JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

Jurnal Eduscience (JES)
Volume 11, No. 2
Desember, Year 2024
Submit : 01 February 2024
Accepted : 5 Desember 2024

PERCEIVED DIFFERENCES IN VR EXPERIENCES: A GENDER-BASED ANALYSIS OF ADOPTION AND ENGAGEMENT

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Abstract
This study explores the perceived differences in Virtual Reality (VR) experiences and engagement between boys and girls in an educational context. Utilizing the VR Learning Experience Gender Survey (VRLEGS), data were collected from 132 pupils, comprising 72 boys and 60 girls, following their exposure to various educational VR applications. The study revealed no significant differences between the genders in terms of VR adoption and engagement. The findings align with previous research indicating that while gender can influence technology adoption and usage, the differences are lways significant and can be influenced by various factors such as cultural context and social support. The results suggest that boys and girls perceive and engage with VR technology, similarly, highlighting the potential for VR as an inclusive educational tool. In conclusion, the study demonstrates that VR technology can be effectively utilized in educational settings without significant gender disparity. It is recommended that educators and policymakers continue to integrate VR into curricula, ensuring equal access and support for all students.

Keywords: Gender difference, virtual reality, adoption, engagement, primary school

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INTRODUCTION

Virtual reality (VR) technology has transformed educational practices by creating interactive learning environments that engage students and improve their understanding, as opposed to passive methods of learning. VR's ability to simulate real-world scenarios allows students to experience situations that would be otherwise inaccessible or dangerous, such as historical events, scientific experiments, and geographical explorations (Merchant et al., 2014; Radianti et al., 2020). Recent developments in the VR technology have, therefore, made it affordable and more accessible to more people, thus increasing its adoption in educational institutions. For instance, VR platforms such as Google Expeditions and ClassVR have a lot of educational content, which can make it easy for a teacher to use VR effortlessly within their curricula. Research has indicated that VR has the capability to increase students' motivation and engagement in learning, hence promoting better learning outcomes for those students (Campos et al., 2022; Martarelli et al., 2023). Moreover, VR can really cater to visual, auditory, kinesthetic learning styles (Begum et al., 2024), thus making it a very flexible tool for personalized education.

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The integration of VR technology into early childhood education is transforming traditional learning environments in remarkable ways. This innovative approach offers immersive experiences that cater to various learning styles, enhances engagement, and fosters cognitive development. By creating virtual worlds where children can explore, experiment, and interact with educational content, VR facilitates a deeper understanding of complex concepts that might be challenging to grasp through conventional methods (Lorusso, et al, 2020). One of the most significant advantages of VR is its ability to provide immersive learning experiences. Oubibi and Hryshayeva (2024) highlighted in their study that children can virtually visit historical sites or conduct science experiments in a safe and controlled environment. This experiential learning approach allows them to learn by doing, significantly improving their retention and comprehension of the material. The multi-sensory nature of VR engages young learners in a way that traditional classrooms often cannot, making lessons more memorable and impactful. Also, VR technology caters to diverse learning styles, which is particularly beneficial for young children who may struggle with standard teaching methods (Nuraisyah et al., 2021). Visual learners can manipulate 3D shapes to understand abstract concepts like geometry, while auditory learners can engage with interactive narratives that enhance their comprehension (Chamekha & Hammami, 2020).

Adaptability of VR makes it a powerful tool for inclusive education, ensuring that all students, including those with special needs, can participate fully and benefit from their learning experiences (Chamekh & Hammami, 2020). In addition to enhancing academic understanding, VR promotes the 21st century skills in children such as creativity, problem-solving skills, and collaboration. By allowing children to explore new ideas and environments without the constraints of physical reality, VR stimulates imaginative thinking (Indrasvari et al., 2021). Collaborative projects within virtual spaces foster teamwork and communication skills, encouraging young learners to work together and share ideas in innovative ways (Oubibi & Hryshayeva, 2024). Engagement and motivation are critical components of effective learning, and research indicates that VR significantly boosts these factors among students. Young learners are more likely to participate actively in lessons when immersed in captivating virtual environments. The interactive nature of VR transforms lessons into engaging experiences that feel more like play than work an essential aspect for younger students who thrive on play-based learning (Hu-Au & Lee, 2017). Social skills development is another area where VR can make a significant impact (Maulana et al., 2022). For children with autism or social anxiety, applications designed for practicing social interactions in controlled environments provide valuable opportunities to learn effective communication strategies without the pressure of real-world interactions. These simulations help build confidence and competence in social settings (Lorusso et al., 2020).

Gender-based differences in VR experiences are crucial to the development of effective educational technology. Research evidence indicates that boys and girls may have different preferences regarding, and may act differently with technology, which can impact learning outcomes, attitude and self-efficacy for the two gender (Cai et al., 2017a; Sun et al., 2020). In a study by Gao et al. (2017) and Nguyen et al. (2022) boys often have a preference for interactive games that are competitive in nature; on the other hand, girls prefer narrative and collaborative games. Differences in VR experiences between the genders can largely be ascribed to spatial awareness, technical confidence, and prior exposure to technology. Studies indicate that boys usually have better spatial skills which might influence their navigation and interaction within virtual environments (Cai et al., 2017; de Castell et al., 2019). On the other hand, girls seem to have higher anxiety toward the use of technology, which may affect their motivation and performance in VR settings (Cai et al., 2017).

Addressing these gender differences is crucial to developing an inclusive VR-based educational tool that meets the needs of all learners. Customizing VR content and interfaces to manage expectations for both boys and girls will help teachers ensure that all students gain equal experiences from innovative learning (Shin, 2018). Finally, better understanding and mitigating gender-based disparities in VR engagement can be helpful in reducing the general STEM gender gap, where women have been traditionally underrepresented (Wang & Degol, 2017). Conclusively, VR technology holds tremendous potential for the transformation of experience learning into an immersive and interactive activity. Realization of its potential to that magnitude shall remain hinged on understanding and correcting the gender differentials in how boys and girls perceive and interact with VR. It will make sure that educational tools are effective through VR and inclusive to promote equal opportunities for all learners.

Despite the growing integration of VR technology in educational settings, there remains a significant gap in understanding of the differing ways in which VR is perceived and engaged by boys and girls. There are accepted benefits from extant research that show that VR will change the learning experiences, but it often fails to capture the gender-based differences and variation in responses that one can be expected to have in this experience. Studies have revealed that boys and girls exhibit dissimilar preferences, levels of involvement, and learning results because of spatial ability, technical self-efficacy, and previous technology experience. Nevertheless, there is a lack of comprehensive insight into these gender differences in VR technology. It is this lack of knowledge that is currently hampering the design of VR tools and content that would be inclusive and effective for all students. Without addressing these differences, educational VR strategies are at risk of continuing gender biases and failing to ensure equity in learning opportunities. The educational potential realized with VR applications can be achieved if, and only if, the way boys and girls perceive and engage with them is considered. Thus, this research has been motivated to explore perceived differences in experiences between genders that may foster more balanced and effective educational technologies.

To address this research gap, two research objectives were raised. The first objective is to investigate the perceived differences in VR experiences between boys and girls toward adoption of VR. The second objective is to analyze engagement levels of VR among different genders. From these objectives, two research questions were formulated: How do boys and girls differ in their adoption of VR technology? How do engagement levels with VR vary between boys and girls?

Gender Difference On Technology Adoption

Research has consistently shown that gender plays a significant role in determining an individual's willingness to adopt new technologies (Goswami & Dutta, 2016). While some studies find that men are generally quicker to adopt new technologies, some research suggests that this is not always the case, and the impact of gender can be influenced by a variety of factors, including cultural context, social influence, and the specific technology being considered (Qazi et al., 2022). This gender gap in technology adoption has been observed across various domains, including education, politics, and the workplace.

The exploration of gender differences in children's performance regarding technology use reveals significant disparities influenced by societal norms, access, and attitudes. Studies indicate that boys and girls exhibit distinct patterns in their engagement with technology, which can affect their learning outcomes and self-efficacy. Historically, boys have been found to demonstrate higher confidence in their technology skills compared to girls. Research shows that boys tend to overestimate their abilities, while girls often underestimate theirs. This disparity in self-perception is rooted in broader societal norms that associate technological proficiency with masculinity. In a report by the European Institute for Gender Equality (2024), it was highlights that boys consistently express greater self-confidence in using digital technologies across various skills, which can lead to differences in performance and engagement levels. In contrast, girls may experience anxiety related to technology use, which can hinder their participation and performance in tech-related tasks (Campos & Scherer, 2024).

Access to technology also plays a crucial role in shaping these gender differences. While the digital divide has been closing over recent years, boys are still more likely to have access to computers and other ICT resources from an early age. This early exposure contributes to a greater familiarity and comfort with technology among boys, further solidifying their confidence and engagement levels (Campos & Scherer, 2024; Qazi et al., 2022). Conversely, girls may have less access or may be socialized to view technology as less relevant to their interests, leading to reduced usage and skill development. Parental perceptions also influence how children engage with technology. Qualitative studies indicate that parents often perceive their daughters as using technology primarily for social connections, while they view sons as engaging more with gaming and technical tasks. This perception can lead parents to monitor and guide their children's technology use differently based on gender, potentially reinforcing stereotypes about appropriate technology engagement for boys and girls (Bolenbaugh et al., 2020).

Moreover, research indicates that while girls may outperform boys in certain digital skills assessments, they often lack the same level of enthusiasm and interest in technology-related activities. This phenomenon is linked to the socialization processes that shape attitudes towards technology from a young age. Girls are frequently socialized into roles that emphasize communication and relational skills over technical prowess, which can impact their long-term engagement with technology (Goswami & Dutta, 2016; Qazi et al., 2022). In educational settings, these gender differences manifest in various ways. Boys often utilize technology for gaming or competitive activities, while girls may engage more in collaborative or creative uses of technology (British Educational Communications and Technology Agency, 2008). This divergence not only affects how children perform academically but also shapes their attitudes towards future careers. The implications of these findings suggest a need for educational strategies that promote equal access to technology and encourage both genders to explore a wide range of technological applications without the constraints of traditional gender roles.

In a systematic review, (Qazi et al., 2022) examined gender differences in ICT use and skills for learning and found mixed results. They highlighted that females tend to use learning tools more frequently than males when using technologies like annotatable multimedia e-readers. The study also revealed that males receive greater computer support, positive attitudes, and self-efficacy from parents and peers compared to females and that boys score higher on technical-oriented ICT questions, while girls score better on topics related to schoolwork and social contact (Qazi et al., 2022). Males are generally found to be more technologically adept compared to females (Goswami & Dutta, 2016). In the context of information technology usage, which encompasses computers, email services, and electronic data management systems, gender acts as an influencing factor in technology adoption (Afonso et al., 2012). Similarly, in an interview on the media habits of children conducted with parents of children aged six months to six years in the U.S., it was found that there is no difference between boys and girls in computer usage at younger ages. However, as the children grew older, the girls' interest in using computers declined (Calvert et al., 2005).

While gender differences are not observed in terms of social media interaction, males and females tend to have different motivations for using social network sites. Females primarily use social networks to maintain existing relationships, whereas males use them to make new friends (Alkhunaizan & Love, 2013; Gutierrez-Leefmans & Olaleye, 2021). In mobile and electronic commerce, males and females are found to be equally likely to engage in online shopping, but females are more influenced by consumer reviews than males (Hou, 2015). Regarding the acceptance of e-learning applications, most of the literature highlights gender as a significant factor, with females facing more technical challenges and risk in using technology compared to males (Qazi et al., 2022). Studies have found that gender stereotypes influence perceptions and use of technology. Women are often perceived as less competent in technical fields like IT compared to men (Gutierrez-Leefmans & Olaleye, 2021), and gender stereotypes provide a basis for adopting theories to address the gender imbalance in IT, such as re-evaluating design and application processes (Sobieraj & Krämer, 2020).

Although extensive research has been conducted on gender differences in technology adoption and utilization, there is a notable gap in understanding these differences specifically in the context of VR technologies. As VR becomes increasingly integrated into educational and professional settings, it is crucial to explore how boys and girls perceive and engage with this immersive technology. Addressing this gap will provide valuable insights for designing inclusive VR experiences that cater to diverse genders.

METHODOLOGY

This study employed a pre- and post-test research design to investigate perceived differences in VR experiences between boys and girls. The participants of the study were 132 primary three pupils, aged between 8 and 9 years. The sample included 72 boys and 60 girls. A questionnaire titled 'VR Learning Experience and Gender Survey (VRLEGS)' was designed to elicit information from the participants following their exposure to VR applications. The VRLEGS questionnaire was used to assess the pupils' perceived attitude towards the adoption and engagement of VR. The study was conducted in four phases:

1) Pre-VR Experience Survey. Pupils completed the VR Learning Experience and Gender Survey (VRLEGS) in a controlled classroom setting prior to introduction to VR experiences.
2) Introduction to VR: Pupils were introduced to VR technology through instructional sessions that included demonstrations of VR applications.
3) Interactive VR sessions: Pupils participated in interactive and immersive VR sessions using Google cardboard and mobile phones to engage with various educational applications.

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4) Post-VR Experience Survey: After these sessions, pupils completed the VR Learning Experience and Gender Survey (VRLEGS) in a controlled classroom setting to ensure accurate and consistent responses, enabling the analysis of gender differences in VR experiences.

The data collected was analyzed using both descriptive and inferential statistical methods. Descriptive statistics, such as means and standard deviations, were used to summarize the data and provide an overview of pupils' adoption and engagement levels. Inferential statistics, including t-tests, were employed to identify significant differences in VR experiences between boys and girls.

Informed consent was obtained from the parents or guardians of all participating pupils and minor ascent form was completed by the pupils. Pupils were assured of the confidentiality and anonymity of their responses. Participation was voluntary, and pupils could withdraw from the study at any time without any consequences.

RESULTS

In addressing the first objective, which aimed to investigate perceived differences in VR experiences between boys and girls regarding VR adoption, Table 1 presents the results of an independent samples T-test conducted to examine variations in their attitudes toward VR adoption. This analysis highlights potential gender-specific attitudes, offering insights into how each gender adopt VR technology.

Table 1. Descriptive statistics on Gender difference on VR adoption

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Pretest VR adoption	Boys	72	6.12	1.688	.218
	Girls	60	5.22	1.915	.226
Posttest VR adoption	Boys	72	17.92	1.344	.174
	Girls	60	14.49	2.828	.333

Table 1 shows the mean scores, standard deviations, and standard errors for boys and girls in both the pre-test and post-test scores on VR adoption. In the pre-test, girls (N = 60) had an average adoption score of 5.22 with a standard deviation of 1.915 and a standard error of 0.226. In comparison, boys (N = 72) had a higher average VR adoption score of 6.12, with a slightly lower standard deviation of 1.688 and a standard error of 0.218. In the post-test, the VR adoption scores for both groups increased, but boys continued to show higher VR adoption. Girls' average post-test VR adoption score was 14.49, with a standard deviation of 2.828 and a standard error of 0.333, indicating increased variability in their responses compared to the pre-test. Boys had a significantly higher average post-test VR adoption score of 17.92, with a lower standard deviation of 1.344 and a standard error of 0.174, showing more consistent adoption levels after their exposure to VR. This suggests that boys, on average, not only began with higher VR adoption but also maintained stronger and more consistent adoption following the intervention.

Table 2. Independent Sample Test of Gender difference on VR adoption

	Levene's Test		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean	Std. Error	95% Confidence Interval of the Difference	
								Lower	Upper
Pretest	.418	.519	-2.818	130	.006	-.894	.317	-1.522	-.266
Posttest	42.284	.000	-9.129	105.381	.000	-3.431	.376	-4.176	-2.685

Table 2 presents the results of the independent samples t-test conducted to compare the mean scores of two groups on pre-test and post-test VR adoption. For the pretest VR adoption variable, Levene's test for equality of variances indicated no significant difference in variances between the groups (F = 0.418, p = 0.519), allowing for the assumption of equal variances. The t-test for equality of means revealed a statistically significant difference between the groups' pretest VR adoption scores (t = -2.818, p = 0.006). Specifically, the mean difference was -0.894, suggesting that the first group scored 0.894 units lower on VR adoption compared to the second group. The 95% confidence interval for the difference ranged from -1.522 to -0.266, further supporting the significance of this difference. For the posttest VR adoption variable, Levene's test showed a significant difference in variances between the groups (F = 42.284, p < 0.001), t-test revealed a highly significant difference in posttest VR adoption scores (t = -9.129, p < 0.001), with a mean difference of -3.431, indicating that the first group's posttest VR adoption score was 3.431 units lower than the second group. The 95% confidence interval for the difference ranged from -4.176 to -2.685, emphasizing the substantial gap in posttest VR adoption between the two groups.

The second objective focused on analyzing VR engagement levels across genders. This section presents findings on how boys and girls interact with VR, highlighting any notable differences in engagement and immersion that could influence VR's effectiveness as a learning tool.

Table 3. Descriptive statistics on Gender difference on Engagement

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Pretest	Boys	72	7.11	2.347	.277
Engagement	Girls	60	7.00	1.804	.233
Posttest	Boys	72	22.30	3.461	.277
Engagement	Girls	60	20.07	2.149	.408

Table 3 presents the descriptive statistics for pre-test and post-test engagement scores. For pre-test engagement, boys (N = 72) had a mean score of 7.11 with a standard deviation of 2.347 and a standard error of 0.277. Girls (N = 60), on the other hand, had a slightly lower mean score of 7.00, with a standard deviation of 1.804 and a standard error of 0.233. The means for boys and girls in pre-test engagement appear to be quite similar. For post-test engagement, the mean scores show a more noticeable difference

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between the two groups. Girls had a mean post-test engagement score of 20.07 (standard deviation = 3.461, standard error = 0.408), whereas boys scored higher, with a mean of 22.30 (standard deviation = 2.149, standard error = 0.277). This indicates that boys had a higher level of engagement after the intervention, with a difference of 2.23 units in post-test engagement between boys and girls. The smaller standard deviation and error for boys also suggest that their scores were more consistent compared to the girls.

Table 4. Independent Sample Test of Gender difference on Engagement

	Levene's Test		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean	Std. Error	95% Confidence Interval of the Difference	
								Lower	Upper
Pretest VR engagement	8.896	.003	.307	129.207	.759	.111	.362	-.604	.827
Posttest VR engagement	42.284	.000	-4.521	120.789	.000	-2.231	.493	-3.207	-1.254

Table 4 presents the results of the independent samples t-test comparing boys' and girls' VR engagement scores in the pre-test and post-test. For the pre-test VR engagement scores, Levene's test for equality of variances is significant (F = 8.896, p = 0.003), indicating unequal variances between the groups. As a result, the t-test results from the row where equal variances not assumed are reported. The t-value is 0.307 with a p-value of 0.759, indicating no statistically significant difference between boys' and girls' pre-test engagement with VR. The mean difference is minimal at 0.111, and the 95% confidence interval for the difference ranges from -0.604 to 0.827, further confirming that there is no meaningful difference in pre-test engagement levels between the two groups. In contrast, the post-test VR engagement scores reveal a significant difference between boys and girls. Levene's test is again significant (F = 42.284, p = 0.000), pointing to unequal variances, so the results from the equal variances not assumed row are considered. The t-test shows a statistically significant difference with a t-value of -4.521 and a p-value of 0.000, indicating that boys had significantly higher engagement with VR compared to girls after the intervention. The mean difference is -2.231, meaning that, on average, boys post-test VR engagement scores were 2.231 points higher than girls. The 95% confidence interval ranges from -3.207 to -1.254, and since it does not include zero, it further confirms the significance of the gender difference in post-test VR engagement. This suggests that while there was no significant difference in VR engagement between boys and girls before the intervention, boys demonstrated significantly higher engagement with VR in the post-test.

DISCUSSION

The findings of this study provide insightful information regarding gender differences in VR adoption and engagement. The findings from the current study align with established research on gender differences in technology usage. The results indicate a significant gender gap in both the adoption and engagement with VR technology, with boys generally demonstrating higher levels of both in the posttest compared to girls. This aligns with the body of literature suggesting that boys typically exhibit greater technological self-efficacy, confidence, and interest in technology-related activities (Goswami & Dutta, 2016; Campos & Scherer, 2024). The posttest findings reflect that boys not only started with a higher baseline in VR adoption and engagement but also maintained and even widened this gap after the intervention. This may be attributed to societal norms that encourage boys to engage with competitive and interactive technological activities more than girls, as previous studies have shown (Cai et al., 2017; Gao et al., 2017). The greater consistency in boys' VR engagement post-test scores, with lower standard deviations compared to girls, also supports the notion that boys are generally more comfortable and confident with technology use, possibly due to earlier exposure and positive reinforcement in such environments (Qazi et al., 2022). Boys' superior spatial awareness and prior experience with interactive gaming and other tech-driven activities, as highlighted by studies like de Castell et al. (2019), could further explain their stronger performance in VR environments. Girls, on the other hand, may face more anxiety or hesitation toward technology, potentially influencing their engagement levels (Cai et al., 2017).

The significant gender disparity in post-test VR engagement scores underscores the need to address these differences when designing and implementing educational technologies like VR. Research by Shin (2018) suggests that designing VR experiences that cater to the preferences and needs of both genders perhaps by creating more collaborative and narrative-driven VR experiences, which girls tend to prefer could help narrow the gender gap in technology adoption and engagement. Moreover, this study's findings echo broader concerns about gender equity in STEM education, where boys have traditionally outperformed girls in technology-related fields (Wang & Degol, 2017). Ensuring that VR and other digital learning tools are inclusive and engaging for both genders is critical to fostering equal opportunities for all learners, particularly in fields like science and technology where gender disparities persist (Mansah & Safitri, 2022; Safitri et al., 2019; Safitri & Ansyari, 2024; Uswatun Hasanah et al., 2023). This study reinforces the importance of considering gender when developing educational technologies. Boys' higher post-test VR engagement and adoption levels emphasize the need for educators and technologists to create more gender-responsive designs to ensure that both boys and girls benefit equally from the immersive potential of VR. Without addressing these disparities, the risk of perpetuating gender biases in educational technology use remains high, and the potential for VR to transform learning experiences may not be fully realized for all students.

CONCLUSION

This study explored gender differences in the adoption and engagement of virtual reality (VR) technology among boys and girls, with a focus on pre-test and post-test scores. The findings demonstrated significant gender-based disparities in both VR adoption and engagement. Boys exhibited higher initial and post-intervention VR adoption and engagement compared to girls. These results align with previous research, which suggests that boys generally demonstrate higher confidence, spatial skills, and motivation when using technology, while girls may experience higher levels of anxiety or less interest, particularly in competitive or technical activities. Despite the benefits of VR in enhancing learning outcomes and

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engagement for all students, gender-specific factors continue to play a critical role in shaping how students perceive and interact with VR technologies.

The study contributes to the growing body of literature on gender differences in technology adoption, underscoring the importance of recognizing and addressing these differences when designing and implementing educational technologies. The gender gap identified in this study highlights the need for more inclusive strategies that cater to the diverse preferences and needs of boys and girls in educational settings.

Based on the findings of this study, several key recommendations are proposed to address the gender disparities observed in VR adoption, engagement, and interest. Firstly, teachers should adopt personalized VR learning approaches that accommodate the varying needs and preferences of both boys and girls. Since boys and girls tend to engage differently with VR technology, it is important to design learning experiences that appeal to each gender. For example, collaborative, narrative-driven content may resonate more with girls, while competitive or spatially oriented tasks may better engage boys. Tailoring VR activities in this way ensures that both genders benefit equally from these technologies. Secondly, it is crucial to focus on gender-inclusive curriculum design. Educational institutions and curriculum developers should aim to create VR learning experiences that offer a balance of activities, including individual tasks, group-based problem-solving, and both technical and creative challenges. This variety will help address the differing interests and strengths of boys and girls, fostering a more inclusive learning environment where all students feel supported.

Moreover, efforts should be made to reduce technology anxiety among girls. One way to achieve this is by introducing additional support programs or workshops that help build girls' confidence and familiarity with VR. These interventions can include introductory sessions focused on developing technical skills in a less competitive and more collaborative setting. This would encourage greater engagement from girls, reducing the barriers they may face in embracing VR technology. Another critical area of focus is teacher training on gender differences in technology adoption. Teachers play an essential role in facilitating equal participation in VR activities, and therefore, professional development programs should include strategies for recognizing and mitigating gender-based disparities in the classroom. By raising awareness and providing educators with tools to create more gender-inclusive environments, schools can ensure that both boys and girls are equally motivated to engage with VR learning. In addition, further research on gender differences in emerging technologies is necessary. While this study provides valuable insights into VR engagement, more in-depth research is needed to explore how boys and girls interact with other forms of emerging technologies in various educational contexts. This would help develop more comprehensive strategies to close gender gaps in technology adoption.

Finally, policy-makers should advocate for gender-sensitive educational technology policies. This includes ensuring that all students, regardless of gender, have equal access to technology and opportunities to explore their interests in VR and other digital tools. By promoting policies that emphasize inclusivity, educational systems can help break down the traditional gender roles that limit students' engagement with technology. By implementing these recommendations, educational stakeholders can take meaningful steps toward fostering a more inclusive and equitable learning environment that encourages all students, regardless of gender, to fully engage with VR and other emerging technologies.

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p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
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LIMITATIONS OF THE STUDY

This study has several limitations that should be considered when interpreting the results. Firstly, the study focus on a single type of VR application may have limited the generalizability of the findings to other forms of immersive or emerging technologies. Different VR applications vary in complexity, content, and user interaction, which could lead to different patterns of engagement and interest among participants. Future studies should consider using a range of VR tools and platforms to provide a more comprehensive understanding of gender differences in technology adoption.

Another limitation is the potential for response bias, as the data were collected through self-reported questionnaires. Students may have responded in a way they believed to be socially desirable or in line with perceived expectations rather than their true experiences and perceptions. Additionally, the study focused on a specific age group, which may limit the generalizability of the findings to other age groups or educational levels. The study also did not account for other factors that might influence VR adoption and engagement, such as prior experience with technology, individual learning styles, or socioeconomic background. These factors could potentially impact students' interactions with VR technology and should be considered in future research. Finally, the cross-sectional nature of the study means that it provides a snapshot of VR adoption and engagement at a single point in time, without examining how these interactions might evolve over longer periods.

Acknowledging these limitations is crucial for understanding the scope and applicability of the study's findings and for guiding future research to address these gaps and build on the current study's insights.

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