that UX is a valuable predictor, and the correlation between UX and learning outcomes could not happen because it is not likely, and thus it should be regarded as the factor in the efficacy of VR serious games.

Table 4: Coefficients

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.014	.838		5.981	.000
	User Experience (UX)	.748	.051	.719	14.552	.000

a. Dependent Variable: Learning Outcomes in VR Serious Games

The table of coefficients indicates that the effect of User Experience (UX) on Learning Outcomes has a significant positive influence in VR Serious Games. The coefficient (B) of UX is not standardized, so, on average, one-unit increase in UX increases the learning outcomes by about 0.748 units, other factors being equal. The 5.014 constant term, indicates the learning outcomes projected by the model in the event of a zero UX. The value of standardized Beta of 0.719 confirms that UX is a significant predictor based on a high relative contribution to the dependent variable. This effect can be determined as highly significant because its t-value of 14.552 and significance level of 0.000 are statistically significant. On the whole, these findings verify that the improvement of UX positively affects learning in VR serious games.

H2: There is a significant relationship between play-based pedagogical elements and UX design factors in VR serious games.

Table 5: Descriptive statistics

Descriptive Statistics			
	Mean	Std. Deviation	N
Play-Based Pedagogical Elements	17.8150	3.78051	200
UX Design Factors	17.2150	3.91348	200

The descriptive statistics show that the participants rated the Play-Based Pedagogical Elements and UX Design Factor of VR serious games rather high. Play-Based Pedagogical Elements have the mean score of 17.815, which is a little bit higher than the mean of 17.215 of UX Design Factors, indicating that learners found pedagogical characteristics slightly better than UX ones. The standard deviations of 3.78 and 3.91 show moderate variations in responses, which implies that there is some variance in perceptions of every individual but the general variations show consistency among the 200 respondents. In general, the findings indicate that pedagogical design and UX are both visible elements of VR learning experience, and learners are equally aware and engage with these elements, to a similar degree.

Table 6: Correlations

Correlations			
		Play-Based Pedagogical Elements	UX Design Factors
Play-Based Pedagogical Elements	Pearson Correlation	1	.760 ^{**}
	Sig. (2-tailed)		.000
	N	200	200
UX Design Factors	Pearson Correlation	.760 ^{**}	1
	Sig. (2-tailed)	.000	
	N	200	200

** . Correlation is significant at the 0.01 level (2-tailed).

The correlation analysis indicates that there is a positive and statistically significant high relationship between Play-Based Pedagogical Elements and UX Design Factors in VR serious games. The correlation coefficient of 0.760 means that the greater the degree of play-based

pedagogical design, the greater the degree of effective UX design and vice versa. The significance ($p = 0.000$) indicates that it is nearly impossible that this relationship may have occurred due to chance, as it has reached the 0.01 significance level. It indicates that under VR serious games, the good pedagogic features are bound to correlate with a good UX feature, which is an important aspect of interaction between pedagogic and UX features in improving the interest and the primary efficiency of VR-based learning spaces.

H3: Learners exhibit distinct and measurable perceptions and usage patterns regarding UX features and play-based pedagogical strategies in VR serious games.

User experience (UX) is an important factor that can influence the effectiveness of learners in VR serious games. Other factors including usability, immersion, interactivity, and feedback mechanism affects the ability of the learners to navigate the virtual environment as well as the motivation to continue doing tasks. Optimization of UX features leads to increased levels of engagement, reduced cognitive load, and increased satisfaction with learning experience among the learners (Fayez, et al., 2023). In addition, VR-specific features, e.g. spatial orientation, control responsiveness, and sensory feedback have a direct impact on the perceived perception of the system by learners and their interaction with it. These perceptions influence usage pattern such as length of time in the exploration, number of interactions, and systematic approach to work. Thus, quantifiable changes in UX perceptions should be correlated to differences in behavioral engagements and learning effectiveness, which means that those factors warrant a specialized study in the serious gaming conditions (Maslov, & Nikou, 2020, June).

VR games based on play pedagogy methods promote active learning through exploration, experimentation, and problem-solving in a VR environment. Factors such as autonomy, cooperation, purposeful challenges, and storytelling provide the learners with a chance to build knowledge in a meaningful way that allows them to stay motivated. When learners are exposed to such pedagogical features, they exhibit unique usage patterns, including the decisions they make when faced with challenges, how they work together, and what strategies they use to solve problematic tasks (Troop, et al., 2020). Such tendencies are all affected by cognitive, emotional, and behavioral elements, and can be measured using in-game actions, decision sequences, and engagement measures. Thereby, the attitudes of the learners to play-based components (i.e., whether they consider the tasks to be challenging, motivating, or relevant) have a direct influence on gameplay behaviour and their learning performance, which is why an empirical inquiry into these relationships in VR serious games should be supported by it (Almusharraf, 2024).

5. Discussion

Wang, (2025) claims that VR serious games that incorporate play-based pedagogy greatly improves learning results because immersive environments promotes active exploration, problem solving, and critical thinking (Dimitriadou, et al., 2021). Ofosu-Asare, (2024) concurs, but underlines that the mentioned pedagogical benefits are extremely conditional upon the user experience (UX) design factors, including the interface usability, interactivity, and feedback mechanisms, which define the engagement and retention (Karimi, & Salavatian, 2018). Buley, & Natoli, (2024) however, warns that although great UX can enhance immediate engagement, it does not necessarily guarantee further learning or knowledge transfer unless pedagogical strategies are well planned and scaffolded. In reaction, Alomari, et al., (2020) uses an analysis of the study that indicates that in cases where play-based elements are carefully coupled with quality UX, learners not only enjoy the experience but also exhibit quantitative cognitive and skills-based benefits. Mittal, et al., (2021) extends the supply that the connection between UX and pedagogy is context-specific, contingent on the age, previous experience, and complexity of the subject matter of a learner, and benchmark standards are mandatory to assess and establish consistency in its design (Ullah, et al., 2022).

Putnam, et al., (2023) raises a point that too much emphasis on UX may lead to more emphasis on entertainment rather than learning, which may impose a dilution on education. Dub'e, & Wen, (2022) refutes that contemporary VR design models combine both engagement and learning goals enabling the UX to be used as a framework instead of a distraction. Anjum, & Chowdhury, (2024) argues in favor of this saying that it has been observed that the learners are known to display peculiarities in terms of interaction which can be both pleasant and understandable, that is, effective UX can actually be complementary to pedagogy, not competing with it. Timileyin, (2024) admits though proposes that in the absence of close supervision, some learners can depend on the trial and error mode of playing which negatively affects learning objectives. Dede, et al., (2017) points out the importance of comparing UX features that include navigation, feedback, and immersion against the pedagogical objectives to determine the occurrence of gaps, and to make sure that VR serious games are both entertaining and efficient. On the whole, the study emphasizes that UX and play-based pedagogy are complementary to each other, but their combination needs a conscious design and evaluation to achieve the best learning results (Fokides, & Chachlaki, 2020).

6. Conclusion

The study finds that learning in VR serious games with the combination of well-designed user experience (UX) and play-based pedagogy contributes greatly to the learning outcomes. This has been supported by empirical evidence that the UX dimensions of usability, immersion, feedback, quality of interaction are very strong predictors of learning efficacy, and play-based pedagogical dimensions are closely associated with effective UX design factors. The observed large statistical correlations indicate that technologies do not determine learning in VR environments on their own, but instead, it is the combination of pedagogical intent and user-centered design. The study helps to bridge the gap between engagement and educational competencies because it sets the UX standards, which are associated with learning outcomes. On the whole, the study supports VR serious games as a valid and evidence-based learning asset in the case of the pedagogy and UX that are aligned with each other.

6.1 Implications of the study

The implication of the study are significant to teachers, educational designers, and VR creators. As an educator, the findings highlight the importance of choosing and introducing VR serious games that can support play-based pedagogical plans and define what learners are expected to achieve. To designers and developers, the laid down UX benchmarks are practically a guide to maximize usability, immersion, and feedback mechanisms without adding to cognitive load. These insights can be used by policymakers and academic institutions in supporting the implementation of VR-based learning by making informed investments and training. Moreover, the study can also add to academic study by providing empirical evidence that UX design and pedagogy are related to quantifiable learning outcomes, which can justify more standardized and evidence-based methods in VR education design.

6.2 Limitations of the study

Although the study has its contributions, there are some limitations that it has. The study is constraint in terms of geography in the sense that the study is localized to the Delhi NCR area of India, which could influence the overall application of the results in other cultural or educational backgrounds. The cross-sectional design record the perceptions and the outcomes of the learners at a given time, which does not provide insights on the long-term retention and transfer of the skills learned. Self-reported measures can also result in response bias because of relying on data. Moreover, the study is more centered on the UX and pedagogical concepts, rather than on the individual differences in the subject matter or individual dissimilarities of learners, i.e., learning styles and cognitive skills. These shortcomings are indicative of care in making generalized inferences concerning the outcome.

6.3 Recommendation for future study

The longitudinal designs must be used in future study efforts to explore the long-term effect of UX and play-based pedagogy on learning retention and transfer of skills into the real-world in VR serious games. The external validity of the results would be improved by studies carried in different geographical areas and in educational institutions. Discipline-specific VR applications can also be studied in further research to evaluate the differences in UX benchmarks between different disciplines including healthcare, engineering, and social science. Causal inferences would be reinforced by introducing objective learning analytics, behavioral tracking and experimental designs. Also, the adaptive and personalized UX, which is sensitive to learner profiles, should be explored in future study to narrow the benchmarks to enable inclusive, scaled and learner-centered VR-based educational systems.

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