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Impact of the Metaverse Platform Mozilla Hubs on University Learner Satisfaction

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[요 약]

본 연구에서는 Mozilla Hubs에서의 학생 경험과 학습 도구로서의 플랫폼에 대한 전반적인 만족도 사이의 관계를 탐구한다. 에콰도르 대학의 31명의 학부생 데이터를 분석하였다. 사용자 경험, 학습 성과, 기능 품질, 상호 작용 효과가 전반적인 만족도에 미치는 영향을 평가하기 위해 다중 회귀 분석 및 상관 분석을 사용했다. 결과는 사용자 경험과 학습 성과가 만족도에 중요한 영향을 미치며, 특정 기능의 품질과 상호 작용이 만족도에 강하게 영향을 미친다는 것을 보여준다. 이 연구는 탐색 용이성, 고품질 기능, 효과적인 상호 작용의 중요성을 강조하며, 가상 학습 경험을 개선하려는 교육자와 가상 학습 환경 개발자에게 중요한 통찰을 제공한다.

[Abstract]

This study examines the relationship between students' experiences on the Metaverse platform Mozilla Hubs and their satisfaction with the platform as a learning tool. Data from 31 undergraduate students at an Ecuadorian university were analyzed using multiple regression and correlation analyses to assess the impact of user experience, learning outcomes, feature quality, and interaction effectiveness on overall satisfaction. Findings indicate that user experience and learning outcomes significantly influence satisfaction, with feature quality and interaction effectiveness also contributing strongly. These results underscore the importance of ease of navigation, high-quality features, and effective interactions in enhancing student satisfaction. This study offers valuable insights for educators and developers of virtual learning environments aiming to improve virtual learning experiences.

색인어 : 메타버스, 교육, 학습 성과, 사용자 경험, Z세대
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Ⅰ. Introduction

Recent studies have shown that higher education is undergoing significant changes due to evolving pedagogies and diverse learning preferences of Generation Z students born between 1997 and 2012[1]. Digital natives are accustomed to high-tech environments and often find traditional teaching methods uninteresting, which can affect their engagement and knowledge retention[2],[3]. Meanwhile, online learning environments offer flexibility and accessibility, but still lack immersive and interactive elements[3]. Higher education demands innovative approaches that cater to the diverse learning styles of Generation Z students[4]. These students prefer interactive and technologically enhanced learning environments and often find traditional lecture-based teaching methods uninspiring[3]. In this context, metaverse platforms are emerging as a pioneering solution that can transform the educational experience in higher education[5],[6]. Metaverse platforms allow users to create and interact with 3D virtual environments, providing a more persistent and interactive learning experience than is possible on traditional online platforms[6]. The development of metaverse education platforms at home and abroad is showing a movement to bridge this educational gap. The most popular metaverse applications in Korea are Naver Zepeto, SK Telecom's Ifland, and Mocha World, a metaverse platform based on KakaoTalk. Internationally, Roblox, Decentraland, and Meta's Horizon Worlds are the most widely used. Despite the clear promise of metaverse platforms, empirical evidence on the impact on Gen Z students' engagement and content retention is noticeably lacking[6].

This study aims to bridge this gap by analyzing the impact of using Mozilla Hubs as an educational tool. By assessing the level of engagement and content retention of Gen Z students participating in educational activities based on Mozilla Hubs, this study aims to provide insight into the effectiveness of the platform as a learning medium. The results of this study are expected to enrich the understanding of the educational applications of virtual reality environments and to facilitate a paradigm shift in the educational delivery methods preferred by higher education institutions. Therefore, this study proposes a solution through the following process. First, we analyze the theoretical background and related literature on the educational preferences of Generation Z, virtual learning environments, and the effectiveness of Mozilla Hubs in improving higher education. Second, we plan and conduct an empirical study to investigate the impact of Mozilla Hubs on increasing the engagement and levels of satisfaction of Generation Z students. This study includes a sample of University students aged 18-24 who will participate in educational activities conducted through Mozilla Hubs. Third, we collect students' satisfaction and feedback on their experience using Mozilla Hubs through a survey. Fourth, we analyze and interpret the collected data and make suggestions for future research. In conclusion, the purpose of this study is to propose recommendations for higher education institutions to effectively integrate metaverse platforms into their curricula to increase the engagement and learning outcomes of Generation Z students.

Ⅱ. Background

2-1 Metaverse Concept and Platform Utilization Trends

The concept of a connected virtual world has its roots in science fiction literature and has captured imaginations for decades. The term "metaverse" originated in Neal Stephenson's 1992 novel "Snow Crash," which describes a vast virtual space populated by avatars as digital proxies for human operators[7],[8]. Once a fantasy limited by technological constraints, recent advances in virtual reality, augmented reality, blockchain, and artificial intelligence have brought the metaverse closer to tangible realization[1],[9]. The metaverse represents a paradigm shift in education that redefines traditional teaching methods through immersive 3D environments[7]. This technology enables a kind of experiential learning in which students can explore historical timelines, perform safe scientific experiments within simulations, and build connections with a global network of peers[7],[10]. The metaverse seamlessly integrates cognitive and tactile experiences, thereby expanding the boundaries of

Table 1. Metaverse platforms in the education field

Platform	Description	Image
Mozilla Hubs	It is an open-source platform that allows users to create and customize virtual spaces for meetings, events, and training. It supports features such as spatial audio, customizable avatars, and 3D content integration, making it ideal for immersive educational experiences.	
AltspaceVR	It is a social VR platform where users can meet, interact, and participate in events in a virtual space. It can be used for virtual conferences, workshops, and training sessions to provide opportunities for collaborative learning and engagement.	
Engage	It is a virtual reality education platform that provides features such as virtual classrooms, interactive presentations, and collaborative projects. It supports a multi-user environment and customized content, making it suitable for a variety of educational purposes.	
Virbela	It is a virtual world platform that replicates the physical environment for meetings, events, and training. It is used by educational institutions for virtual campuses, lectures, and student collaboration, providing a sense of presence and community in online learning.	
Rec Room	Rec Room is a social VR platform that offers a variety of multiplayer games, activities, and creative tools. Although primarily focused on games, it has also been used for educational purposes such as virtual field trips, language learning, and coding workshops.	
Spatial	It is a mixed reality collaboration platform that allows users to meet and work together in a virtual space using augmented reality (AR) and virtual reality (VR) devices. It can be used in virtual meetings, training sessions, and training workshops to allow participants to interact with 3D content and simulations.	

student engagement and learning[7].

The metaverse is poised to reshape the educational landscape by personalizing educational content and democratizing accessibility across geographic and socioeconomic constraints, providing tailored learning experiences that foster deep conceptual understanding across a broad range of learner demographics[6],[7].

Table 1 presents a summary of the major metaverse platforms currently being utilized in educational settings.

When comparing popular metaverse platforms used in education, Mozilla Hubs offers distinct advantages for higher education. As an open-source platform accessible via web browsers, it allows students to participate regardless of hardware, which is especially beneficial in regions like Ecuador where access to high-end devices may be limited. Its low technical requirements reduce barriers for students from diverse socioeconomic backgrounds. Additionally, Mozilla Hubs provides flexibility for educators to create customized virtual spaces tailored to specific course content, a feature less prominent in other platforms. Given the limited research on its educational use, this study offers valuable insights that could inform future educational strategies and policies, particularly in regions with similar technological and socio-economic contexts.

2-2 Previous Research

Previous studies have shown that user satisfaction of metaverse platforms in an educational context is influenced by several key factors: user experience, learning outcomes, quality, and interactions within the platform.

User experience emphasizes the importance of designing intuitive and engaging interactive technologies, as discussed in “Interaction Design: Beyond Human-Computer Interaction” by Preece, Rogers, and Sharp[11]. Their study emphasizes the need to collect user feedback to improve ease of navigation and overall engagement, which directly

impacts user satisfaction. Similarly, Hassenzahl and Norman emphasize the important role of user experience in technology acceptance and user satisfaction, emphasizing that positive experiences lead to higher engagement and satisfaction[12],[13].

Learning outcomes are also an important factor. John Hattie's "Visible Learning" synthesizes extensive research on factors that influence learning, providing insights into the importance of measuring learning outcomes to evaluate the effectiveness of educational interventions such as Mozilla Hubs[14]. Hattie's meta-analysis emphasizes the importance of students' confidence in understanding learning materials as a predictor of educational success. In addition, Bloom's study on educational objectives and Biggs' study on constructive alignment support the idea that aligning learning activities and assessments with desired learning outcomes is important for improving students' understanding and satisfaction[15],[16].

The quality of specific features within an educational platform also plays an important role. Studies by various researchers have shown that high-quality audio, immersive environments, and accessibility features are essential for increasing user satisfaction. These findings are consistent with the perspectives of authors such as Coates, who investigated the impact of virtual learning environments on student engagement and satisfaction, and concluded that well-designed technical features significantly enhance the learning experience[17].

Interaction and collaboration are essential elements in virtual learning environments. Moore's study shows that three types of interaction—learner-content, learner-instructor, and learner-learner—are important for maintaining student engagement and satisfaction, as are effective interaction tools and real-time collaboration capabilities[18]. These findings are supported by the work of Vrasidas and McIsaac, who explored the role of interactivity in online learning and its impact on student satisfaction and learning outcomes[19]. Jack C. Richards, in his curriculum development work, emphasizes the importance of continuous feedback for improving educational programs. This is consistent with the need to regularly evaluate and improve the quality and interactivity of platforms such as Mozilla Hubs to meet the changing needs of students[20].

Ⅲ. Research Methodology

3-1 Operational and Measurement Methods of Variables

The objective of this study is to understand the factors that influence student satisfaction when using the Mozilla Hubs platform as a learning tool. The independent variables are user experience, learning outcomes, quality, and interaction, and the dependent variable is user satisfaction. Each variable was measured using specific questions, using a Likert scale from 1 to 5. Similar methodology has been used in previous studies to assess variables in the educational technology context[11],[17],[18],[21].

1) Independent Variables

In this study, User Experience was defined as "the ease of navigation and level of participation in the Mozilla Hubs platform"[11]. The measurement items consisted of two questions: "Mozilla Hubs was very easy to navigate" and "the level of participation in Mozilla Hubs was very high" and were measured using a 5-point Likert scale.

Learning Outcomes were defined as "confidence in understanding the subject content and the learning efficiency of the platform after using Mozilla Hubs"[14]. The measurement items consisted of two questions: "I understood the subject content very well" and "The Mozilla Hubs environment was very efficient for learning" and were measured using a 5-point Likert scale.

Quality was defined as "Mozilla Hubs' immersive 3D virtual environment, audio quality, and accessibility"[17]. The measurement items consisted of three questions: "The immersive 3D environment was very helpful," "The audio quality was very good," and "It was very helpful because it could be accessed from anywhere," and were measured using a 5-point Likert scale.

Interaction was defined as "the effectiveness of Mozilla Hubs' social activity and collaboration tools and real-time collaboration"[18],[19]. The measurement items consisted of two questions: "The social activity and collaboration tools were very helpful," and "The real-time collaboration function was very effective," and were measured using a 5-point Likert scale.

2) Dependent Variable

User satisfaction: This was the primary outcome variable that captured students' overall satisfaction when using Mozilla Hubs as a learning tool. Previous research by Cho and Lin Shen highlighted the importance of user satisfaction as a key indicator of the success of educational technologies[22].

3-2 Research Model and Research Question

In this study, we designed a research model based on previous studies on the use of metaverse platforms in the education field. Through a literature review, we have the following research question:

Research Question 1 – How do students' perceptions of the quality and effectiveness of specific features of Mozilla Hubs (immersion, audio, accessibility, interactivity, collaboration) relate to their overall satisfaction with the platform?

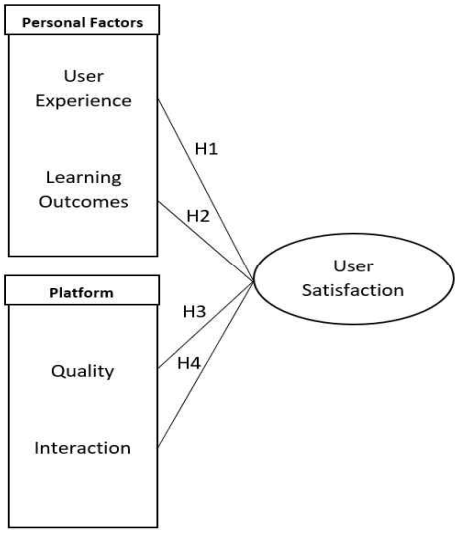

Fig. 1. Research model

3-3 Research Hypothesis

The hypotheses to achieve the purpose of this study are as follow.

(1) H1: There will be a positive correlation between students' self-reported positive user experience with Mozilla Hubs (e.g., ease of navigation, high engagement, few technical issues) and their satisfaction with the platform as a learning tool.

(2) H2: There will be a positive correlation between confidence in understanding learning materials after using Mozilla Hubs and overall satisfaction with the platform as a learning tool.

(3) H3: Students' ratings of the quality of specific features of Mozilla Hubs (immersive 3D environments, audio, accessibility) will have a positive causal relationship with their overall satisfaction with the platform as a learning tool.

(4) H4: There will be a positive correlation between students' evaluations of the effectiveness of Mozilla Hubs ("Social Presence and Collaboration Tools" and "Real-Time Collaboration") and their overall satisfaction with the platform as a learning tool.

3-4 Method

To evaluate the variables measured in this study, a survey was made based on previous studies. The survey was conducted at a university in Ecuador from May 21 to 31, 2024. The participants were students aged 18 to 24 representing Generation Z, and a total of 31 people participated in the survey. They attended classes held in the Mozilla Hubs virtual environment, and the data were collected through an online survey via Google Forms. After data collection, quantitative analysis was performed using SPSS version 27.

Ⅳ. Research Results

4-1 Demographic Characteristics of Respondents

The 31 students who participated in the survey in this study had diverse demographic characteristics. The gender distribution of the respondents consisted of 13 males (41.9%) and 18 females (58.1%). The average age of the participants was 24.65 years.

All respondents (100%) had access to the Internet, and the quality of their Internet connection was as follows: 6 (19.4%) poor, 8 (25.8%) average, 9 (29%) good, and 8 (25.8%) very good.

In the question about their experience using technology, 30 respondents (96.8%) answered that they

had previously used virtual reality technology. Regarding their ability to use virtual reality technology, 21 (67.7%) rated themselves as 'excellent (5)', 9 (29%) as 'good (4)', and 1 (3.2%) as 'insufficient (2)'.

This results can be appreciated in Table 2 and Table 3.

Table 2. Demographic characteristics

Metaverse Class		
	n	%
Gender		
Male	13	41.9
Female	18	58.1
Age		
Mean age (years)	24.65	
Internet Access		
Yes	31	100
No	-	-
Internet Quality Connection		
Very Bad	-	-
Bad	6	19.4
Regular	8	25.8
Good	9	29
Very Good	8	25.8

Table 3. Results of prior experience with technology

Prior experience with technology		
	n	%
Previously used virtual reality technology		
Yes	30	96.8
No	1	3.2
Ability using virtual reality technology		
5 = Excellent	21	67.7
4 = Good	9	29
3 = Fair	-	
2 = Poor	1	3.2
1= Bad or Insufficient.	-	

4-2 Reliability and Validity Analysis

In this study, internal consistency was measured using Cronbach's alpha to increase the efficiency of reliability measurement. As a result of the measurement, most of them showed high internal consistency of 0.7 or higher (user experience 0.68, learning performance 0.84, quality 0.83, interaction 0.87). The results are summarized and shown in Table 4. These reliability analysis results serve as an important factor in increasing the validity of research results, and in follow-up studies based on this, consistent research results can be derived by using a highly reliable measurement tool.

Table 4. Reliability analysis results

Variable	Number of Items	Cronbach's alpha
User Experience	2	0.68
Learning Outcomes	2	0.84
Quality	3	0.83
Interaction	2	0.87

In this study, a factor loading analysis was conducted to measure validity, and the results are summarized in Table 5. The factor loadings of all items were 0.7 or higher, confirming high convergent validity. These results suggest that the measurement items well reflect the concepts of each variable, contributing to increasing the validity of the study.

Table 5. Validity analysis results

Concept	Question	Factor Loading	Eigenvalue	Dispersion Percentage %
User Experience	Mozilla Hubs easiness of navigation	0.825	1.36	68.01
	Mozilla Hubs Participation Level	0.825		
Learning Outcomes	Confidence in understanding what was covered after participating in the class	0.931	1.73	86.76
	Mozilla Hubs Environment Efficiency	0.931		
Quality	Immersive 3D virtual environment	0.856	2.24	74.78
	Audio	0.934		
	Accesibility	0.798		
Interaction	Social activity and collaboration tools	0.942	1.77	88.78
	Real time collaboration	0.942		

4-3 Research Question and Hypothesis Evaluation

1) Correlation Analysis

In this study, the Pearson correlation model was used, and the last row of the table below shows the

Table 6. Correlation analysis results

Variable	User experience	Learning outcomes	Quality	Interaction	User satisfaction
User Experience	1				
Learning Outcomes	0.295	1			
Quality	0.455*	0.633*	1		
Interaction	0.357*	0.576*	0.753*	1	
User Satisfaction	0.409*	0.732**	0.786**	0.661**	1

*p < 0.05, **p < 0.01

correlation coefficients between all variables considered in this study and user satisfaction.

Correlation between User Experience and User Satisfaction: There is a moderate positive correlation (r = 0.409), indicating that better user experience is associated with higher user satisfaction. The positive value indicates a direct relationship in which user satisfaction increases as user experience increases. The moderate strength suggests that user experience has a noticeable but weak effect on satisfaction. This is consistent with previous research on virtual learning environments, which emphasizes that user experience plays a significant role in overall satisfaction[23].

Correlation between Learning Outcomes and User Satisfaction: There is a strong positive correlation (r = 0.732), indicating that better learning outcomes are strongly associated with higher user satisfaction. The strong positive value suggests a strong relationship in which improved learning outcomes significantly improve user satisfaction. This is consistent with research findings on educational platforms that emphasize the impact of learning outcomes on satisfaction[23],[24].

Correlation between Quality and User Satisfaction: There is a very strong positive correlation (r = 0.786), indicating that higher quality is strongly associated with higher user satisfaction. The very strong positive value indicates a very strong relationship in which the quality of features significantly influences user satisfaction. Previous studies also support the importance of quality features in virtual environments[24].

Correlation Interaction and user satisfaction: There is a strong positive correlation (r = 0.661), indicating that better interaction is strongly related to higher user satisfaction. The strong positive value indicates a strong relationship where effective interaction significantly improves user satisfaction. Similar studies have found that interaction features are important in engaging students and increasing their satisfaction[23].

To further analyze the correlations, we categorized the variables into two general groups: personal factors (user experience, learning outcomes) and platform factors (quality, interaction). We also analyzed the correlations between these groups and user satisfaction.

Correlation between Personal Factors and User Satisfaction: There is a strong positive correlation (r = 0.655), indicating that better personal factors are associated with higher user satisfaction. The strong positive value suggests that improvements in personal factors such as user experience and learning outcomes significantly improve satisfaction.

Table 7. Correlation analysis results

	Personal factors	Platform	User satisfaction
Personal factors	1		
Platform	0.730**	1	
User Satisfaction	0.655**	0.846**	1

**p < 0.01

Correlation between Platform Factors and User Satisfaction: There is a very strong positive correlation (r = 0.846), indicating that better platform factors are highly associated with higher user satisfaction. The very strong positive value highlights the significant impact of platform features such as quality and interactivity on satisfaction.

Correlation between Personal Factors and Platform Factors: There is a strong positive correlation (r = 0.730), indicating that improvements in personal factors are likely to be associated with improvements in platform factors. The strong positive value suggests that improvements in personal factors are correlated with better platform features, reflecting an interdependent relationship.

These correlations provide insight into how the grouped variables relate to each other and overall user

Table 8. Regression analysis results

Variable	Non-standardized Coefficients	Standard Error	t-value	Significance (p-value)	Result
Intercept (Constant)	2.046	0.709	2.883	0.007	Accept
User Experience	0.626	0.181	3.454	0.002	
Intercept (Constant)	0.706	0.834	0.847	0.404	Accept
Learning Outcomes	0.898	0.191	4.706	0	
Intercept (Constant)	0.219	1.049	0.209	0.836	Accept
Quality	0.942	0.234	4.029	0	
Intercept (Constant)	0.783	1.061	0.738	0.467	Accept
Interaction	0.902	0.245	3.667	0.001	

$p < 0.01$

satisfaction. The high correlation between platform factors and user satisfaction highlights the importance of high quality features and effective interactivity in increasing user satisfaction.

2) Research Problem Evaluation and Proof-independent variable

In this study, regression analysis was conducted to examine the impact of user experience, learning outcomes, quality, and interaction on user satisfaction. The results of the analysis are summarized in Table 8.

As a result of the regression analysis, the impact of each variable on user satisfaction was found as follows. The regression coefficient for User Experience was 0.626, with a standard error of 0.181. The t-value was 3.454, and the p-value was 0.002, indicating statistical significance. This means that user experience has a positive impact on user satisfaction. It suggests that the ease of navigation in Mozilla Hubs and the level of active participation play a crucial role in increasing students' satisfaction with the platform. This result aligns with previous studies, emphasizing the importance of a user-friendly interface and elements that encourages participation.

The regression coefficient of Learning Outcomes was 0.898, and the standard error was 0.191. The t-value was 4.706 and the p-value was 0.000, which was highly significant. This means that learning outcomes have a strong positive effect on user satisfaction. The higher the students' understanding of the course content and their confidence in the effectiveness of the learning environment, the higher their satisfaction. This is consistent with previous studies that emphasize the importance of learning outcomes in educational success.

The regression coefficient of Quality was 0.942, and the standard error was 0.234. The t-value was 4.029 and the p-value was 0.000, which was highly significant. This means that high-quality features have a significant effect on user satisfaction. This suggests that high-quality features such as immersive 3D environments, high-quality audio, and accessibility are important factors in improving the learning experience.

The regression coefficient of Interaction was 0.902, and the standard error was 0.245. The t-value was 3.667 and the p-value was 0.001, which was significant. This means that interaction has a strong positive effect on user satisfaction. It shows that social activity and collaboration tools, and real-time collaboration functions promote effective interaction between learners, contributing to increasing overall satisfaction.

Therefore, the results of this study confirmed that user experience, learning outcomes, quality, and interaction have a significant impact on the satisfaction of students who use Mozilla Hubs as a learning tool.

V. Conclusions

This study explored the relationship between students' experiences using Mozilla Hubs as a learning tool and their overall satisfaction with the platform. It focused on how students' perceptions of specific features such as immersive environment, audio quality, accessibility, interactivity, and collaboration were related to their satisfaction. The study was conducted with 31 undergraduate students from a university in Ecuador, many of whom had prior experience using virtual reality technology. The Ecuadorian context,

characterized by diverse socio-economic backgrounds and varying levels of access to technology, provides important regional and cultural insights into the adoption of metaverse platforms in higher education.

All hypotheses were supported by the statistical analysis. First, user experience had a significant positive effect on overall satisfaction. This suggests that features such as navigational ease and technological reliability, which may vary depending on students' access to quality hardware and internet connectivity in Ecuador, are critical to enhancing satisfaction. Second, learning outcomes were positively correlated with satisfaction, and satisfaction increased as students' understanding of the learning materials improved after using Mozilla Hubs. This may reflect Ecuadorian students' appreciation for platforms that can provide immersive learning experiences, especially in regions where traditional educational resources may be limited.

Third, the quality of specific features, such as immersive environments, audio quality, and accessibility, had a positive causal relationship with satisfaction. This highlights the need for high-quality virtual environments, particularly in Ecuador, where varying internet speeds and equipment quality can influence the overall user experience. Finally, interaction and collaboration tools showed a positive correlation with satisfaction, confirming that effective use of social presence and real-time collaboration contributed to increasing students' satisfaction. Given Ecuador's collective learning culture, features that enhance social interaction and collaboration are likely to resonate strongly with students.

This study provides important implications. First, improving user experience through better navigation and a user-friendly interface can significantly improve satisfaction in a virtual learning environment, especially in a context where access to technology may not be uniform across different socio-economic groups. Second, creating an environment that fosters confidence in learning outcomes is essential, especially in Ecuador, where students may seek additional support in subjects due to educational disparities in certain regions. Maintaining high-quality features such as immersive environments, sound quality, and accessibility, along with promoting real-time collaboration tools and features that enhance social presence, is crucial for delivering a more engaging and effective virtual learning experience.

However, the study has several limitations. First, the small sample size may limit the generalizability of the findings, particularly in a diverse country like Ecuador. Second, reliance on self-reported data limits the objectivity of the findings regarding learning outcomes and engagement. Future research should focus on larger and more diverse samples, especially across different regions in Ecuador, and incorporate objective measures of engagement and learning outcomes.

In conclusion, this study shows that user experience, learning outcomes, feature quality, and interactivity are important contributors to students' satisfaction when using Mozilla Hubs as a learning tool. These findings offer valuable insights for developing more effective virtual learning environments in higher education, particularly in countries like Ecuador, where digital learning platforms have the potential to transform traditional educational methods and address regional disparities in educational access. Metaverse platforms like Mozilla Hubs can provide dynamic and interactive virtual spaces that meet the needs of modern learners while being adapted to the socio-cultural context of different regions.

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