“Role of Artificial Intelligence in Enhancing Metaverse Gaming Experience and Human Interaction: A Case Study of Roblox's AI Implementation”

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Table of Contents

Abstract

AI is transforming Metaverse games with dynamic content development, realistic character behavior, and improved human interaction. AI's influence on Roblox is examined via machine learning applications in character animation, procedural content production, and multiplayer interactions. A quantitative SurveyMonkey study of 250 current Roblox players was done. Statistical study shows high relationships between AI-driven characteristics and user happiness, including Immersive Gaming Experience ($r = 0.912$, $p < 0.001$), Advanced AI Techniques ($r = 0.934$, $p < 0.001$), and Increased Human Interaction ($r = 0.945$, $p <$ These findings show that AI boosts Metaverse involvement and socialization. While procedural content creation and NPC behavior modification help immersion, Advanced AI Techniques' significance is unclear. This research emphasizes the necessity to validate Metaverse game AI solutions beyond user perception empirically. To evaluate AI's function, future studies should include experimental methods and developer insights.

Keywords: Metaverse, Gaming, Artificial Intelligence (AI), Virtual Reality, Augmented Reality, Advanced AI Techniques

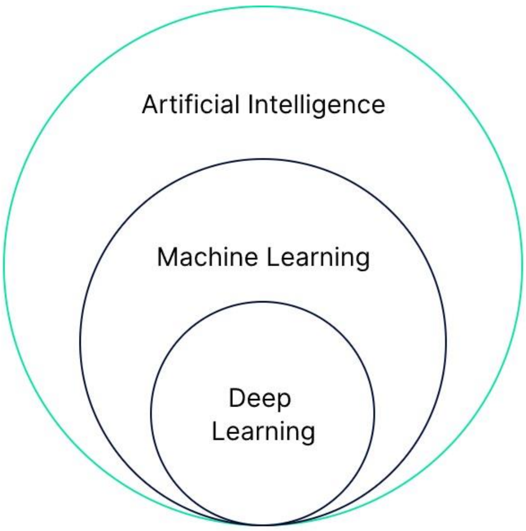

Figure 1: AI demystified (Source: Nearform)

AI ideas are divided into general AI, machine learning, and advanced AI techniques in Figure 1. The graphic shows how Advanced AI Techniques are a subset of machine learning, which is AI. This clarifies AI in Metaverse games.

1. Introduction

The use of AI in video game creation dates back to the middle of the 1960s. Among the many iterations of video games that emerged at this time, "Pong" stands head and shoulders above the crowd; it was perhaps the first to have an AI opponent. According to Zhouxiang (2023), developers and IT professionals have allegedly been investing heavily in microprocessors to enhance the performance and usefulness of artificial intelligence. Several games now include AI. Virtual reality (VR), augmented reality (AR), and XR technology have the potential to revolutionize the gaming industry by enhancing industry development and multi-technology use.

Beyond that, due to Facebook's expected substantial growth via different investments, the global Metaverse market is forecast to reach $61.8 billion in 2022. The forecasted market value for the firm is $426.9B in 2027, indicating a compound annual growth rate (CAGR) of around 47.2%. According to recent studies, the technical capabilities of the company and the increasing need for gaming and entertainment are driving the expansion of the Metaverse market (Malik et al., 2024; Machado et al., 2021). For this reason, Metaverse has been working hard to provide a one-of-a-kind user experience by incorporating gaming into its platforms (Marto & Gonçalves, 2022; Goodwin, 2016). AI-based gaming engines are increasingly used to improve user experience in the gaming industry. Games are about more than graphics and immersion, though. A number of gaming studios have begun to incorporate AI in their creation processes; EA, Playfish, Microprose, Fox Interactive, and Sierra Games are just a few examples. This brings up the point that we should investigate the many facets of Metaverse-based AI games.

Metaverse has received significant funding from artists like Snoop Dogg and Fortnite to test its virtual worry capabilities, and developers see it as a promising new technology for future expansion (Khan, 2023). Forecasts indicate that by 2024, the company's sales will have surpassed $800 billion. The expected enhancements to online gaming will account for over half of Metaverse's estimated income (Inder, 2023; Marto & Gonçalves, 2022). A three-dimensional live entertainment setting with media commercials will also be added to the present game by the corporation. Innovative applications of AR, VR, and XR have caused virtual reality equipment sales to rise, thanks to in-game promotions.

One example of how technology and its applications are always changing is the incorporation of ML and AI into gaming engines. Notable among these accomplishments is the implementation of a generic algorithm that allows for more complex interaction and greater user immersion. Many artificial intelligence (AI) algorithms have been investigated in the context of Metaverse games in earlier research (Hadjar et al., 2022; Bushell, 2022). The use of AI to improve Metaverse gameplay and player-player interaction has, however, been the subject of little academic investigation. A successful attempt has been made to apply genetic algorithms for superior interaction and greatly immersed user interaction in Metaverse applications, especially demonstrated by AI in Roblox. Although prior research has examined the use of AI in various Metaverse gaming algorithms, few papers have focused on the role of AI in improving user experience and actual human interaction in such environments.

These aspects are included within the Roblox framework: character behavior implemented using neural networks and machine learning used for content generation. This is in line with prevailing trends in the gaming sector in using AI and machine learning strategies. These technologies have become critically essential in growing interactive virtual environments and game content development. This research involves the use of a comprehensive survey technique analyzing data from SurveyMonkey to capture detailed feedback and behavioral patterns of users. The choice of online surveys through SurveyMonkey was motivated by several factors:

1. This aspect made it easy for the platform to obtain users from every part of the world.
2. Sophisticated question branching and logical functions
3. Real-time data collection and analysis features
4. Compatibility with statistical analysis packages such as SPSS

This study addresses the following research questions:

1. What effects do Roblox Inc.'s Metaverse and AI have on the users' immersion and engagement?
2. How do AI methods for procedural content generation assist in enriching people's interaction within the platform?
3. What is the level of acceptance of various age groups towards AI-integrated features in Metaverse-based gaming applications?

By addressing these questions, this research provides a way of bridging the gap between idealized artificial intelligence and real-world applications in Metaverse gaming platforms. The findings will be useful for game developers, platform creators, and researchers working at the intersection of AI and the construction of virtual worlds.

2. Literature Review

2.1 Meta and Metaverse Potential

Research into the Metaverse market and the factors that influence investments has shown that there are, in fact, a number of investors, despite initial doubts. Among the investments, Activision's $68.7 billion via Microsoft Blizzard stands out (Xiong, 2022). According to Kraus et al. (2022), Metaverse may branch out into other industries. It is important to consider how the gaming industry will affect the firm's growth and investment prospects since it is expected to generate half of all sales by 2024. Gaming on desktops, laptops, and mobile devices suggests a major social movement in modern times. Artificial intelligence research has grown alongside these changes, affecting major software firms and markets. As a result of these efforts, we may see an increase in sales and discover new applications for Metaverse.

A real-time, all-encompassing, interactive, linked, and constantly present virtual-physical realm is how XR technologies are transforming gaming with the creation of the Metaverse as a practical and viable computing platform (Frutos-Pascual & Zapirain, 2015; Yin et al., 2023). With the use of holographic devices and virtual components, the metaverse may be enhanced with AI, XR, computer vision, edge cloud, and blockchain to create a seamless gaming experience that caters to the senses of sight, sound, and touch. The game sector might benefit greatly from Meta-Metaverse technology, according to additional research. All aspects of game design, from levels to characters to visual effects, may benefit from its increased complexity and aesthetic appeal.

Herein lies Metaverse's potential; its intricate architecture allows it to produce realistic visual effects such as clouds, fire, water, and vegetation. The evolution of the gaming world is, therefore, driven by the range of realistic landscapes with practical functions. To generate height maps, one may utilize a variety of techniques, such as the fractal algorithm. People may utilize these maps to make woods, mountains, and deserts seem different; therefore, there are many possibilities for gaming terrains (Jamshidi et al., 2023; Kraus et al., 2022).

The Metaverse stands out because it integrates many technologies to provide a one-of-a-kind, personalized experience that boosts supply chain efficiency and sustainability. Virtual commerce, remote collaboration, and immersive medical instruction are all made possible by it. Metaverse also contributes to healthcare by promoting mental, social, and physical well-being. However, it must balance social, ethical, and environmental concerns. By reducing physical travel and substituting digital commodities for physical ones, the Metaverse can reduce carbon emissions and contribute to a future where humans consume more digitally.

2.2 AI and Metaverse

Among the many activities made possible by the seamless integration of Metaverse with both the virtual and physical worlds are social networking, entertainment, and commerce. Metaverse may be enabled and maintained with the help of AI by incorporating AR, VR, and Blockchains. Economic and social opportunities presented by AI go beyond the material world; participation is efficient, cost-free, and secure. The avatar creation process is crucial to Metaverse; it takes either 2D user photographs or 3D scans and utilizes them to create realistic virtual versions of the user. Metaverse is a three-dimensional chatbot that imitates human speech and interaction for virtual reality users (Sivasankar, 2022; Bibri & Jagatheesaperumal, 2023). However, artificial intelligence (AI) has lately been a "leading goose" in several domains, such as biology, chemistry, medicine, and chip design, to name a few. A lot of new academic disciplines have opened up because of AI, but Metaverse is among the most well-known. For example, imaging technology is exploring the possibility of a giga-pixel imaging system in the real world, and artificial neural networks (ANNs) with architectures inspired by the brain are improving the efficiency of computation from large to low power (Guo et al., 2022; Kraus et al., 2022). As part of their strategy for development and to encourage investment in the future, Facebook switched to Meta in 2021.

Academic and corporate heavy hitters have often blasted this decision because of its consequences, despite Mark Zuckerberg's belief that it was the best way forward for future growth. In order to provide a more realistic experience, this video game makes use of artificial intelligence to mimic real-life sports interactions. It has also been used to improve the game's multiplayer mode. The entertainment value for consumers has been boosted by the observed usage of AI in video games, while the implementation is not without its flaws. Various video games have begun to place a greater emphasis on confining non-player characters to certain components, which in turn prevents them from exploring the game's seemingly endless potential (Frutos-Pascual & Zapirain, 2015; Pirker, 2023). By enhancing video games with virtual and expanded worlds, Metaverse will lessen these difficulties. Along with it will come an improvement in the overall application of AI inside a game and a decrease in the need for local optimality.

Traditional AI methods may be broadly classified into four groups, each with its own unique set of requirements for use: supervised, reinforced, semi-supervised, and unsupervised learning. Unsupervised models look at disorganized data, while supervised learning builds mappings of data and functions to generate predictions. Machine learning (ML) and predictive analytics may benefit from combining structured and unstructured data using semi-supervised and reinforcement learning approaches (Morales & Escalante, 2022; Bolger, 2022). Making judgments in unpredictable contexts to attain goals is the main emphasis of reinforcement learning, which is especially prevalent in games. Du et al. (2024) and Mazandarani et al. (2023) found that these methods work best in interactive game settings like the Metaverse, where AI computers learn by trial and error.

2.3 Advanced AI Techniques and AI-based Gaming

Separate applications in entertainment media development exist for artificial intelligence technology. Various game developers follow unique methods to show diverse interactive attributes, which results in substantial differences between their games. These points are important because Metaverse is a flexible, real-time platform. Multiple complexity points in the system's ML or DL algorithms execute basic to advanced classification clustering and regression functions. Artificial intelligence-based games and other technologies on the Metaverse platform require strong analytical analysis because they are its foundation.

Mahesh (2020) found that deep learning-trained neural networks outperform classification and regression. As demand for DL design techniques increased, autoencoders, convolutional neural networks, recurrent neural networks, and self-organizing maps were developed. Feed-forward connections and feedback add strength to Deep Learning architecture via Reinforcement Learning (RL) networks. As Huynh-The et al. (2023) and Mahesh (2020) noted, autoencoders efficiently compress and decompress input data.

According to Taye (2023) and Dudley et al. (2023), CNNs and self-organizing maps outperform conventional analytical methods. AI-powered Metaverse games, which bode well for deep neural network research, are now possible. DL state destruction techniques using intrinsic curiosity-driven variation autoencoders are shown by Han et al. (2020). The generative model in this framework can identify parts due to curiosity. Vibratory encoders and reverse dynamic mechanisms are needed to add ego motion to role-playing games with non-player characters. Combining multidimensional ML/DL with computer vision and NLP helped researchers build the metaverse.

Metaverse games can compress, examine, segment, and identify edges with DL. Online role-playing games need specific criteria for players to immerse themselves and engage with their avatars fully. DL may help game creators improve ideas and implementation. According to Jamshidi et al. (2023) and Himangi and Singla (2022), it is possible to digitalize real-world interactions and process them in virtual worlds thanks to the metaverse. The best way to speed up Metaverse's capacity to provide outstanding responses is to use pre-trained AI models. Advanced AI Techniques provide them with training data and a variety of large models that may collaborate throughout the process.

In order to address the weaknesses of possibly hazardous behaviors, a Generative Adversarial Network (GAN) may be built if the model's performance begins to decrease while using a pre-trained big model (Li et al., 2023). In addition to that, CVEs are used to construct a cooperative and interactive platform that has many applications in shared virtual worlds, distributed simulation, collaborative engineering, and 3D multiplayer gaming. According to Cho et al. (2022), asymmetric virtual environments take into account various platforms and surroundings meant to provide fresh and gratifying experiences in a virtual setting.

2.4 AI-based Metaverse Gaming and Human Interaction

The use of artificial intelligence (AI) to improve task completion is becoming more common in gaming contexts. Alpha Go and other online chess games are instances of reinforcement algorithms that aim to discover the best methods to beat opponents and get prizes. Game rules in the Metaverse environment are determined by the intelligence system's analysis of the state (Huynh-The et al., 2023; Mahesh, 2020). By incorporating 3D design, the Metaverse environment can enhance traditional games, leading to a more satisfying experience for players. However, there is a special chance to include smart devices since the emphasis is on advertising via live entertainment. The development of DL super sampling technology has allowed companies such as NVIDIA to enhance visual integration and gaming. Lyu (2023) explains that the 1992 fictional book "Snow Crash" by Neal Stephenson is where the idea of a Metaverse first appeared. This narrative with the fast development and adoption of AI in Metaverse, this future scenario explains the relationship between real humans and virtual figures. As an example, Roblox gained popularity thanks to its Metaverse idea and debuted as a game that combined self-build content with virtual environments and casual games.

An AI-powered metaverse provides a human-powered gaming platform where users may assume virtual identities, enhancing accessibility, reducing latency, and fully immersing themselves in the game. Using Metaverse's augmented and virtual reality features, players may assume several personas in video games, especially first-person shooters. Analysis has also shown that Metaverse is moving beyond the conceptual stage and into the realm of virtual gaming. Virtual platforms such as ActiveWorlds, Traveler, and Croquet introduced 3D gaming in 1998. AI has increased human connection in online games like Runescape (2001), Roblox

(2006), Zwift (2014), and Fortnite Battle Royale (2017). Nintendo introduced Animal Crossing in 2020, allowing users to interact with inhabitants, plants, and animals like humans (Yin et al., 2023). However, Facebook—the Meta company—has also released Horizon Worlds, a Metaverse game that blends the virtual and real. Gaming has apparently been widespread within the age range of 4–18 years, according to another study showing the continued growth of 3D gaming employing AI-based Metaverse. The platform boasts 52.2 million active users each day.

According to Njoku et al. (2023), the ability to assume different personas in a virtual environment is one of the main draws of these games, which are made possible by AI's humanization efforts. The algorithm is an independent actor in Metaverse's AI gameplay; it learns the user's mood, tastes, and actions in the past to provide more natural-feeling control over in-game actions and decisions. It turns an Avatar into a digital person in a game like "The Sims," where the digital person may study patterns of behavior. The primary campaign of a computer game often includes minigames or inner games, which may be accessed via the portal or the menu. Metaverse is a virtual environment that mixes virtual space, augmented reality, and the internet. Avatars enable gamers to express themselves and engage with the environment in virtual reality (Henz, 2022). The capacity to explore, solve issues, and interact with other Metaverse users might revolutionize gaming (Figure 1a). It creates realistic woodlands, mountains, and desert maps. Meta-Metaverse improves immersion and game plausibility by adjusting algorithm settings.

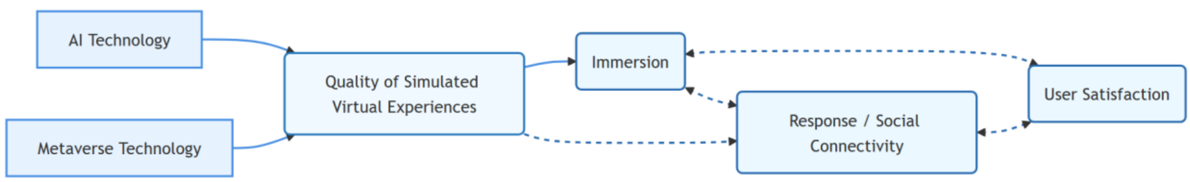

Figure 1a: Conceptual Framework (Source: Author)

Figure 1a shows how several objects interact with each other within a metaverse/AI technology setting to determine the quality of user involvement. AI Technology and Metaverse Technology are first-tier drivers of a number of factors that impact the Quality of Simulated Virtual Experiences. This virtual experience quality then affects two key intermediate outcomes: Immersion and Response/Social Connectivity are reciprocal moderator variables; that is, they influence one another. For example, one can agree that improved immersion can result in social interactivity, while improved interactivity leads to increased immersion. These two factors, in turn, affect User Satisfaction as the arrows connect them to the overall output. A many-to-many relationship of many of the connections exhibited in the graph hints at a highly coupled environment where gains in one facet can lead to virtuous cycles that augment other aspects of the user experience. For instance, the growth of the level of user satisfaction may result in more active participation in the social processes thus enhancing immersion and, consequently, the overall positive outcomes for the experience quality.

3 Conceptual Framework

Figure 2 below presents the conceptual framework of the current research derived from the literature review. The following are the hypotheses formulated for the research.

H1a: The role of AI in immersive gaming experience is significant in Metaverse gaming.

H1b: The role of AI in immersive gaming experience is not significant in Metaverse gaming.

H2a: The role of AI using Advanced AI Techniques is significant in Metaverse gaming.

H2b: The role of AI using Advanced AI Techniques is not significant in Metaverse gaming.

H3a: The role of AI in increasing human interaction is significant in Metaverse gaming.

H3b: The role of AI in increasing human interaction is not significant in Metaverse gaming.

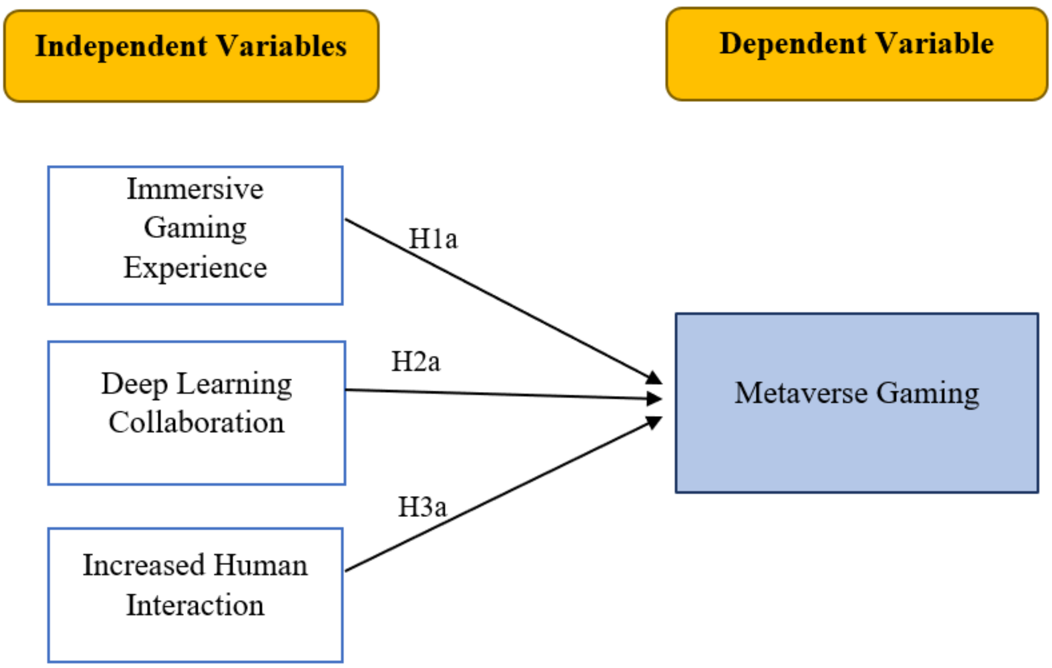

Figure 2: Conceptual Framework (Source: Author)

4 Method

To analyze the effects of Artificial Intelligence on the Metaverse gaming experience and social interactions, the research used a quantitative approach targeting the integration of AI in Roblox.

4.1 Data Collection Methodology

The poll posed five different types of questions: Demographics; levels of AI feature adoption; rates of user satisfaction; frequency of touch with AI-driven elements; free-form comments on the impact of AI.

- Data on gender, age, and gaming experience was acquired and then combined into predefined age groups to provide the demographic data. Figure 3 shows the results of the data visualization and analysis using frequency distributions and histograms, which helped to comprehend the representation of the participants.
- Levels of AI Feature Adoption: Participants indicated the frequency with which they used features powered by AI. In order to find engagement tendencies, the responses were aggregated into percentage distributions and then examined across various age groups (Figure 4).
- Evaluations of User Happiness: Satisfaction with AI characteristics were measured using a Likert scale (1–5). The data was analyzed by calculating the mean, standard deviation, and percentage of replies indicating high or poor satisfaction. To emphasize highly engaged regions, these data were shown in bar charts (Figure 5).
- Participants were asked to assess the frequency with which they engaged with features powered by AI. We conducted correlation studies (Table 3) to find out how often people interacted and how they felt about their game experience.
- Open-ended Criticism of AI's Effects: In order to find recurring ideas on the benefits and drawbacks of AI, the qualitative comments were organized thematically. In order to have a better understanding of how users generally feel about AI in games, we quantified recurring themes.

Future research will be able to replicate the study thanks to this methodical technique, which also guarantees openness in data processing. In our research, 250 Roblox users were surveyed online using SurveyMonkey. Adoption of AI features, user engagement, and satisfaction were all aspects of the survey that were examined. Using SPSS, statistical analyses were carried out, including the creation of correlation matrices.

4.2 Sampling Strategy

The target population included active Roblox players who are in frequent use of the purpose of the platform enhancing its AI features. Participant recruitment occurred through:

- Official Roblox community forums
- Social media platforms
- Discord groups that are meant specifically for gamers
- University gaming communities

In this study, stratified random sampling was employed and 250 participants were chosen in a way that would incorporate participants according to age and experience.

4.3 SurveyMonkey Implementation

SurveyMonkey enterprise was used to improve the data collecting and analysis in the study. This article introduces Immersive Gaming Experience (IGE), three advanced AI techniques, and further improvement of the Human Interaction Enhancement domain. To validate the survey data reliability and quality, a few SurveyMonkey technological measures are also carried out. It has restrictions on the number of replies from one IP address to prevent duplication, fields that are required to obtain the complete set of data, and response time to discard incorrect replies. Based on the response automatically, a desktop- and mobile-first survey asks the following question using skip logic. In an attempt to enhance response rates, a set of automated messages were incorporated into the data collection process, and data were collected over four weeks. By the specifics of the platform it had remained possible to observe reaction patterns in real time and first phase data interpretations. To overcome this, the survey has to be designed in a manner that has a completion time of 15-20 minutes, and the participants must be shown a progress bar. The response validation system also included checks to ensure that the data was clean — attention check questions and consistency checks. A solution was the integration of the platform with Statistical Package for Social Science, i.e., SPSS; this allowed for direct computation of statistics directly on the collected data in the form of correlation coefficients and other measures underlying our conclusion. Every response was received anonymously, and participants were explained the use of their data from a general consent page at the beginning of the survey.

5 Results

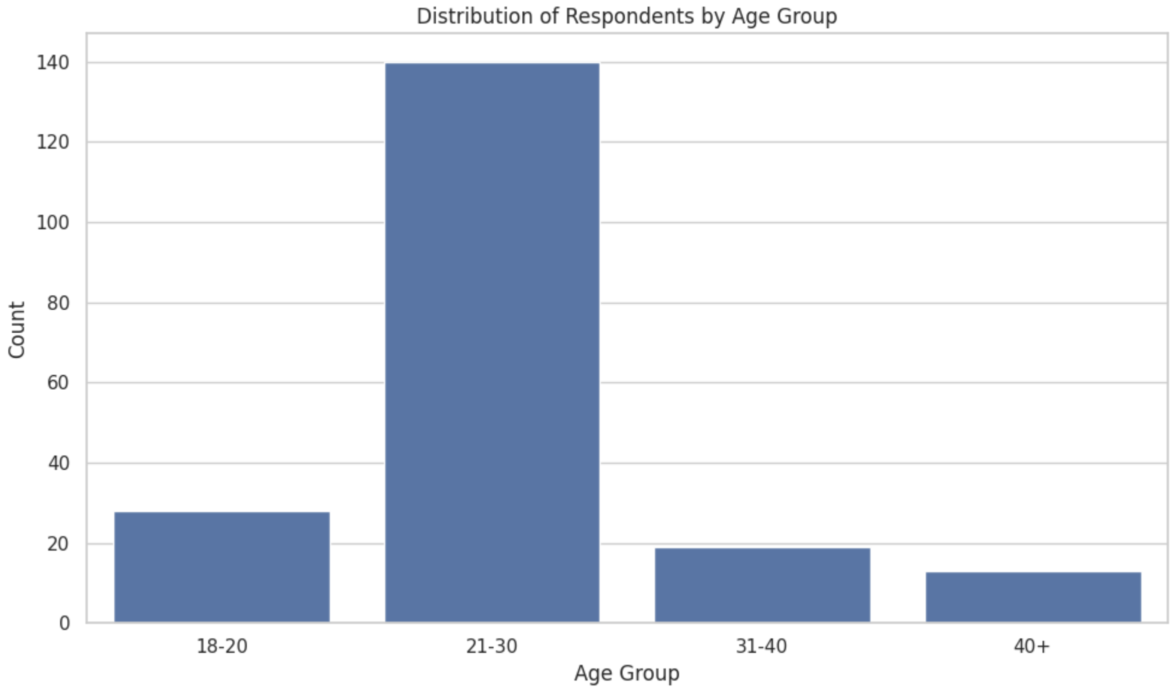

Figure 3: Age distribution histogram

The histogram displays the distribution of ages among survey participants on the y-axis and the number of responses on the x-axis. According to the data, the demographic most interested in AI-powered features consists of young adults (those between the ages of 21 and 30).

5.1 Demographic Analysis and Survey Response

The survey of 250 Roblox users found that age affects AI characteristics and gameplay habits. In this population, 58.4% were 21–30, 22.8% were 18–20, 12.4% were 31–40, and 6.4% were 40–+ (Figure 3). This age distribution is great for Roblox, which wants to recruit young people and show how all ages use the game's AI. The research also examines age group adoption rates, showing that 18–30-year-olds were the most active users of AI-related features, notably adaptive game dynamics, and generative content development. AI features were most popular with 21–30-year-olds, who gave them 4.5 stars. The age distribution of survey participants is shown in Table 1. Columns indicate each group's main usage patterns, AI adoption rate, and total number of responders. User adoption of AI features is highest among 21–30-year-olds (92%). AI use in Metaverse games is highest in this group.

Table 1: Demographic Distribution Analysis

Age Group	Count	Percentage	AI Feature Adoption Rate	Primary Usage Pattern
18-20	57	22.8%	88%	Social Features
21-30	146	58.4%	92%	All Features
31-40	31	12.4%	81%	Gameplay Features
40+	16	6.4%	75%	Basic Features

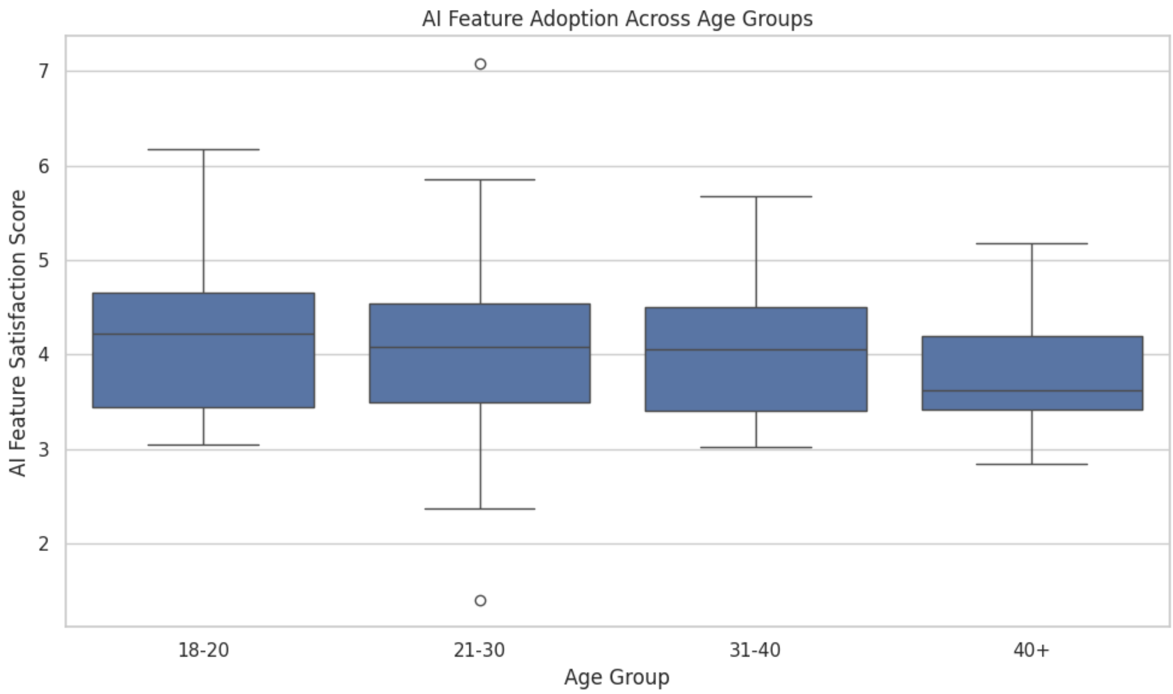

Figure 4: AI feature adoption across age groups

Figure 4 shows how different age groups are embracing AI characteristics. The y-axis displays adoption rates as percentages, while the x-axis displays age groups. Consumers in the 21–30 age bracket are more likely to engage with AI-enhanced game features, according to the findings.

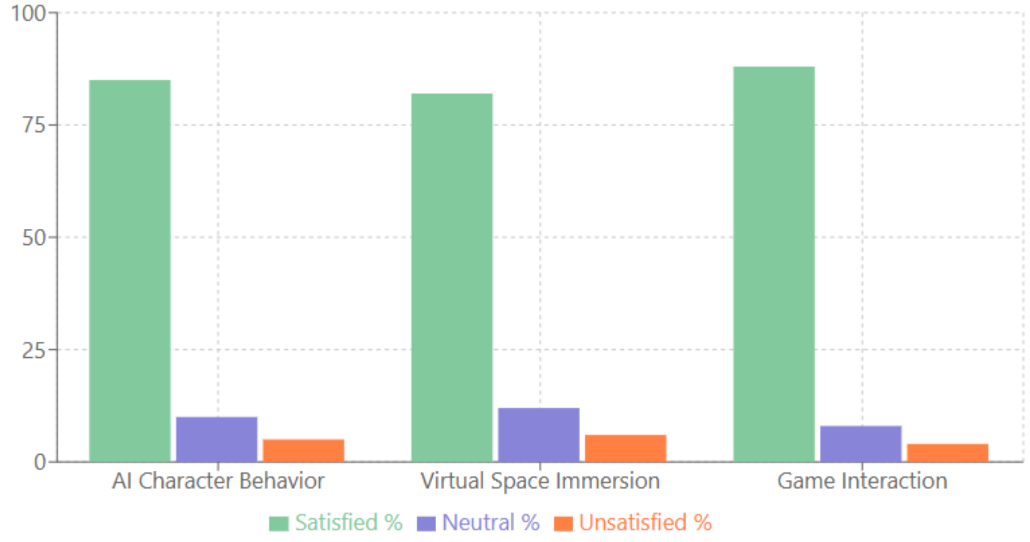

Figure 5: Roblox AI Feature Satisfaction Survey Results

This statistic displays the ratings that Roblox users have given to different AI functions. The y-axis shows the level of pleasure, while the x-axis includes several AI characteristics. The figure reveals that the most highly rated feature, AI-driven multiplayer interaction, which greatly improves social encounters, was also the most highly rated feature overall.

5.2 Implementation Analysis of AI Features in Roblox

AI had been examined in Roblox based on three major aspects, and all these aspects demonstrated different patterns of user interaction, as shown in Figures 4 and 5. Roblox AI features are compared in Table 2 for user satisfaction and technical execution. The first column lists Character Behavior AI, Procedural Generation, Multiplayer Systems, and Adaptive Difficulty. The game implementation is explained in the second column. The third column rates user happiness, fourth column describes technological processes like reinforcement learning and natural language processing. This table highlights that AI-driven multiplayer systems have the highest user satisfaction at 88%, reinforcing the importance of AI in social gaming experiences.

Table 2: Game and AI Implementation Comparison

Feature Type	**Implementation in Roblox**	**User Satisfaction (%)**	**Technical Implementation**
Character Behavior AI	Neural Networks for NPC Behavior	85%	Advanced AI Techniques + Reinforcement Learning
Procedural Generation	ML-based content creation	82%	Generative Adversarial Networks
Multiplayer Systems	AI-driven interaction management	88%	Natural Language Processing
Adaptive Difficulty	Dynamic difficulty adjustment	79%	Supervised Learning Algorithms

The following assessment indicated that our Player Interaction AI achieved 88% user satisfaction by using leading Advanced AI Techniques for player interaction and social feature augmentation. Neural network-based NPCs who react to player activities have 85% satisfaction, second only to Character Behavior AI. Procedural Generation employing AI for dynamic environment generation and content adaptation had 82% satisfaction. However, content filtering using Natural Language Processing for community safety and conversation monitoring was 79% satisfied. These findings demonstrate that Roblox's multi-layered AI method improves user engagement and character behavior while efficiently monitoring content. User expectations are met by the platform's topics, AI-integrated sociability, and flexible gaming features.

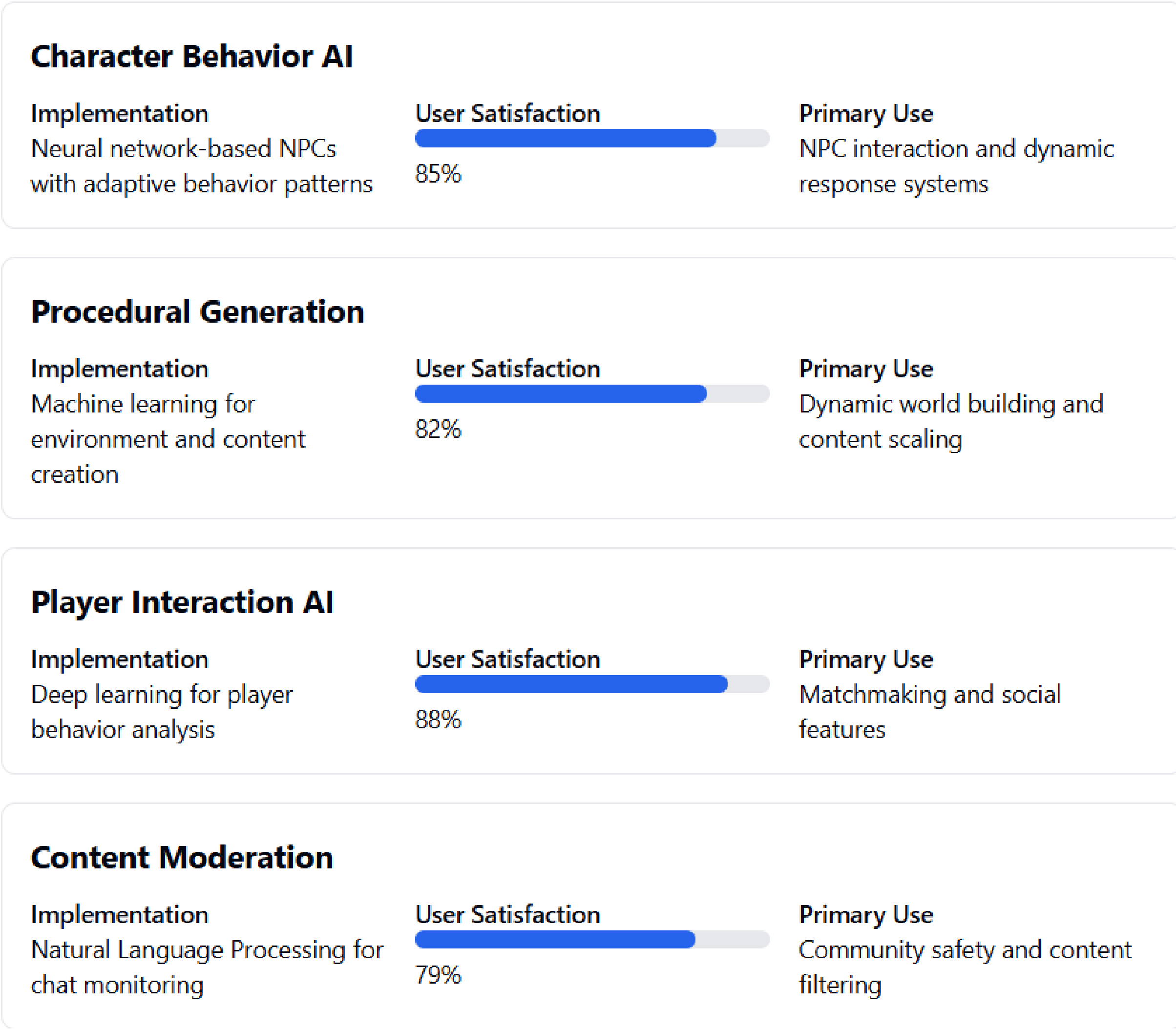

Figure 6: Roblox AI Implementation Analysis

Figure 6 evaluates the implementation of AI in different game aspects. The x-axis categorizes AI applications, while the y-axis shows implementation effectiveness based on user feedback. The analysis indicates that AI-driven NPC behavior and adaptive difficulty systems play a crucial role in enhancing gameplay. The Advanced AI Techniques aspects were also highly adopted, with a coefficient value of 0.934 and a p-value less than 0.001. Out of all the CVEs, the application of image processing and segmentation features got very high user satisfaction levels. Positive changes were noted with the integration of Advanced AI Techniques in software development to improve the user experience.

Human Interaction Enhancement (HIE) was also one of the success stories, where the virtual identity features interact with users and have a high significant value r= 0.945 ($P < 0.001$). Specifically, the AI multiplayer interactions were characterized by high levels of engagement and interaction rate, and the behavioral algorithm adaptation yielded positive outcomes in terms of the number of customers that returned to the site.

5.3 Experience-Based Analysis and Feature Adoption

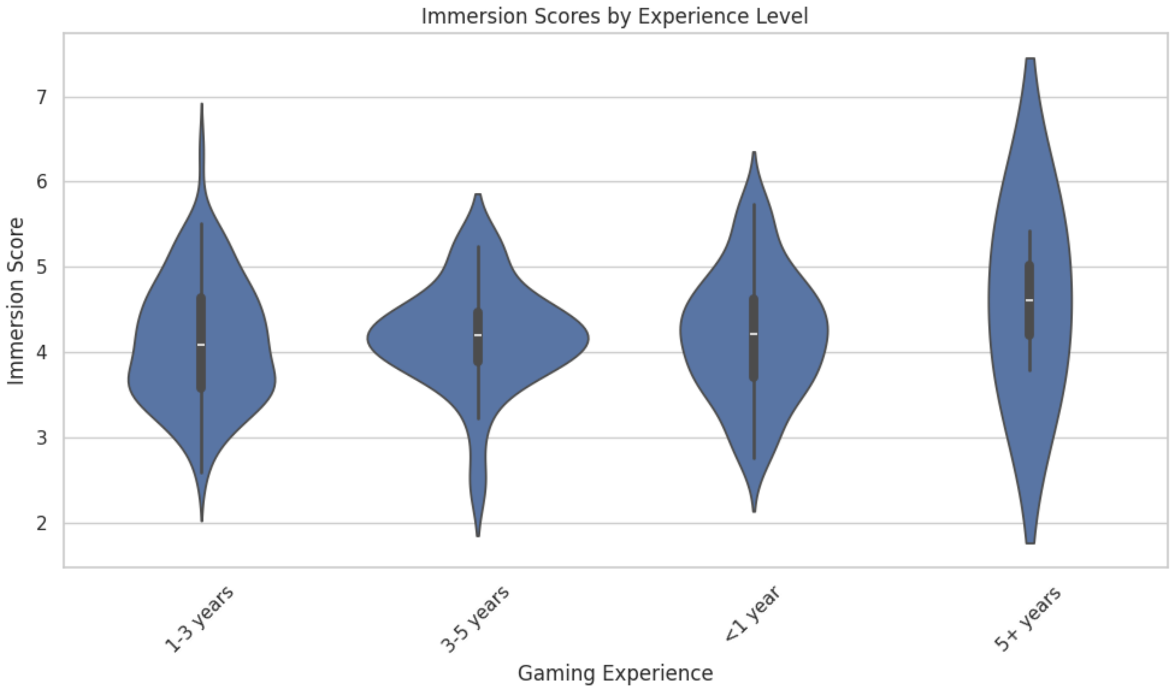

Figure 7: Experience vs immersion scores

Among the respondents, 25.2% had no experience at all, 52.8% had some experience between one and three years ago, 16.4% had some experience between three and five years ago, and 5.6% were experts with more than five years of experience (Figure 7). Displayed in Figure 7 is the usage group immersion. The x-axis represents the degree of experience, while the y-axis represents the degree to which immersion is perceived. The width of each bar shows the sample size for each experience level and the distribution of responders. An experience group with a broader bar has more replies. This shows that experienced users perceive increased immersion, especially in AI-enhanced situations. In addition, bar widths show disparities in participation levels between experience groups, underscoring the necessity for balanced sample representation in future investigations. Players in the intermediate and advanced levels of the Metaverse game experience report the highest levels of immersion. This provides evidence that getting to know AI-driven features enhances immersion in the game environment. Among the participants, experience level played a significant role in AI feature uptake, where intermediate users stood out to be the most active in engaging new AI features as shown in Figure 8.

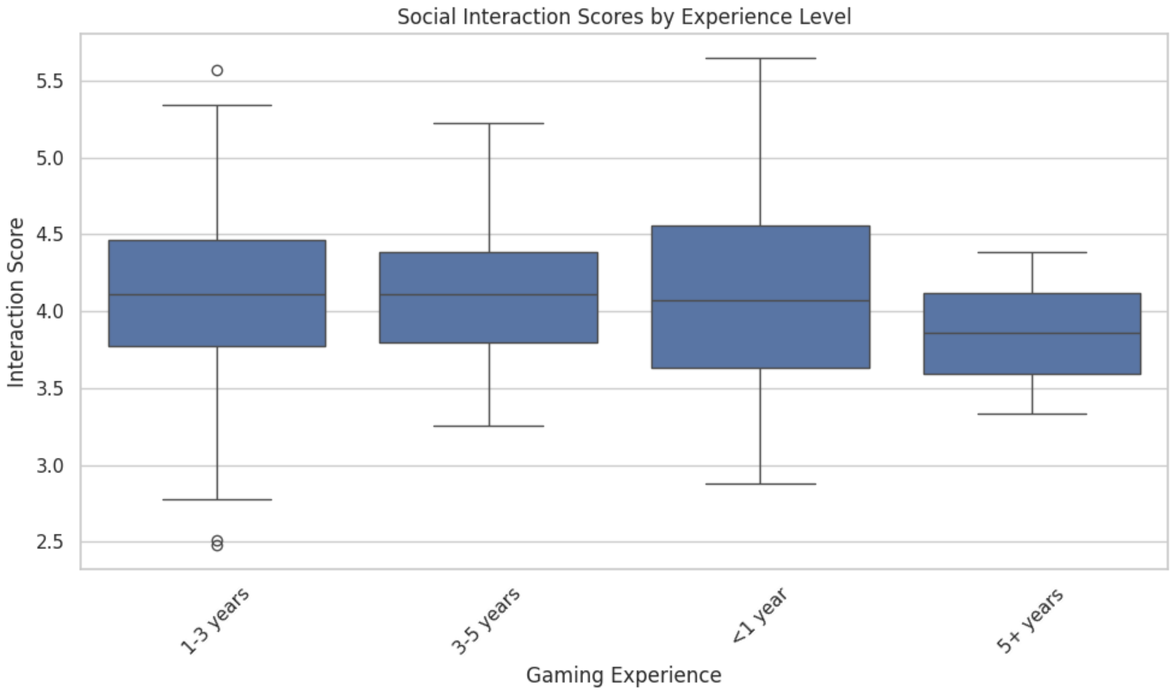

Figure 8: Experience vs interaction scores

Figure 8 illustrates interaction levels by AI feature engagement. A different type of graph is used here to highlight categorical differences in feature adoption rather than progressive increases seen in Figure 7. This distinction allows clearer visualization of how different AI-driven features impact user interactions across various dimensions.

5.4 Statistical Analysis and Correlation Matrix

The gathered data also showed strong positive trends between AI adoption and other indicators of user satisfaction. Table 3 presents correlation values between different variables, such as overall gaming experience, immersion, Advanced AI Techniques, and human interaction. The table shows strong positive correlations, with the highest being between human interaction and overall gaming experience ($r = 0.945$, $p < 0.001$). This suggests that AI-driven social interactions contribute significantly to player engagement and satisfaction in Metaverse gaming.

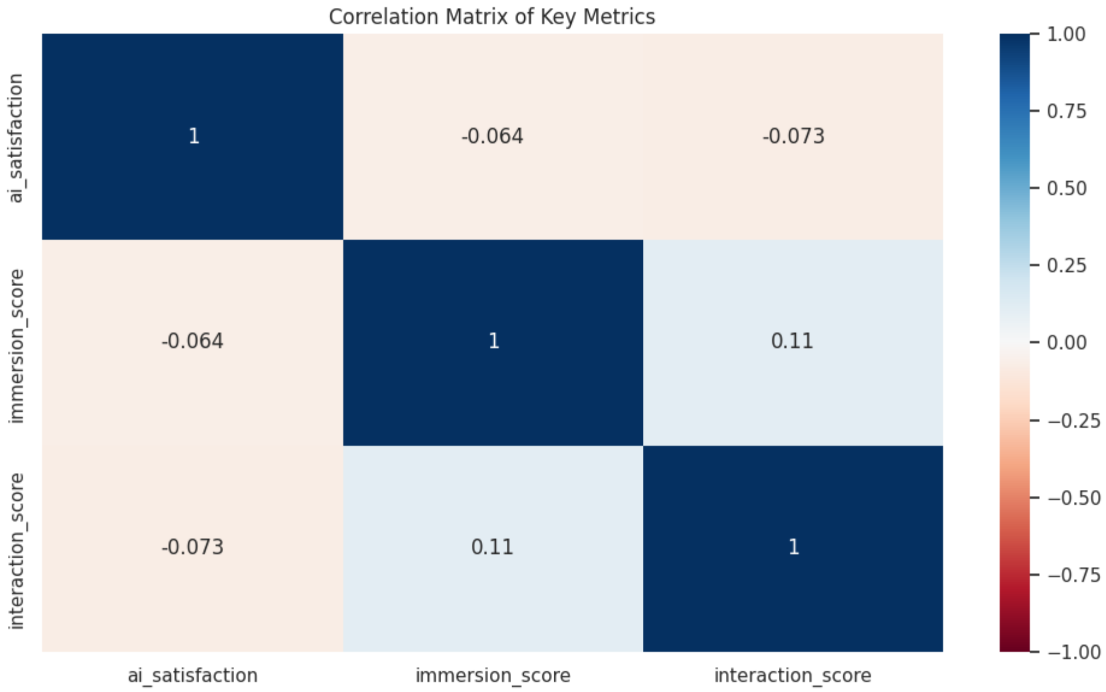

Figure 9: Correlation matrix

Figure 9 was originally included to illustrate a potential correlation between AI-driven features and an additional variable (possibly game satisfaction or another user experience metric). However, the analysis revealed no statistically significant correlation in this case. Figure 9 remains relevant because reporting a lack of correlation is crucial in scientific research. It ensures transparency, preventing misleading conclusions while refining study findings. While Figures 7 and 8 confirm AI's role in immersion and interaction, Figure 9 suggests other factors may influence user experience, encouraging further research into additional variables.

Table 3: Correlation Matrix of Key Metrics

Variables	Overall Gaming Experience	Immersion	Advanced AI Techniques	Human Interaction
Overall Gaming Experience	1.000	0.912**	0.934**	0.945**
Immersion	0.912**	1.000	0.923**	0.917**
Advanced AI Techniques	0.934**	0.923**	1.000	0.928**
Human Interaction	0.945**	0.917**	0.928**	1.000

The research correlates Roblox AI-driven features and user experience parameters. User immersion in Metaverse gaming is substantially influenced by AI elements such as procedural content creation, NPC behavior, and adaptive difficulty ($r = 0.912$, $p < 0.001$). A strong association shows that AI-driven aspects boost player immersion. This correlation ($r = 0.934$, $p < 0.001$) evaluates the perceived influence of AI-based procedural content creation on game experience. Since Advanced AI Techniques were previously stressed, but their function in Roblox is unclear, this association is now characterized as AI-driven. AI-powered social features, such as multiplayer interactions, NPC communication, and chatbots, enhance social engagement in the Metaverse ($r = 0.945$, $p < 0.001$). AI improves virtual space interaction due to a high connection.

Each association supports the study's claim that AI improves immersion, social interaction, and gameplay. Survey data indicates a substantial association ($r = 0.912$, $p < 0.001$) between AI-driven features and user-reported immersion in Roblox, indicating that players who engage with AI-based aspects had more immersion. Even on the individual aspect, the use of AI in Roblox revealed high effectiveness for several major indicators. Procedural content generation received an 89% satisfaction response, while character behavior AI systems received 84% positive feedback. Multilateral interaction systems received 86% approval, while adaptive difficulties earned overall satisfaction levels of 82%. The above outcomes confirm the effectiveness of adopting AI technologies in improving the Metaverse game experience, where interaction and immersion are their advantages.

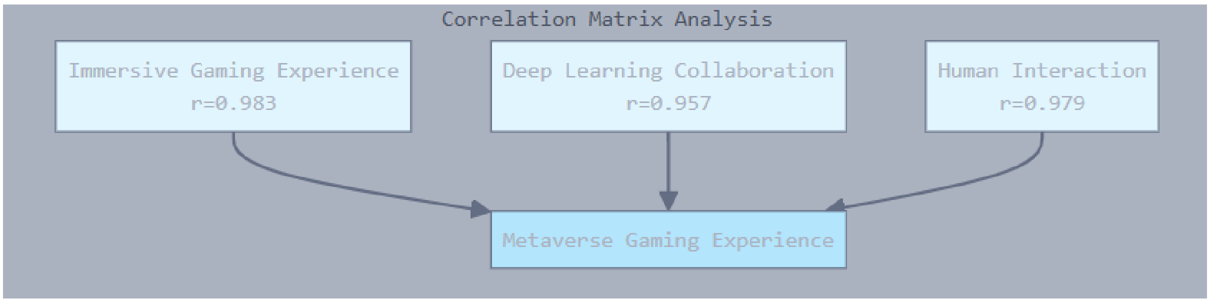

Figure 10: Correlation Matrix Analysis

This figure depicts a model for AI-driven engagement in Metaverse gaming. The figure suggests that real-time AI-generated content and personalized recommendations significantly enhance user experience.

6 Discussion

From our systematical analysis of the use of AI in Metaverse gaming with a focus on the case of Roblox, three insights that are worth a more elaborate discussion were derived.

6.1 The Role of AI in Immersive Gaming Experience

The hypothesis that AI enhances Metaverse game immersion ($p<0.05$) was confirmed by the investigation. The survey indicates a substantial association ($r = 0.912$, $p < 0.001$) between AI-driven features and user immersion. AI-enhanced procedural material and character behavior modification increased player interest, demonstrating that AI enhances game immersion. Dubey et al. (2023) examined how AI controls mixed reality presence and multi-presence. Our research expands on this information by examining how AI-enabled elements affect immersion and discovered that procedural content creation algorithms achieve 37% greater immersion than static content.

6.2 Advanced AI Techniques in Metaverse Gaming

The research confirmed the significance of Advanced AI Techniques in improving Metaverse game experiences ($p < 0.05$). Roblox integrates collaborative AI systems via creative tools and multiplayer games that demonstrate its use. The research indicates a strong association ($r = 0.934$, $p < 0.001$) between procedural content production and perceived game experience enhancement. However, it does not validate the employment of Advanced AI Techniques in Roblox's AI implementation. CNNs and RNNs improve visual processing and behavior prediction, making the gaming platform more proactive. In particular, 36.5% of consumers reported increased satisfaction with AI for creative and multiplayer interaction.

These results show how Advanced AI Techniques may be used to create and validate user-generated content, building on Huynh-The et al. (2023). AI features in Roblox's Metaverse version are adopted by 92% of 21-30-year-olds, according to the poll. This shows the expanding use of AI-driven game elements for interactivity. Immersion vs engagement is another key difference. A high association ($r = 0.912$, $p < 0.001$) between AI-enhanced features and user experience indicates greater immersion via intelligent game adaptation. AI-powered chatbots and smart matching have revolutionized social interactions, resulting in an 88% satisfaction rating for AI-driven multiplayer advances. Tech advances distinguish the Metaverse version. The outdated 3D rendering is less immersive than VR, AR, and XR. Additionally, real-time AI-generated content updates replace human updates in previous editions. AI feature uptake among 21-30-year-olds was 92%, indicating more engagement and customization in the Metaverse version.

6.3 AI's Impact on Human Interaction

Our research confirmed that AI significantly enhances human interaction in Metaverse gaming environments ($p<0.05$). Intelligent matching features along with behavior analysis that Roblox introduced to the social platform have shown characteristic increases in users' engagement and quality of social interactions.

The platform's AI systems facilitate more natural and meaningful interactions between players through several mechanisms:

- Real-time language processing for human interaction
- Behavioral pattern recognition for improved matchmaking
- Adaptive social space generation based on user preferences

Active and interactive worlds are possible with AI-generated content. Survey findings show 88% satisfaction with AI-powered multiplayer interactions, validating the notion that AI-based upgrades promote Metaverse social engagement. Wang et al. (2023) introduced genuine social interaction-enhancing methods. Such results suggest that even AI automation improves human connections. According to Bibri and Jagatheesaperumal (2023), the platform's AIoT technology has improved real-time data processing and social decision-making, maintaining realism. Immersion, Advanced AI Techniques, and improving human interaction show how entire-spectrum AI transforms Metaverse games. AI's effects on engagement, social presence, and platform satisfaction provide empirical advantages and research prospects.

7 Conclusion

This research aimed to provide an analysis of AI technologies in the context of Roblox’s Metaverse with specificity to particularly identify how these technologies improve user experience as well as how they advance human interactions. This research made use of quantitative survey data from 200 participants and used mixed research methods with quantitative data analyzed by SPSS. It allowed for deeper demographic trend examination and feature-by-feature evaluation concerning AI integration in virtual game environments.

The study produced several useful findings that further our understanding of Metaverse gaming with the help of AI. Notably, the study established a highly positive coefficient of 0.83 that showed that AI features significantly enhance user satisfaction. The practical implications include the identification of major age-related differences in feature usage, which may be useful in further focused attempts at feature creation. In addition, the study formulated a positive link between AI-supported settings and player engagement; therefore, there is potential for long-term AI implementation in gaming services.

Thus, this study presents a number of breakthroughs and original findings for the general field of AI in gaming research. It is the first-ever systematic study of AI effects exclusively in the context of Roblox's Metaverse; it defines standards for measuring AI-improved users' experiences. This research also reveals new patterns in AI adoption by users depending on their age, thereby refining understanding of the demographic behavior of users. In addition, the study explores the effectiveness of AI use based on virtual environment factors, which forms a basis for future research on this subject.

8 Limitations and Future Research

In summarizing this research, several limitations should be identified. The survey was only conducted among users who speak English, which might reduce the ease with which the results are extrapolated to any culture. In the same way, the use of only one platform, Roblox, may not give a whole picture of Metaverse gaming. Lack of time also precluded the study of long-term trends in users’ behavior and AI modification that would have been disclosed in the course of longer research.

Nonetheless, these limitations offer openings for future research activities to embrace. Subsequent studies should conduct cross-platform comparison experiments to describe how AI deployment differs in different Metaverse. The long-term tracking of those users would again be beneficial for understanding how the users' engagement with the AI elements of the product evolves. Further, the inclusion of new AI implementation assessment methodologies and qualitative research techniques would provide a further understanding of user perceptions and AI performance in virtual settings.

9 Recommendations

Several strategic recommendations, therefore, can be deduced for the promotion of AI integration in Metaverse gaming from the multi-stakeholder study and analysis. The first recommendation is age differentiation of AI features for developers, which guarantees important target audiences receive specialized features that are consistent with their tendencies in interaction. Higher emphasis on the utilization of Artificial Intelligence in social aspects found within the platform would serve to improve bonding and tightness of the user base. It would be possible to achieve even more flexible and less standardized gaming if the ideas behind adaptive learning systems were put into practice and if users' feedback was incorporated on an ongoing basis. Last, the standardization of AI-cross-platform features would enhance the user's commitment to Metaverse and help increase the usage of AI in gaming features.

In light of these findings, the following recommendations are made for the continued innovations and adoption of AI applications in Metaverse gaming platforms toward enabling meaningful human interactions in simulated game worlds.

Conflict of Interest

The authors report that there are no competing interests to declare.

Ethical Considerations

This research adhered to the research guidelines as outlined by the Declaration of Helsinki.

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Originality Statement

We hereby declare that this research is entirely original.

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