International Journal of Research in E-learning
Vol. 11 (1), 2025, pp. 1–22

DOI 10.31261/IJREL.2025.11.1.08

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A Study on the Impact of Verse in the Metaverse: Exploring the Role of Avatars in Scientific Storytelling

Abstract

The current research focuses on the effects of Avatar-Based Storytelling within a metaverse-type environment on the learning performance, engagement, and emotional-social experience of primary school students within science education. In Poland, a quasi-experimental pre-test post-test control group design was used with 50 students aged between 8 and 12. Because it was conducted on an experimental basis, the first group experienced a two-week intervention, in which avatars used interactive science scripts, while the second group interacted with the same content via conventional digital media. The results of pre- and post-tests, as well as the engagement survey, showed that learning and engagement in the experimental group improved significantly ($p < .001$). Data from the focus group interviews in the form of qualitative results showed that the participants perceived avatars positively as credible and relatable characters that evoked emotions. The findings contribute to the positive view that short-term avatar-based narratives can support improvements in cognitive performance, motivation, and emotional bonding of virtual learning contexts. Discussions on the implications of immersive pedagogy and directions for future longitudinal research are provided.

K e y w o r d s: Avatar-Based Learning, Metaverse Education, Storytelling, Virtual Learning

Introduction

The integration of virtual reality (VR) and augmented reality (AR) technologies into primary education has become a growing research trend. These immersive technologies are valued for their ability to enhance engagement, support experiential learning, and visualize abstract concepts (Elmqaddem, 2019; Villena-Taranilla et al., 2022). At the primary level, children's cognitive development is characterized by the transition from concrete to abstract thinking (Piaget, 1970), making VR/AR particularly suitable for bridging conceptual understanding through multisensory, interactive learning experiences (Wu et al., 2024).

Young learners often require multisensory stimulation and interactive environments to maintain attention and motivation. Studies show that AR and VR environments significantly increase student engagement and intrinsic motivation in primary school contexts (Sökmen, et al., 2024; Pahmi, et al., 2023). AR applications, for example, allow pupils to manipulate 3D objects overlaid on the physical environment, promoting curiosity and active participation (AlNajdi, 2022).

Background and Rationale

Immersive technologies create a sense of "being there" (presence) and allow learners to interact with 3D objects and simulations rather than only viewing static text or images. This aligns well with constructivist and experiential learning theories which emphasize active manipulation and situated practice. Conceptual work by Elmqaddem (2019) argues that recent advances in affordable hardware and software make VR/AR genuinely viable for mainstream education, offering new pedagogical models that better fit 21st-century learners. A large narrative review by Zekeik et al., (2025) synthesized 53 studies and concluded that both VR and AR are particularly promising for domains requiring spatial reasoning, complex procedure training and multimodal representations, because they can simulate environments that would otherwise be dangerous, expensive or impossible to access (e.g., surgery, hazardous industrial contexts, remote locations).

Primary students frequently face challenges in understanding abstract ideas such as geometry, scientific processes, or historical time. AR can make invisible phenomena visible, allowing learners to “see” magnetic fields, molecules, or geometric relationships (Wu et al., 2024). In a controlled experiment, Wu and co-researchers (2024) found that AR mathematical picture books improved elementary students’ geometric reasoning while reducing cognitive load compared with traditional books. Similarly, AR-based math tools foster better spatial understanding and conceptual change in early STEM learning (Alibraheim et al., 2023). VR offers a safe and controllable environment for simulations, virtual field trips, and skill practice. Primary school students can explore a rainforest or human anatomy virtually without logistical or safety constraints. Villena-Taranilla et al. (2022), in a meta-analysis of VR in K-6 education, reported moderate-to-large learning effects (Hedges’ $g \approx 0.66$) when VR was used for exploratory, guided, or inquiry-based learning tasks. Introducing immersive technologies early contributes to the development of digital literacy and spatial reasoning-key components of future digital competence frameworks (Maryani, et al., 2024). By engaging with VR/AR, pupils also begin to understand responsible, creative, and collaborative uses of technology, essential for 21st-century learning (Jiang et al., 2025). Empirical evidence suggests positive learning outcomes. Sökmen et al. (2024) found that AR interventions in mathematics significantly improved achievement and motivation among 4th-grade students compared with control groups. Pahmi et al. (2023) also demonstrated that AR applications helped overcome math anxiety and increased problem-solving confidence in primary learners. A recent meta-analysis by Sandoval-Henríquez et al., (2025) revealed that immersive technologies in primary education yield a moderate overall effect ($g = 0.52$) on learning outcomes, confirming their pedagogical value when effectively implemented.

Beyond cognitive benefits, VR/AR positively affect learners’ enjoyment, engagement, and flow. Wu et al. (2024) reported that AR picture books produced higher flow experiences and lower extraneous cognitive load. These findings suggest that the immersive and interactive nature of AR/VR enhances students’ emotional connection to learning tasks, an important factor in early education (AlNajdi, 2022). Despite clear benefits, challenges persist. Teachers often report barriers such as lack of infrastructure, insufficient training, and time constraints (Villena-Taranilla et al., 2022; Jiang et al., 2025). Studies emphasize that effectiveness depends heavily on pedagogical integration—VR/AR must be aligned with learning goals and scaffolded with teacher guidance (Elmqaddem, 2019). For younger children, simplicity of interface and age-appropriate content are also critical to prevent cognitive overload (Wu et al., 2024).

The Metaverse is a digital space, appearing as a part of the physical reality in specific places and moments. It is based on state-of-the-art technologies, including VR, AR, 3D simulation and AI. Within it, users can interact not only with each other but also with digital objects in real time. This is known as “parallel digitalized world' containing economic, social and cultural systems like the real-life physical world that offer intelligent applications and services for extending human experiences beyond their capabilities (Shi et al., 2024; Riva & Wiederhold, 2022). Thus, the metaverse emerged as a promising paradigm that may potentially change cognitive phenomena of embodiment, social presence and emotional engagement in learning. With leading technology companies investing heavily in its development, application-based learning is fast making inroads on education communication, and daily life, promising new opportunities for experiential activity-based learning.

The Metaverse represents a parallel digitalized world in which virtuality and reality converge. It mirrors economic and social structures of the real world and provides intelligent applications and services (Shi et al., 2024). The Metaverse is designed to expand connectivity, provide information and services to users, and offer limitless benefits and opportunities for innovation. Its use is changing our lives and allowing us to experience immersive and fantasy elements (Raad & Rashid, 2023).

By enabling students to generate their avatars in an online learning environment, the Metaverse promotes collaboration, success, and helps students "see" and get to know their classmates. According to Gavaldon et al. (2022), VR learning activities involving self-avatars and immersion resulted in higher knowledge, understanding, objective programming ability, presence, and attitudes toward computer science and computational thinking in middle school students. Using avatars and distance simulation as effective adjuncts to realistic face-to-face simulation, especially when assessing communication and leadership skills, can reduce travel distance and cost improving accessibility (Löllgen et al., 2022) as educators face persistent restrictions to face-to-face education of medical students and healthcare professionals.There is paucity of published data regarding the benefits and barriers of distance and avatar simulation training modalities.MethodsFollowing a 2-day virtual pediatric simulation competition facilitated by Netzwerk Kindersimulation e.V., using remote human avatars and distance simulation, we conducted a multicenter survey to explore the advantages and challenges of avatar and distance simulation among participants. We used a modified Delphi approach to draft and develop the 32-item online questionnaire with 7-point Likert-like scales (7 being the highest rating).

Digital storytelling provides students with tools that enhance their learning by encouraging them to explain engineering concepts while tinkering, and later recall what they learned during these activities (Pagano et al., 2024).

Çetin (2021) found that digital storytelling significantly enhanced the digital literacy of students, with the highest gains observed in the creation phase. Similarly, Wu and Chen (2020) note that while digital storytelling has become an increasingly popular pedagogy across countries and educational levels, it still faces challenges such as linguistic barriers, overly optimistic expectations, and the need for further research.

In conclusion, although both the metaverse and digital storytelling have shown great promise to learn, limited evidence is available regarding their combined use through avatar-based narratives in primary science education. Accordingly, this study explores how metaverse-based avatars affect students' cognitive learning, engagement, and emotional-social development.

In this context, the study *aims* to address this gap and contribute to a better understanding of how immersive technologies can support learning in ways that are meaningful and effective.

Methodology of research

Objectives of the Study were:

1. To assess the impact of avatar-driven storytelling on student engagement in the metaverse.
2. To evaluate knowledge retention and cognitive comprehension when students learn through Avatars.
3. To explore the role of Avatars in emotional and social learning within virtual environments

Research Questions were identified:

RQ1: In what ways does Avatar-based storytelling shape student engagement in virtual learning environments?

RQ2: How does knowledge retention differ between students experiencing Avatar-based learning and those using traditional digital methods?

RQ3: How do students perceive Avatars as guides and educators in immersive learning environments, and what factors do influence these perceptions?

Hypothesis H1-H3 were formulated adequate to RQ1-RQ3:

H1: Storytelling using avatars in the metaverse resulted in higher cognitive learning outcomes as compared to traditional digital learning.

H2: Avatar-based storytelling enhanced student interest as compared to other non-immersive teaching-learning provisions.

H3: Avatar-based narration helped improve emotional and social attachment to the learning process for students.

Methodology

Using a quasi-experimental pre-post-test control group design (Somuncu & Aslan, 2022), this study investigated the effects of the avatar-based storytelling in a metaverse on students' recall knowledge, engagement, and perception of learning outcomes. The participants were completely randomized into two groups: the experimental group and the control group. The experimental group interacted with scientific stories through avatars on the Verse metaverse platform, where avatars served as interactive guides to explain and demonstrate critical scientific processes using stimulating storytelling (Dudley et al., 2023). On the other hand, the control study group had the same scientific content presented through traditional digital methods of videos, PowerPoint, and text materials, without avatars and interactive narrative.

All participants completed a pre-test measuring existing knowledge before the intervention (Shahzad et al., 2024). A similar post-test was conducted after a two-week intervention to assess cognitive, emotional, and social attachment. Supplementary data included an engagement survey, teacher observations, and focus group interviews to assess emotional and social reactions to the intervention. The mixed-methods approach allowed for an in-depth analysis of the learning experiences of the two groups and offered general conclusions on the power of avatar-based storytelling as a means of promoting science education (Xu et al., 2024; Popa et al., 2020).

Students in the experimental group learned science through avatar-performative stories using audio narration and the Verse platform (VERSE, 2025). VERSE (Virtual Environment) is a metaverse-based educational tool that helps provide immersive, narrative-driven education. Within this virtual world, learners interacted with animated avatars who explained science-related concepts through dialogue, visuals, and built-in tasks.

Participants Selection Criteria and Sample Size

This study involved children aged 8–12 years from the Primary School No. 1 in Ustroń, Poland. A total of 50 students participated, with 25 assigned to the experimental group and 25 to the control group. This sample size is consistent with the recommended sample for studies (Zheng et al., 2020). The participants were selected using stratified random sampling to ensure diversity in cognitive ability, prior digital exposure, and experience with virtual environment, providing a balanced representation across groups (Chang et al., 2021; Triveni et al., 2024). Parental consent was obtained, and all participants received orientation to ensure basic digital literacy.

Data Collection Methods

Data were collected through pre- and post-tests assessing knowledge retention (Stratton, 2019) , Likert scale questionnaires (Koo & Yang, 2025) measuring engagement and motivation, and teacher observations monitoring participation. Focus group interviews provided qualitative insights (Adler et al., 2019) into students' experience with avatar-based storytelling. The mixed-methods design provides rigorous testing of the learning intervention (Mulili et al., 2025).

Assessment Implementation

Evaluation was continuous via a systematic process to evaluate learning effectiveness and progress (Miller et al., 2020). Formative evaluation occurred during lessons via quizzes, immediate feedback, and student reflection with avatars. Summative evaluation took place after the intervention via pre- and post-tests to evaluate knowledge retention and conceptual understanding. Engagement surveys were used to evaluate students' interest and motivation levels in the metaverse-enabled learning environment.

Systematic evaluation techniques were used to quantify student learning outcomes through assessment. Quizzes, feedback, and avatar-mediated interactive discussions were used to track students' development during the intervention as formative assessments (Nauta et al., 2023). Pre- and post-tests assessed knowledge retention, comprehension, and problem-solving capabilities via summative assessments. Student engagement questionnaires assessed motivation and interest levels in avatar-mediated storytelling classes.

Evaluation was comprised of formative and summative methods (Svensäter & Rohlin, 2023). Formative evaluation included immediate instructor feedback and interactive quizzes in the metaverse. Summative evaluation was based on pre- and post-conceptual understanding tests, levels of engagement, and student reflections (Divjak et al., 2024; Holmes, 2018). Performance metrics were examined to ascertain the efficacy of avatar-based storytelling in learning.

Scenario-Based Lesson Design

Adoption of a scenario-based teaching methodology was a fundamental instructional strategy used in this study to engage students, promote critical thinking, and apply real-world problem-solving (Wang et al., 2024). Scenarios were created in a fictional or semi-realistic setting for students to interact with the characters or avatars. These practice-based scenarios presented a central problem or focus for the students to investigate and work on together in groups to propose a resolution to be solved through various creative means (Hosseinzadeh et al., 2022) predominantly from India (40.5%). The learning process was divided into steps, involving narrative exploration, group tasks, presentations, and reflective conversations. The method was designed to support deep learning through the contextualization of academic material. Tasks addressed both cognitive processing (retention and conceptual understanding) and affective engagement (motivation, presence, and emotional connection), in accordance with the Cognitive Affective Model of Immersive Learning (CAMIL) (Makransky & Petersen, 2021). Student learning and participation were assessed through the observation of small group work, formative assessment of group products, peer review of these products, and student reflection at both the individual tool-mediated level as well as the cognitive (and affective engagement and social presence) one.

Pre- and Post-Tests

Pre- and post-tests were designed corresponding to CAMIL (Makransky & Petersen, 2021), which aims to assess the cognitive development at a suitable level for 8–12-year-olds. Test content covered three main cognitive categories based on which the contents of the exams were prepared: remember, understand, and apply. The pre-test (in which students were provided an instructional storytelling session) assessed their background, prior knowledge of basic science concepts such as plant growth requirements, photosynthesis, and reproduction. It included recognitional multiple-choice items (e.g., asking about what plants need to grow) and short-answer response items that were designed to get students to articulate their preliminary understanding of the critical terms and concepts (e.g., "photosynthesis") and to tell what they currently know about plant reproduction. Those items represented the lower levels of Bloom's revised taxonomy – Remember and understand (Anderson, et al., 2001). The post-test was given immediately after the lesson and was designed to measure the level of understanding and transfer of information. It consisted of both multiple-choice and open-ended questions. Requirements involved explanatory writing (e.g., students needed to make meaning by explaining scientific language and processes (e.g., how chlorophyll works, what leaves do during photosynthesis)). Several open-ended questions (Hauer et al., 2020; Nedjat-Haiem & Cooke, 2021) were also included to assess whether learners could use information in context, e.g., they were asked to explain pollination, the start of plant life, and the significance of photosynthesis to organisms. Reflective questions, however, were integrated to stimulate personal reflection and conclusion regarding the story information.

Data Analysis

A mixed-methods study design (Hoffman et al., 2022; Biwer et al., 2020) was utilized to examine the effectiveness of avatar-based storytelling within the Verse metaverse. Python was used to analyze quantitative data (pre-posttests and engagement surveys). Data cleaning was conducted through libraries such as Pandas and NumPy, and statistical analysis through libraries such as Matplotlib and Seaborn sponsored by the Library of Science (Shepherd, Edo, Parasta, Van Vu, & Burke, 2016). Differences between control and experimental groups were evaluated by statistical tests, such as paired t-tests and ANOVA.

NVivo was used for qualitative data (open-ended survey responses and interviews) (Dixon-Woods et al., 2020) collate, and analyze routine patient data have prompted optimism about the potential of learning health systems. However, real-life examples of such systems remain rare and few have been exposed to study. We aimed to examine the views of design stakeholders on designing and implementing a US-based registry-enabled care and learning system for cystic fibrosis (RCLS-CF). This program facilitated systematic coding and thematic analysis by assisting in identifying patterns and understanding themes regarding students' experiences and perceptions. Triangulation of quantitative and qualitative analyses resulted in a holistic view of the intervention effect (Dixon-Woods et al., 2020) collate, and analyze routine patient data have prompted optimism about the potential of learning health systems. However, real-life examples of such systems remain rare and few have been exposed to study. We aimed to examine the views of design stakeholders on designing and implementing a US-based registry-enabled care and learning system for cystic fibrosis (RCLS-CF; McGregor et al., 2022).

Quantitative Data Analysis

The internal consistency of the pre-test and post-test instruments was analyzed using Cronbach's alpha (α). The pre-test, administered to 10 students, 5 from each group, had 0.723 Cronbach's alpha, indicating acceptable reliability (George & Mallery, 2003).

The posttest consisted of 10 items and was applied to the same 50 students in pretreatment. Although there were only 50 samples, Cronbach's alpha was computed from a total of 158 responses, encompassing responses on all the test items. The final alpha value of 0.789 indicates a good internal consistency."

To evaluate the effectiveness of the instructional intervention, total test scores were compared before and after the two-week learning period. As shown in Table 1, students' scores improved notably. Before the intervention, the mean total score was M = 4.24 (SD = 0.84), while post-intervention scores increased to M = 7.22 (SD = 1.89). These results suggest a positive impact of the instructional approach on student learning outcomes.

Table 1

Descriptive Statistics: Total Score (Before vs. After)

Statistic	Mean (Before)	SD (Before)	Mean (After)	SD (After)
Total Score	4.24	0.84	7.22	1.89

S o u r c e: Own elaboration.

To compare mean scores of post-tests in the experimental (avatar-based) group and control group, an independent samples t-test was used. The analysis showed a significant difference in performance levels, t (48) = 9.84, p < 001, and the experimental group scored significantly higher than the control group. This may suggest that the learners who were first exposed to avatars enjoyed and remembered the story content more effectively and possibly maintained positive memories about avatars than those in the traditional essay-based condition. Statistical significance was set at an alpha level of 0.05.

Table 2

Independent Samples t-Test: Post-Test Scores by Group

Comparison	T	Df	p-value
Post-Test (Experimental vs. Control)	9.84	48	< .001

Source: Own elaboration.

Paired samples t-tests were conducted for each group (n = 25). The experimental group showed a significant increase in scores from pre- to post-test, t (24) = –9.39, p < .001. The control group also demonstrated significant improvement, t (24) = –4.53, p < .001. Degrees of freedom (df) reflect n-1 for each paired sample group. These results suggest the avatar-based instructional method had a stronger effect on student learning outcomes.

A two-way mixed-design ANOVA was conducted to examine the effects of instructional group (Experimental vs. Control) and time (Pre-test vs. Post-test) on students' total test scores. The analysis revealed a significant main effect of time, F (1, 198) = 959.62, p < .001, indicating that student scores improved overall following the intervention. The main effect of group was not statistically significant, F (1, 198) = 2.99, p = .086. However, there was a significant interaction between group and time, F (1, 198) = 243.14, p < .001, suggesting that the experimental group showed a greater improvement in test scores compared to the control group.

Table 3

Paired Samples t-Test Results for Pre- and Post-Test Scores

Group	t	Df	p-value
Experimental	–9.39	24	< .001
Control	–4.53	24	< .001

Source: Own elaboration.

A two-way mixed ANOVA was conducted on students' total test scores to evaluate the effects of both instructional group factor (Experimental vs. Control) and time factor (Pre-test vs. Post-test). The analysis indicated a significant group main effect, F (1, 96) = 157.94, p < 001, indicating the experimental group achieved higher overall scores than the control group. A significant main effect of time was also observed, F (1, 96) = 32.95, p < 001, indicating that the scores improved greatly from pretest to post-test. Most importantly, there was a strong interaction effect between group and time, F (1, 96) = 67.70, p < 001; that is, the experimental group exhibited more improvements with scores across time than the control group. It can be inferred that the error bars are comparatively smaller in the post-test scores of the experimental group, which indicates less variation in performance.

Table 4
Mixed-Design ANOVA Results (Group × Time)

Effect	F	Df	p-value
Group	157.94	1, 96	< .001
Time	32.95	1, 96	< .001
Group × Time	67.70	1, 96	< .001

Source: Own elaboration.

A Wilcoxon signed-rank test was performed to evaluate whether students' total engagement scores significantly differed from the neutral midpoint value (24), based on eight Likert-scale items (1–5 scale). The test indicated a statistically significant difference, W = 0.00, p < .001, suggesting that students reported significantly higher engagement levels compared to a neutral expectation. The mean engagement score was 32.28 (SD = 2.26), with scores ranging from 28 to 36 out of a maximum possible of 40.

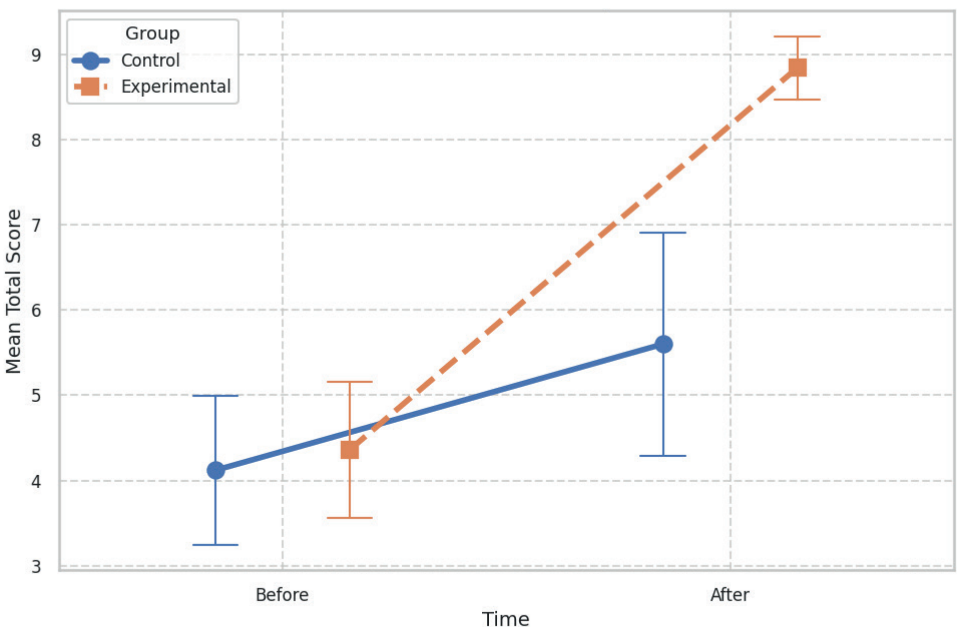

Figure 1. Interaction Plot: Mean Total Scores Before and After by Group

Source: Own elaboration.

Table 5
Descriptive Statistics for Engagement Scores (n = 25)

Metric	Value
Mean	32.28
Standard Deviation	2.26
Minimum	28.00
25th Percentile	31.00
Median	32.00
75th Percentile	34.00
Maximum	36.00
Wilcoxon W	0.00
p-value	< .001

S o u r c e: Own elaboration.

Engagement scores were calculated from eight 5-point Likert-scale items (maximum score = 40). The neutral midpoint score was 24. W = Wilcoxon signed-rank test statistic. $p < .05$ was considered statistically significant.

Qualitative Analysis of Focus Group Interviews

Table 6
Frequency of Themes Identified in Focus Group Responses

Theme	Frequency
Uncoded	10
Engagement	5
Understanding	3
Avatar Preference	3
Confusion	2
Total	10

S o u r c e: Own elaboration.

Frequencies represent how many responses under each theme were coded by participants. Uncoded responses refer to answers that were uncertain, off-topic, or unrelated to the study's aims.

A second theme, Engagement, was strong across comments to this question, with students invariably reporting the avatar activities were ‘‘fun”, ‘‘game-like,” and ‘‘more interesting than normal lessons”. This theme was the most prevalent (n = 5), implying that avatar-based storytelling may increase emotional engagement and motivation. Some students highlighted that the narrative and interactive aspects helped them feel immersed. "I felt like I was a part of the story, not just learning".

The study findings suggest that an avatar-based storytelling approach can contribute to students' intrinsic motivation through the process of engaging routine course content in meaningful and personally relevant ways, in accordance with constructivist and narrative-driven approaches to learning.

The same (n = 3) was found concerning students' understanding that avatar learning influenced cognitive achievement. According to students, the avatars helped remember key concepts, especially in complex areas like ecosystems or food chains. "It helped me to remember things better when I hear the voice and the mission," said one student. Some mentioned a better understanding because of the visual and interactive nature. These observations are consistent with the notion that instruction with avatars can scaffold learning, particularly through multimodal reinforcement that contributes to memory encoding and recall.

This research question directly relates to Avatar preference (n = 3). The students described the avatar as "funny," "like a teacher," or "cool to follow." This feedback indicates that avatars were not only entertaining but also considered credible and relatable guides. For example, one participant said, "The avatar was explaining better than the videos because it was speaking like a person."

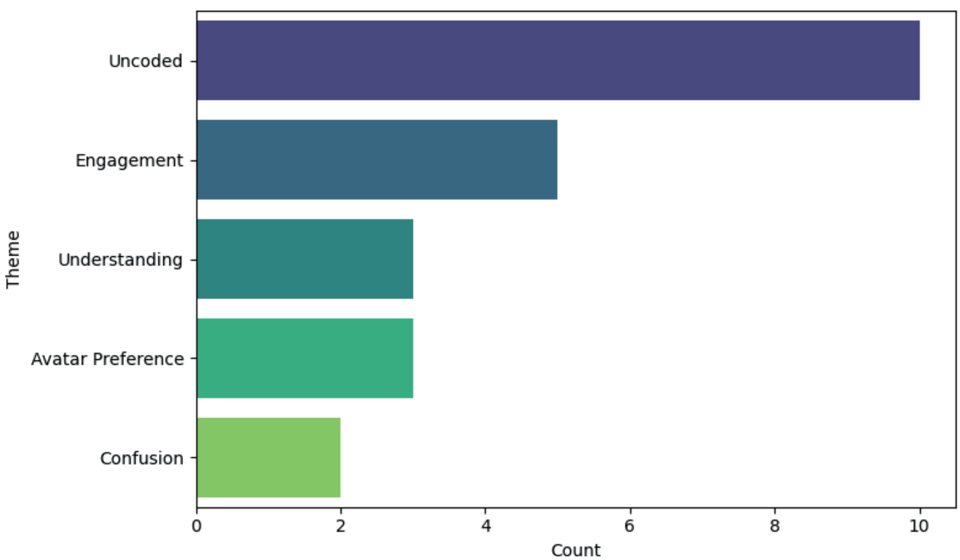

Figure 2. Theme Frequency from Thematic Analysis. The frequencies reflect the number of participant responses coded under each theme

S o u r c e: Own elaboration.

Moreover, the theme of Confusion (n = 2) emerged, indicating technical difficulties and accessibility burdens. Some students reported that the avatar was "too fast" or "hard to understand," revealing opportunities for better designing the voice and pacing.

Ten responses (n = 10) were not categorized, mostly because they were unclear or off-topic (e.g., I do not know, or it was okay). These represent different levels of engagement and suggest that clearer qualification questions should be formulated in the future focus group protocol.

Results and Discussion

H 1: Cognitive Learning Outcomes

An independent-samples t-test was used to compare the post-test scores of the experimental group (M = 7.22, SD = 1.89) with those of the control group (M = 4.24, SD = 0.84) to analyze whether the results of the avatar-based storytelling exercise were found to enhance cognitive learning. The difference was of a clear statistical significance ($t\ (48) = 9.84$, $p < .001$).

Within-group improvements were also confirmed by paired-samples t-tests. The test by the group engaged in the experiment has presented a very high increase in the score on the pre-test and post-test ($t\ (24) = –9.39$, $p < .001$). The control group also demonstrated improvement, albeit, with a modest effect, $t\ (24) = –4.53$, Also, a two-way mixed ANOVA demonstrated that there was a significant interaction effect between time (pre-test and post-test) and group (experimental and control), $F\ (1, 96) = 67.70$, $p < .001$, indicating greater gains in the avatar-based condition. This finding supports Hypothesis 1: the use of storytelling through avatars led to better performance among students compared to traditional digital classrooms.

H 2: Student engagement

Engagement was assessed in terms of an 8-item Likert scale (15 scale; the highest score = 40). The study group found the experiment engaging (M = 32.28, SD = 2.26). A Wilcoxon signed-rank test of this against the neutral midpoint (24) indicated again that there was a statistically significant difference, $W = 0.00$, $p <.001$. Hypothesis 2 was confirmed. Students in the avatar-based condition demonstrated engagement well above the neutral midpoint, highlighting the motivating effect of avatar-based storytelling in the learning environment.

H3: Perception of Emotional and Social Learning

Focus group interviews were analyzed thematically using NVivo. Some of the themes were emotional engagement, enhanced understanding, avatar preference, and immersion. Students reported that the activity was enjoyable, game-like, and easier to learn than typical lessons. Avatars were viewed as realistic, interactive, and emotive. These impressions reflected deeper emotional and social learning experiences.

The findings support Hypothesis 3: students exhibited higher emotional and social responses to storytelling when using avatars compared to traditional learning methods.

Across these reviews and meta-analyses, several consistent conclusions emerge:

1. Effect sizes are generally positive and often moderate-to-large for achievement, especially in STEM and science education, when VR/AR are used for hands-on practice, simulations and interactive tasks ($g \approx 0.4–0.9$ in many meta-analyses).
2. Motivational and affective benefits (engagement, enjoyment, interest) are robustly reported, even when test scores only modestly improve (Sviridova, et al., 2023).
3. Instructional design is crucial: the strongest effects occur when VR/AR are embedded in well-structured pedagogies (inquiry-based learning, collaborative learning, game-based learning, guided practice) rather than used as isolated "wow" demonstrations.
4. Challenges include cognitive overload, motion sickness, hardware cost, technical instability, and lack of teacher preparation. Reviews repeatedly note that poor interface design or insufficient scaffolding can neutralize or even reverse potential benefits (Sviridova, et al., 2023).

Overall, the literature suggests that VR/AR are important in education not simply because they are novel technologies, but because they enable forms of experiential, embodied, and contextualized learning that are difficult to achieve otherwise-and that, when appropriately designed and implemented, they can lead to meaningful gains in both learning outcomes and learner engagement.

Research to date supports the integration of VR and AR technologies in primary education as powerful tools for increasing engagement, facilitating conceptual understanding, and supporting experiential learning. Meta-analytic findings and classroom studies confirm moderate-to-strong effects on both cognitive and motivational outcomes when immersive technologies are pedagogically grounded (Villena-Taranilla et al., 2022; Sandoval-Henríquez, et al. 2025).

Nevertheless, sustainability and equity remain challenges. Implementation requires adequate teacher training, infrastructure, and thoughtful instructional design. When these conditions are met, VR and AR can meaningfully enrich primary school learning environments and foster digital competence from an early age.

Conclusion

This quasi-experimental study investigated how avatar-based storytelling in a metaverse environment affected science learning, engagement, and emotional-social development of primary school students over a two-week intervention. The results supported all three research hypotheses.

Statistical analyses showed that the learning outcomes and engagement levels of students who participated in the avatar-based storytelling activities were significantly higher than those of the control group. Thematic analysis of qualitative data also showed that students experienced greater emotional involvement, attachment, and interest in the avatars and the learning content.

These results indicate that even short-term interventions using avatars and narrative design in immersive virtual environments can produce quantifiable educational outcomes. This study reveals the pedagogical potential of avatar-based storytelling in digital learning, especially for STEM subjects among primary school learners. Future research should examine long-term retention and adaptive personalization, multi-site replication to ensure further scale, and validation of using metaverse-based learning interventions.

Acknowledgements

The authors are grateful to the Faculty of Arts and Educational Sciences in Cieszyn at the University of Silesia in Katowice (Katowice, Poland), the University of Bari Aldo Moro (Bari, Italy). We would also like to thank Ustroń Primary School No. 1 and No. 2 for making this experimental study possible. We also thank the PNRR (Italian National Recovery and Resilience Plan,) that financed the period of mobility abroad through which it has been possible to conduct a part of the research activities related to the Doctorate Thesis “Leadership, Empowerment and Digital Innovation in Education and Learning: Educational Impact Assessment of Verse, Education and Training in Metaverse” (project code BORSA DI STUDIO D.M. 117/2023). The ChatGPT-5 tool was used cautiously exclusively for language editing and some specific sources searching. The authors are the owners of the illustrations. The authors reported no potential conflict of interest.

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Saima Mehboob, Alberto Fornasari, Eugenia Smyrnova-Trybulska

Badanie wpływu Verse w Metaverse: badanie roli awatarów w opowiadaniu historii naukowych

Streszczenie

Niniejsze badania koncentrują się na wpływie opowiadania historii opartego na awatarach w środowisku metawersum na efektywność uczenia się, zaangażowanie oraz doświadczenia emocjonalno-społeczne uczniów szkół podstawowych w ramach edukacji przyrodniczej. W Polsce zastosowano quasi-eksperymentalny schemat grupy kontrolnej, składający się z testu wstępnego i testu końcowego, obejmujący 50 uczniów w wieku od 8 do 12 lat. Ponieważ badanie miało charakter eksperymentalny, pierwsza grupa uczestniczyła w dwutygodniowej interwencji, w której awatary korzystały z interaktywnych skryptów naukowych, podczas gdy druga grupa korzystała z tych samych treści za pośrednictwem konwencjonalnych mediów cyfrowych. Wyniki testów wstępnych i końcowych, a także ankiety zaangażowania, wykazały znaczną poprawę w zakresie uczenia się i zaangażowania w grupie eksperymentalnej ($p < 0{,}001$). Dane z wywiadów grupowych w formie wyników jakościowych pokazały, że uczestnicy postrzegali awatary pozytywnie, jako wiarygodne i wiarygodne postacie, które wzbudzały emocje. Odkrycia te potwierdzają pozytywny pogląd, że krótkoterminowe narracje oparte na awatarach mogą wspierać poprawę sprawności poznawczej, motywacji i więzi emocjonalnych w kontekście wirtualnego uczenia się. Przedstawiono dyskusje na temat implikacji pedagogiki immersyjnej i kierunków przyszłych badań longitudinalnych.

Słowa kluczowe: uczenie się oparte na awatarach, edukacja metawersalna, opowiadanie historii, wirtualne uczenie się

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Estudio sobre el impacto del Verse en el Metaverse: Explorando el papel de los avatares en la narrativa científica

Resumen

La presente investigación se centra en los efectos de la narrativa basada en avatares, dentro de un entorno de tipo metaverso, en el rendimiento académico, la participación y la experiencia emocional y social de estudiantes de primaria en el ámbito de la educación científica. En Polonia, se utilizó un diseño cuasiexperimental de grupo de control con pre-test y post-test, con 50 estudiantes de entre 8 y 12 años. Dado que se realizó de forma experimental, el primer grupo experimentó una intervención de dos semanas en la que los avatares utilizaron guiones científicos interactivos, mientras que el segundo grupo interactuó con el mismo contenido a través de medios digitales convencionales. Los resultados de los pre-tests y post-tests, así como la encuesta de participación, mostraron que el aprendizaje y la participación en el grupo experimental mejoraron significativamente ($p < 0{,}001$). Los datos de las entrevistas de los grupos focales, en forma de resultados cualitativos, mostraron que los participantes percibieron positivamente a los avatares como personajes creíbles y cercanos que evocaban emociones. Los hallazgos refuerzan la visión positiva de que las narrativas a corto plazo basadas en avatares pueden contribuir a mejoras en el rendimiento cognitivo, la motivación y la vinculación emocional en contextos de aprendizaje virtual. Se presentan debates sobre las implicaciones de la pedagogía inmersiva y las directrices para futuras investigaciones longitudinales.

Palabras clave: aprendizaje basado en avatares, educación metaversa, narrativa, aprendizaje virtual

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Исследование влияния Verse в Metaverse: изучение роли аватаров в научном повествовании

Аннотация

Текущее исследование фокусируется на влиянии повествования с использованием аватаров в среде метавселенной на успеваемость, вовлеченность и эмоционально-социальный опыт учащихся начальной школы в рамках естественнонаучного образования. В Польше был использован квазиэкспериментальный план контрольной группы, включающий предварительное и последующее тестирование, с участием 50 учащихся в возрасте от 8 до 12 лет. Поскольку исследование проводилось на экспериментальной основе, первая группа прошла двухнедельное вмешательство, в ходе которого аватары использовали интерактивные научные сценарии, в то время как вторая группа взаимодействовала с тем же контентом через традиционные цифровые медиа. Результаты предварительного и итогового тестирования, а также опроса о вовлеченности показали, что усвоение материала и вовлеченность в экспериментальной группе значительно улучшились ($p < 0,001$). Данные фокус-групповых интервью, представленные в виде качественных результатов, показали, что участники положительно воспринимали аватары как достоверных и узнаваемых персонажей, вызывающих эмоции. Эти результаты подтверждают позитивное мнение о том, что краткосрочные истории с использованием аватаров могут способствовать улучшению когнитивных способностей, мотивации и эмоциональной связи в контексте виртуаиммерсивной педагогики и даны направления для будущих лонгитюдных исследований.

Ключевые слова: обучение с использованием аватаров, образование с использованием метавселенной, научные и образовательные повествования, виртуальное обучение