sustainability

MDPI

Review

Virtual Worlds for Learning in Metaverse: A Narrative Review

Robertas Damaševičius [1,*] and Tatjana Sidekerskienė [2]

[1] Department of Applied Informatics, Vytautas Magnus University, LT-44404 Kaunas, Lithuania
[2] Department of Applied Mathematics, Kaunas University of Technology, LT-51368 Kaunas, Lithuania
* Correspondence: robertas.damasevicius@vdu.lt

Abstract: As digital technologies continue to evolve, they offer unprecedented opportunities to transform traditional educational paradigms. Virtual worlds offer a dynamic and immersive platform for fostering sustainability education, bridging the gap between theoretical knowledge and practical application. In these interactive environments, students can engage with complex ecological systems and sustainability challenges in a risk-free setting, allowing for experimentation and exploration that would be impractical or impossible in the real world. This study aims to investigate the application of various types of virtual worlds in educational settings, examine their characteristics and potential, and explore how they foster critical 21st-century skills like critical thinking, creativity, communication, and collaboration. This paper comprehensively explores various types of virtual worlds—Adventure World, Simulation World, Creative World, Role-Playing World, and Collaborative World—assessing their impact on educational processes and outcomes. Adventure Worlds, with narrative-driven quests, engage students in exploratory learning within a story context. Simulation Worlds replicate real-world environments, allowing students to practice and hone practical skills in a risk-free setting. Creative Worlds provide open-ended, sandbox-like environments where innovation and imagination are paramount. Role-Playing Worlds facilitate empathy and perspective-taking through character-driven scenarios, while Collaborative Worlds emphasize teamwork and problem-solving in group projects. The narrative review methodology was adopted for the comprehensive analysis and synthesis of the literature to assess the impact and integration of virtual worlds in education, focusing on identifying trends, challenges, and opportunities within this domain. The evaluation methodology used in this study incorporates a mix of the Theory of Inventive Problem Solving (TRIZ), Concept-Knowledge (C-K) theory, Structure-behavior-function (SBF) modeling, the Framework for 21st Century Learning (P21), and Universal Design for Learning (UDL) to evaluate the characteristics and educational potential of different virtual world types. Findings indicate that virtual worlds effectively support critical thinking, creativity, communication, and collaboration skills, presenting a comprehensive analysis of how these environments can support, supplement, or transform traditional educational models. The main outcome of the study is the comprehensive exploration of various types of virtual worlds—Adventure World, Simulation World, Creative World, Role-Playing World, and Collaborative World—in education, demonstrating their significant potential to enhance learning experiences and outcomes through immersive, interactive environments that foster critical thinking, creativity, communication, and collaboration skills.

Keywords: virtual worlds; educational technology; immersive learning; interactive education; digital learning environments; educational dames

Citation: Damaševičius, R.; Sidekerskienė, T. Virtual Worlds for Learning in Metaverse: A Narrative Review. *Sustainability* **2024**, *16*, 2032. https://doi.org/10.3390/su16052032

Academic Editors: Hao-Chiang Koong Lin, Yu-Shan Chang and Hung Yue Suen

Received: 30 December 2023
Revised: 25 February 2024
Accepted: 26 February 2024
Published: 29 February 2024

1. Introduction

The advent of digital technology has ushered in a new era in the field of education, bringing forth innovative tools and methods that have the potential to revolutionize how teaching and learning are conducted. Among these innovations, the educational sector has witnessed a paradigm shift with the advent of the Metaverse—a collective virtual shared space created by the convergence of virtually enhanced physical reality, augmented reality

(AR), and the internet [1]. This emerging technology heralds a new era in educational methodologies, offering immersive and interactive learning experiences that transcend traditional classroom boundaries [2,3]. The integration of virtual worlds within the Metaverse framework has opened up unprecedented opportunities for educators and learners, promising a transformative impact on the educational landscape [4].

Virtual worlds have emerged as a particularly intriguing and promising domain [5,6]. These digital environments, characterized by their immersive and interactive nature, offer an alternative to traditional classroom settings, providing a platform where learning can be both engaging and effective [7]. Their application within the Metaverse context presents a unique set of possibilities and challenges. The integration of virtual worlds into educational contexts stems from the growing need to align teaching methods with the technological proficiency of today's digital-native learners [8]. Virtual worlds in education, such as collaborative platforms, simulation environments, and game-based learning spaces, have shown considerable potential in enhancing student engagement, motivation, and learning outcomes [9,10]. These digital realms offer a sandbox for creative exploration, problem-solving, and experiential learning, making education more accessible, engaging, and tailored to individual learning styles, and represent a promising area of research [11].

The primary purpose of this study is to investigate the application and efficacy of various types of virtual worlds in educational settings. This study aims to provide a comprehensive understanding of how different virtual world environments can be used to enhance learning experiences and outcomes. By examining the specific characteristics and educational potential of each type of virtual world, the study seeks to elucidate how these digital platforms can support, supplement, or even transform traditional educational models while aiming to support crucial 21st-century skills such as critical thinking, creativity, communication, and collaboration [12].

The study focuses on investigating the application and efficacy of various types of virtual worlds—Adventure World, Simulation World, Creative World, Role-Playing World, and Collaborative World—in educational settings. It aims to provide a comprehensive understanding of how these digital environments can enhance learning experiences and outcomes by examining their specific characteristics and educational potential. This research seeks to elucidate how virtual worlds can support, supplement, or even transform traditional educational models, particularly in fostering critical 21st-century skills such as critical thinking, creativity, communication, and collaboration.

The specific objectives of the study are outlined as follows:

- Objective 1: Investigate the application of various types of virtual worlds in educational settings.
- Objective 2: Examine the specific characteristics and educational potential of each type of virtual world: Adventure World, Simulation World, Creative World, Role-Playing World, and Collaborative World.
- Objective 3: Explore the role of virtual worlds in fostering 21st-century skills such as critical thinking, creativity, communication, and collaboration.

To guide our study, we formulate the following research question:

How do various types of virtual worlds in educational settings enhance learning experiences and outcomes, specifically in fostering critical thinking, creativity, communication, and collaboration skills?

The novelty of this study lies in its holistic approach to examining the spectrum of virtual worlds in education. While previous research has often focused on specific aspects or individual types of virtual worlds, this study offers a comprehensive analysis that encompasses a range of virtual environments.

The study contributes to the field by analyzing the use of virtual worlds in educational settings, identifying various types and their potential to enhance learning outcomes. It employs a theoretical framework combining Theory of Inventive Problem Solving (TRIZ) [13], Concept-Knowledge (C-K) theory [14], Structure-behavior-function (SBF) modeling [15], Framework for 21st Century Learning (P21) [16] and Universal Design for

Learning (UDL) [17] to assess these environments' capacity to support 21st-century skills like critical thinking, creativity, communication, and collaboration. This review offers insights into how each type of virtual world can uniquely contribute to educational goals and by identifying the challenges and opportunities associated with their implementation in educational settings. The study also contributes to the theoretical understanding of digital learning environments, offering a framework for educators and policymakers to assess and integrate virtual worlds into educational curricula effectively.

The narrative review methodology employed in this study involves a comprehensive analysis of existing literature on virtual worlds in educational settings, aiming to synthesize findings from various studies to provide a holistic view of the field. This approach allows for the exploration of the diverse applications and impacts of virtual worlds—Adventure World, Simulation World, Creative World, Role-Playing World, and Collaborative World—on education. By evaluating these different environments through theoretical frameworks (TRIZ, C-K, SBF, P21 and UDL), the study not only highlights the unique characteristics and educational potentials of each virtual world type but also addresses their implications for teaching practice and student engagement. This methodological choice enables a broad understanding of the field, identifying trends, challenges, and opportunities for future research and application.

2. Related Work

We present a comprehensive analysis of various scholarly articles and conference papers, offering a rich overview of the current state and evolution of virtual worlds, augmented reality (AR), and their applications in education. The selected references span a range of topics, including the use of virtual worlds in education [18], the emergence of the Metaverse [19], AR applications in learning [20], and the integration of these technologies into various educational contexts [21].

Battal and Taşdelen (2023) conducted a bibliometric analysis of publications related to virtual worlds in education, highlighting the fluctuation in the number of publications over time and identifying key themes such as e-learning and higher education [9]. Dreamson and Park (2023) discussed metaverse-based learning and identified six educational values, emphasizing the importance of collaborative and transdisciplinary learning [22]. Porat, Shamir-Inbal, and Blau (2023) explored the integration of Open Sim-based virtual worlds in K-12 education, focusing on the shift from teacher-centered to student-centered learning practices [23]. De La Asuncion Pari-Bedoya et al. (2023) conducted a systematic literature review on the use and applications of the Metaverse in education, underscoring the need for further investigation into its concrete applications [4]. Li et al. (2023) emphasized the importance of collaborative learning in virtual worlds and introduced the concept of "we-intention" to explain the dynamics of collective actions in these environments [24]. Richter and Richter (2023) provided insights into the Metaverse's evolution from previous virtual worlds like Second Life, proposing a framework to differentiate the Metaverse from its predecessors [25].

The works of Masters and Gregory [26] and Örnek and Özer [27] explored the practical applications of virtual worlds in education, with a focus on Second Life and Open Simulator platforms, respectively. Zafeiropoulos et al. (2014) and Sukhov et al. (2018) discussed the educational potential of game-based learning in biology labs and medieval history, highlighting the role of adventure-style games and historical strategy games in educational discourse [28,29]. Chang et al. (2019) and Bravo and García-Magariño (2015) focused on the creative educational use of virtual reality, particularly in the context of clothing design and activity elaboration in higher education [30,31]. Maciuszek and Martens (2014) and Gregory (2013) addressed the design of learning tasks in virtual worlds, emphasizing the importance of task difficulty and degree of instructional guidance in educational virtual environments [32,33]. Nocchi (2018) and Endicott-Popovsky et al. (2013) explored foreign language teaching and security awareness training in virtual worlds, respectively, offering insights into the practical implementation and pedagogical strategies [34,35]. Riedmann et al. (2013)

and Qassem et al. (2016) presented case studies on the learning requirements elicitation skills and augmented immersive reality technology in high school chemistry education, respectively, demonstrating the application of virtual and augmented reality in specific educational contexts [36,37]. Cao et al. (2014) and Czok et al. (2023) discussed the integration of virtual reality in science and engineering teaching, focusing on the development and evaluation of AR applications [38,39]. Gopalan et al. (2018) and Sukhov (2022) reviewed augmented reality elements in science learning and the gamification of the Middle Ages, respectively, highlighting the role of AR in enhancing learning experiences and exploring historical themes [40,41]. Wozniak et al. (2020) and Tang et al. (2022) presented virtual lab implementations in aerospace structures education and explored AR for scientific inquiry, respectively, showcasing the practical applications of AR and VR in laboratory and scientific contexts [42,43]. Jamshidi et al. (2023) and Iqbal et al. (2022) focused on the Metaverse and microorganism digital twins, and the challenges and future research directions in AR for education, offering a forward-looking perspective on the potential and limitations of these technologies in educational settings [44,45]. Fernandes et al. (2021) and Scorgie et al. (2024) provided a brief review of immersive virtual environments for teaching microbiology and a systematic literature review and meta-analysis of VR for safety training, underscoring the diverse applications of VR in specialized educational domains [46,47]. Ventoulis and Xinogalos (2023) and Creed et al. (2023) discussed the design and pilot evaluation of an AR educational game for Greek mythology and the research agenda for inclusive AR and VR, highlighting the importance of engaging learning experiences and accessibility in immersive technologies [48,49]. AlGerafi et al. (2023) and Uriarte-Portillo et al. (2023) evaluated AR and VR in education and presented intelligent AR for learning geometry, emphasizing the effectiveness of these technologies in enhancing learning outcomes and facilitating geometry education [50,51]. Jim et al. (2023) and Hidayat and Wardat (2023) explored trustworthy Metaverse and conducted a systematic review of AR in STEM education, respectively, offering insights into the challenges and potential of AR and VR in educational settings [52,53]. Monteiro et al. (2022) and Tsutsui et al. (2020) presented "Sea of Cells" for learning biology through VR and the implementation of virtual labs in aerospace structures education, showcasing innovative approaches to integrating VR in specific scientific disciplines [54,55]. Paxinou et al. (2022) and Hutson et al. (2024) discussed a distance learning VR technology tool for science labs and learning communities in the Metaverse, highlighting the evolving role of VR and the Metaverse in distance education and first-year experience courses [56,57]. Shiradkar et al. (2021) and Paxinou et al. (2020) focused on VR as an interactive safety training platform and the implementation and evaluation of a 3D virtual-reality biology lab, respectively, demonstrating the practical applications of VR in safety training and biology education [58,59]. Zafeiropoulos et al. (2023) and Golemati et al. (2020) presented the V-Lab VR educational application framework and 3D simulations in a civil engineering lab, offering examples of VR applications in lab settings and civil engineering education [60,61].

The integration of virtual worlds into existing educational platforms and frameworks has been discussed by several authors. Griol et al. (2014) [62] discussed integrating immersive virtual environments, natural language processing, and AI to create intelligent learning environments. It emphasizes the flexibility of virtual worlds like Second Life and OpenSimulator for global collaboration in education. Morgado et al. (2017) [63] presented the MULTIS architecture for integrating virtual worlds into Learning Management Systems (LMS), allowing educators to manage virtual world activities alongside traditional e-learning activities. Díaz (2020) [18] explored the integration of virtual worlds with hybrid and mobile learning models, emphasizing its potential to enhance accessibility and inclusivity in education. Díaz et al. (2020) [10] focused on the design and implementation of virtual worlds as complementary tools in hybrid education, this article explores the flexibility and alternative knowledge transmission methods offered by these environments. Badilla-Quintana et al. (2021) [64] investigated immersive experiences in virtual worlds; this

study highlighted the importance of interactivity, presence, and flow in creating engaging educational environments.

The relationship between virtual worlds and educational strategies has been discussed by Porat et al. (2023) [23] explored teaching prototypes and strategies for integrating Open Sim-based virtual worlds in K-12 education, focusing on student-centered learning practices. Dreamson et al. (2023) [22] argue for metaverse-based learning as a distinct form of education, emphasizing collaborative learning, co-authorship, and transdisciplinary research-driven learning. Richter et al. (2023) [25] offered a comparative analysis of the Metaverse and previous virtual worlds; this study highlighted the evolution of user experience in virtual environments and its implications for educational settings.

User behavior and virtual world dynamics have been analyzed by Chesney et al. (2014) [65], who examined the impact of gaming experience on behavior in virtual worlds, analyzing communication, movement, avatar creation, and world customization. Li et al. (2023) [24] focused on promoting collaborative learning in virtual worlds; this study emphasized the importance of "we-intention" and examined how it influences team collaboration and learning.

Technological challenges have been analyzed by Cruz et al. (2015) [66] who discussed the technological challenges in using virtual worlds for education, particularly emphasizing the need for identity federation to overcome barriers in classroom management, content reuse, and learning analytics. De La Asuncion Pari-Bedoya et al. (2023) [4] discussed the applications and challenges of using the metaverse in education, highlighting its potential for interactive and immersive learning. Battal et al. (2023) [9] examined publications related to virtual worlds in education, providing insights into the trends, challenges, and future research directions in this field. Quinonez-Beltran et al. (2023) [67] investigated the use of virtual worlds to enhance teacher participation in distance education; this study highlighted the positive impact of virtual environments on teacher engagement and participation. Hoter et al. (2023) [68] focused on technical support in online courses and MOOCs; this study explored the effectiveness of various support types in courses with a significant virtual world component.

These studies collectively illustrate the diverse and evolving landscape of virtual worlds, augmented reality (AR), and virtual reality (VR) in enhancing educational experiences. They focused on immersive learning environments, innovative educational strategies, and user behavior dynamics, and addressed technological challenges while pointing toward future research directions in this evolving field [69]. They highlighted the potential of these technologies to enhance learning experiences, foster skill development, and address specific educational challenges [70], while also acknowledging the need for further research and development to fully realize their potential in educational contexts [71].

3. Virtual Worlds in Education

3.1. Methodology

The narrative review stands as the cornerstone of our methodology, providing a deep dive into the extensive corpus of literature surrounding virtual worlds in education. This thorough examination encompasses a wide array of sources, including academic journals, educational technology reports, and firsthand user testimonials, which collectively offer insights into the operational dynamics, pedagogical strategies, and user experiences within these digital realms [72]. Through this process, we meticulously catalog the salient features and educational applications of diverse virtual worlds, ranging from Adventure and Simulation Worlds to Creative, Role-Playing, and Collaborative Worlds. This narrative exploration is instrumental in painting a comprehensive picture of the current state of virtual worlds in education, highlighting their strengths, limitations, and the pedagogical opportunities they present [73]. Complementing the narrative review, we use a structured analytical lens through which the identified characteristics of virtual worlds can be assessed. This model is predicated on the establishment of a set of criteria derived from the theoretical

frameworks underpinning our study, including the Theory of Inventive Problem Solving (TRIZ), Concept-Knowledge (C-K) theory, Structure-behavior-function (SBF) modeling, the Framework for 21st Century Learning (P21), and the Universal Design for Learning (UDL). By applying this model, we are able to systematically categorize and evaluate the educational value of virtual worlds, facilitating a nuanced understanding of how these environments can be optimized to support effective learning.

3.2. Background and Concepts

The concept of virtual worlds in education has gained unprecedented momentum with the advent of the Metaverse, a term that encapsulates a future interconnected virtual space [25]. This digital realm, fostered by rapid technological advancements, is poised to revolutionize the educational landscape by offering immersive, interactive, and engaging learning environments [52]. The surge in interest and feasibility of the Metaverse in educational contexts can be attributed to several key technological advancements. High-speed internet and powerful computing capabilities have made complex virtual environments more accessible and seamless. The development of sophisticated VR and AR technologies has enabled the creation of highly immersive and interactive virtual spaces [39,62]. These technologies allow users to experience a sense of presence and agency within virtual environments, making learning more engaging and experiential [33,74]. Furthermore, advancements in artificial intelligence (AI) are enhancing the adaptability and interactivity of these environments, enabling personalized and dynamic learning experiences [75].

The Metaverse can be conceptualized as an expansive network of 3D virtual worlds, where individuals interact with each other and the environment in real-time, using avatars as their digital representations [33,76,77]. It transcends the traditional boundaries of physical space, allowing for a blend of reality and virtuality. This digital universe is not just a single platform but a collection of interconnected spaces and experiences, encompassing various aspects of social interaction, entertainment, and education. In the context of education, the Metaverse offers a platform where traditional educational paradigms can be reimagined, leading to innovative teaching and learning methods [78]. Within the broader framework of the Metaverse, virtual worlds play a pivotal role in reshaping educational experiences [18,62,63]. These worlds (or metaworlds [79]) provide a simulated environment where learners can engage in a variety of activities, from attending virtual classes to participating in interactive simulations that mirror real-world scenarios. They offer a unique blend of realism and creativity, enabling educators to create learning experiences that are otherwise impossible or impractical in the physical world. For instance, students can explore historical events as if they were there, conduct dangerous scientific experiments in a safe virtual space, or collaborate on projects with peers from across the globe. The potential of virtual worlds in education lies in their ability to foster engagement, collaboration, creativity, and critical thinking, providing a rich and diverse learning landscape that prepares students for the complexities of the modern world [80,81].

3.3. Selection for Analysis

For further analysis, we have selected the following virtual worlds:

- Adventure World: A narrative-driven world where students embark on quests, solving educational challenges to advance the story. Collaborative education in virtual learning environments supports this by using non-player characters and quest activities for tutoring and training, incorporating active learning and progress [82].
- Simulation World: A world that simulates real-world environments or historical events, allowing students to interact with and learn from real-life scenarios. The role-playing game for software project management in a virtual world enhances experiential learning of project team members' communication and collaboration, simulating real-life company scenarios [83].
- Creative World: A sandbox environment where students can build and create, fostering creativity and problem-solving skills. The study on "Free the sheep: improvised

song and performance in and around a Minecraft community" explores how children's creative practices in virtual worlds shape the nature of the space around them, fostering creativity and problem-solving skills [84].

- Role-Playing World: Students assume roles in a simulated environment, learning through acting out various scenarios or historical events. "Enhance learning on software project management through a role-play game in a virtual world" demonstrates how role-playing in virtual environments can enhance experiential learning and simulate real-life scenarios [83].
- Collaborative World: A world focused on group projects and teamwork, where students must work together to solve complex problems or complete tasks. The "Model for Effective Collaborative Learning in Virtual Worlds with Intelligent Agents" proposes a model to achieve effective collaborative learning in virtual environments, enhancing teamwork and problem-solving skills [85].

These worlds can provide immersive and interactive learning experiences, making education more engaging and effective.

The identification and selection of specific virtual worlds, namely Adventure World, Simulation World, Creative World, Role-Playing World, and Collaborative World, for further analysis in educational contexts were guided by a focused and strategic approach. This process was driven by the intent to cover a broad spectrum of educational needs and pedagogical approaches, ensuring a comprehensive understanding of the potential of virtual worlds in education. The selection process involved a detailed review of virtual worlds with a focus on their educational potential. We chose virtual worlds based on their unique teaching and learning benefits. This involved examining scholarly articles, reports on educational technology, and feedback from users to gain a comprehensive view of what each platform offers in practical educational settings. It contributes to previous typologies of virtual worlds proposed by Messiger et al. [86].

Adventure World was selected for its narrative-driven environments, which are ideal for engaging students in storytelling and exploration-based learning [87]. The choice to include Adventure World was motivated by the educational value of narratives in enhancing memory retention, critical thinking, and problem-solving skills. These worlds offer immersive experiences where learners can embark on quests and solve challenges, making learning an active and engaging process.

Simulation World was chosen due to its ability to replicate and imitate real-world scenarios and environments [88]. These worlds are particularly valuable in fields like science, engineering, and medicine, where practical, hands-on experience is crucial. The inclusion of Simulation World was driven by the need to provide students with realistic experiences where they can apply theoretical knowledge in safe, controlled, virtual settings.

Creative World was identified for its emphasis on creativity and design [89]. These environments allow students to build, create, and experiment in a sandbox-like setting, fostering creativity, innovation, and design thinking [90]. The selection was based on the increasing importance of creative skills in modern education and the ability of these worlds to provide a canvas for imaginative expression.

Role-Playing World was included for its focus on social interaction and perspective-taking. In these worlds, students assume different roles, which is invaluable for developing empathy, communication skills, and an understanding of diverse viewpoints [91]. The decision to analyze Role-Playing World was influenced by the educational potential of experiential learning in developing social and emotional skills.

Finally, Collaborative World was chosen for its ability to facilitate teamwork and cooperative learning. These platforms, originating from board games and other cooperative games [92], are designed to enable group projects and collaborative tasks, making them ideal for teaching teamwork, leadership, and collaborative problem-solving. The inclusion of Collaborative World reflects the growing emphasis on collaboration in both educational and professional settings.

3.4. Adventure World

3.4.1. Adventure World: Definition and Key Elements

Adventure World, in the context of educational virtual worlds, is a narrative-driven environment where students are engaged in a story-driven journey. In this world, originating from adventure games [93], students embark on quests, encountering various educational puzzles and challenges that are integrated into the storyline. As they progress, their success in solving these puzzles or overcoming challenges allows them to advance the narrative. This type of world is designed to make learning more engaging and immersive, fostering a deeper understanding and retention of educational content through an interactive and enjoyable experience.

The key elements of Adventure World include:

- Storyline: A compelling narrative [94] that guides the educational journey, making learning more engaging and meaningful [95].
- Quests: Specific tasks or missions aligned with educational objectives, providing a sense of purpose and direction [96].
- Puzzles and Challenges: Interactive problems that require critical thinking, creativity, and application of learned concepts [97].
- Progression Mechanism: A system that tracks student progress and unlocks new parts of the story as they learn and succeed [98].
- Interactive Learning: Opportunities for students to interact with the environment, characters, and each other, enhancing the learning experience [6].

3.4.2. Typical Interactions

In an Adventure World, a virtual environment designed for immersive storytelling and exploration, interactions are the pivotal elements that bring the narrative to life and engage participants. These interactions are not just confined to the actions of the players, but they extend to encompass a complex web of relationships between various elements within the world, including characters, objects, the environment, and the underlying narrative structure. Central to these interactions are the player characters, who are often tasked with navigating through a series of quests and challenges. These characters interact with non-player characters (NPCs)—entities controlled by the game's AI [99]—to gather information, seek guidance, or obtain critical items necessary for their journey. The nature of these interactions can range from simple dialogue exchanges to more complex negotiations or conflicts, depending on the storyline and the characters' roles within it.

The environment itself plays a crucial role in shaping these interactions. Players might interact with their surroundings to uncover hidden paths, solve environmental puzzles, or use specific features of the landscape to overcome obstacles. The setting of an Adventure World is often richly detailed, offering not just a backdrop for the action but an active participant in the narrative. For instance, a player might need to navigate treacherous terrains, decipher ancient ruins, or adapt to changing weather conditions, all of which require interaction with the environment.

Objects within the Adventure World also form a critical component of player interactions. These objects can range from mundane items like keys and potions to powerful artifacts with unique abilities. Players must discover, utilize, or combine these items in creative ways to advance the story or enhance their character's abilities. The interaction with objects often involves puzzle-solving elements, where the player must figure out the right way to use an item to progress further.

The narrative structure of the Adventure World dictates the course and nature of interactions. Players are presented with choices that can significantly impact the story's progression. These decisions not only affect the immediate situation but can have long-lasting repercussions, altering future interactions and the world's state. The narrative-driven nature of these interactions means that players are not just passive recipients of a story but active participants shaping the tale through their choices and actions.

Lastly, social interactions between players, when the Adventure World supports multiplayer modes, add another layer of complexity. Players can collaborate, compete, or simply coexist within the same world, forming alliances, engaging in battles, or trading resources. These social dynamics contribute to a rich and varied experience, as every player brings their own style and perspective to the game.

These interactions are represented in Figure 1. This diagram illustrates the flow of interactions between the student, the Adventure World platform, the educational content, and the progress tracker. It captures how students access the platform, engage with the educational content through quests and puzzles, and how their progress is tracked and used to unlock further elements of the story.

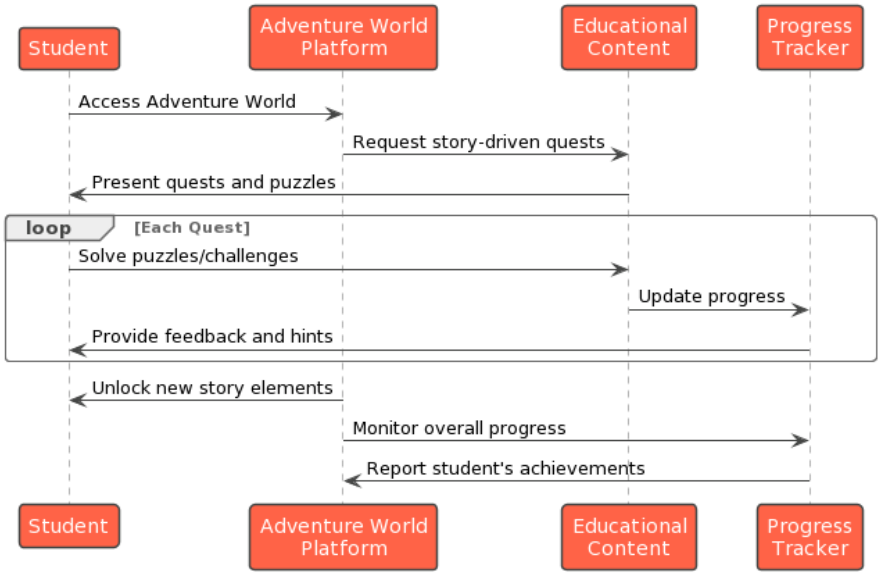

Figure 1. Typical interactions in Adventure World.

3.4.3. Educational Applications

These examples leverage storytelling, quests, and interactive challenges to enhance learning:

Minecraft Education Edition [100] is Minecraft's educational version that allows students to engage in a block-based, open-world environment with various terrains, where they can explore historical landmarks, understand scientific concepts, and even learn coding. Teachers often create quest-like scenarios where students solve problems and learn through exploration, while its educational content focuses on STEM.

Zoombinis [101] is a classic educational game that has been re-released for modern platforms. It involves leading a group of small creatures through a series of logic puzzles. Each puzzle is part of a larger journey narrative, teaching problem-solving and logical thinking skills.

The Oregon Trail [102] is a well-known educational video game that simulates the experiences of pioneers traveling on the Oregon Trail in 19th-century America. While older, it is a prime example of using narrative and adventure in an educational context, teaching American history and geography through survival and resource management quests.

We present the comparison of these educational worlds in Table 1. Here, "Setting" describes the environment or world where the game takes place. "Storyline" provides a brief overview of the game's narrative. "Quests" details the types of challenges or missions players undertake in the game. "Social Interactions" explains how players interact with each other or with in-game characters. "Educational Content" specifies the learning material or educational objectives integrated into the game. This structured comparison highlights the unique aspects of each game, including their educational content and how they engage players through their respective worlds and storylines.

Table 1. Comparison of Educational Games Implementing Adventure World.

Game	Setting	Storyline	Quests	Social Interactions	Educational Content
Minecraft Education Edition	Virtual world with diverse biomes and terrain	Player-driven, open-ended exploration	Building, crafting, and survival challenges	Collaborative projects and problem-solving with other players	STEM concepts, creativity, problem-solving, digital citizenship
Zoombinis	Fantasy islands	Rescue Zoombinis by solving puzzles	Logic puzzles with increasing difficulty	Single-player (no direct social interaction)	Logical reasoning, data analysis, pattern recognition
The Oregon Trail	19th-century American West	Settlers traveling the Oregon Trail	Survival, resource management, decision-making	Limited, based on encounters and choices along the trail	American history, geography, resource management

3.4.4. Educational Affordances

Adventure World, as a narrative-driven virtual environment for education, offers several unique affordances that enhance the learning experience. These affordances can be discussed under various categories as summarized in Table 2.

Table 2. Affordances of Adventure World in Education.

Affordance	Description
Narrative Immersion	The use of storytelling captivates students, making learning more engaging and memorable. Narratives provide context and meaning, making abstract concepts easier to understand and retain.
Motivation Through Quests	The quest-based approach provides clear objectives and a sense of purpose. As students complete tasks, their achievements contribute to story progression, which serves as a powerful motivational tool.
Problem-Solving Skills	Solving puzzles and overcoming challenges within the game enhance critical thinking and problem-solving skills. These skills are transferable to real-world situations.
Dynamic Interaction	Students interact with the environment, characters, and each other, fostering collaborative learning and communication skills.
Adaptive Challenges	The world can adapt to different skill levels, offering personalized challenges that cater to the individual learning pace of each student.
Peer Learning	Opportunities for teamwork and peer-to-peer interaction can emerge, encouraging cooperative learning and social skill development.
Real-Time Feedback	Instant feedback mechanisms help students understand their progress and areas for improvement, facilitating a more responsive learning process.
Educational Content Integration	The adventure can be designed to align with specific curriculum goals, ensuring that the gaming elements complement educational objectives.
Cross-Disciplinary Learning	The narrative can incorporate elements from various disciplines, providing a holistic education experience that goes beyond traditional subject boundaries.
Cultural Relevance	The storyline and content can be tailored to reflect diverse cultures and perspectives, making the learning experience more relevant and inclusive.
Sustainability of Interest	The evolving narrative can sustain students' interest over longer periods compared to traditional learning methods.
Skill Development	Beyond academic knowledge, students develop life skills like resilience, persistence, and creative thinking through engaging in story-driven challenges.

The affordances of Adventure World in the educational context are multifaceted, focusing not only on imparting knowledge but also on developing a broad range of cognitive, social, and emotional skills. This comprehensive approach to education aligns well with 21st-century learning paradigms.

3.5. Simulation World

3.5.1. Simulation World: Definition and Key Elements

Simulation World refers to a type of virtual environment designed for educational purposes, which replicates real-world settings or historical events. Simulation worlds originate from simulation games [103]. The primary goal of this virtual world is to provide an immersive, interactive learning experience that closely mirrors actual situations, places, or periods. By simulating real-life scenarios, students can engage with content in a more meaningful and impactful way.

Core characteristics of Simulation Worlds are as follows:

- Realistic Environments: The simulation closely replicates real-world environments, whether it is a modern city, a historical battlefield, a scientific laboratory, or a natural ecosystem. The level of detail in these simulations can vary but generally includes sensory experiences like visual, auditory, and sometimes tactile elements.
- Historical Accuracy: When simulating historical events, accuracy is key. Everything from the architecture, clothing, language, and societal norms of the period is recreated to provide an authentic learning experience.
- Dynamic Scenarios: The world changes in response to student interactions. For example, a simulation of an ecological system might show the impact of pollution or climate change based on students' actions [104].

Simulation World offers a unique and powerful way to enhance education by combining the realism of real-world scenarios with the safety and flexibility of a virtual environment. This approach not only makes learning more engaging but also provides practical, hands-on experience that can be difficult to achieve in a traditional classroom setting.

3.5.2. Typical Interactions

In a Simulation World, interactions are designed to mimic real-life scenarios, processes, or systems, allowing users to engage in a virtual environment that closely resembles a specific aspect of reality. This type of virtual environment is particularly effective in educational and training contexts, where the practical application of knowledge and skills is crucial. The essence of a Simulation World lies in its ability to replicate real-world dynamics and systems, offering an immersive experience that is both informative and engaging. Users often take on roles that mirror real-life positions, such as a pilot in a flight simulator, a city planner in an urban development simulator, or a doctor performing virtual surgeries. The fidelity of these simulations can vary, ranging from highly realistic recreations to more abstract representations that still adhere to the fundamental principles of the simulated system. Interactions in a Simulation World are typically governed by the same rules and laws that apply to their real-world counterparts. This means that users must apply relevant knowledge and skills to navigate these environments successfully. For instance, in a flight simulator, the user must understand and manage various aircraft controls and respond to changing weather conditions, just as a real pilot would [105]. These interactions not only reinforce theoretical knowledge but also develop practical skills and decision-making abilities. Simulation Worlds often include scenarios or challenges that require problem-solving and critical thinking [106]. These scenarios are designed to test the user's ability to apply their knowledge in practical situations. For example, in a medical simulation, a user might be required to diagnose and treat patients based on their symptoms, using the same diagnostic reasoning that a healthcare professional would use.

Another key aspect of Simulation Worlds is the feedback loop. Users receive immediate feedback on their actions, allowing them to understand and reflect on the consequences of their decisions [107]. This feedback is essential for learning and skill development, as it helps users to identify areas where they need improvement and to understand the complexities of the system they are interacting with. Social interactions are also common in Simulation Worlds, especially in those designed for team training or multiplayer experiences. Users can work together to achieve common goals, communicate and delegate tasks,

and learn from each other's strategies and approaches. This not only enhances the learning experience but also helps in developing teamwork and communication skills.

Simulation Worlds are adaptive, meaning they can be tailored to different skill levels and learning objectives. This adaptability ensures that users remain engaged and challenged, regardless of their prior knowledge or experience. Advanced users can face more complex scenarios, while beginners can start with simpler tasks, allowing for a personalized learning journey.

Figure 2 illustrates the interactions within a Simulation World, covering the student's engagement with the simulation interface, the simulation engine's processing of actions and scenarios, the real-time feedback mechanism, and the role of the instructor in providing guidance and assessments. The cycle of interaction, feedback, and instructor intervention outlines a comprehensive educational experience within the simulation.

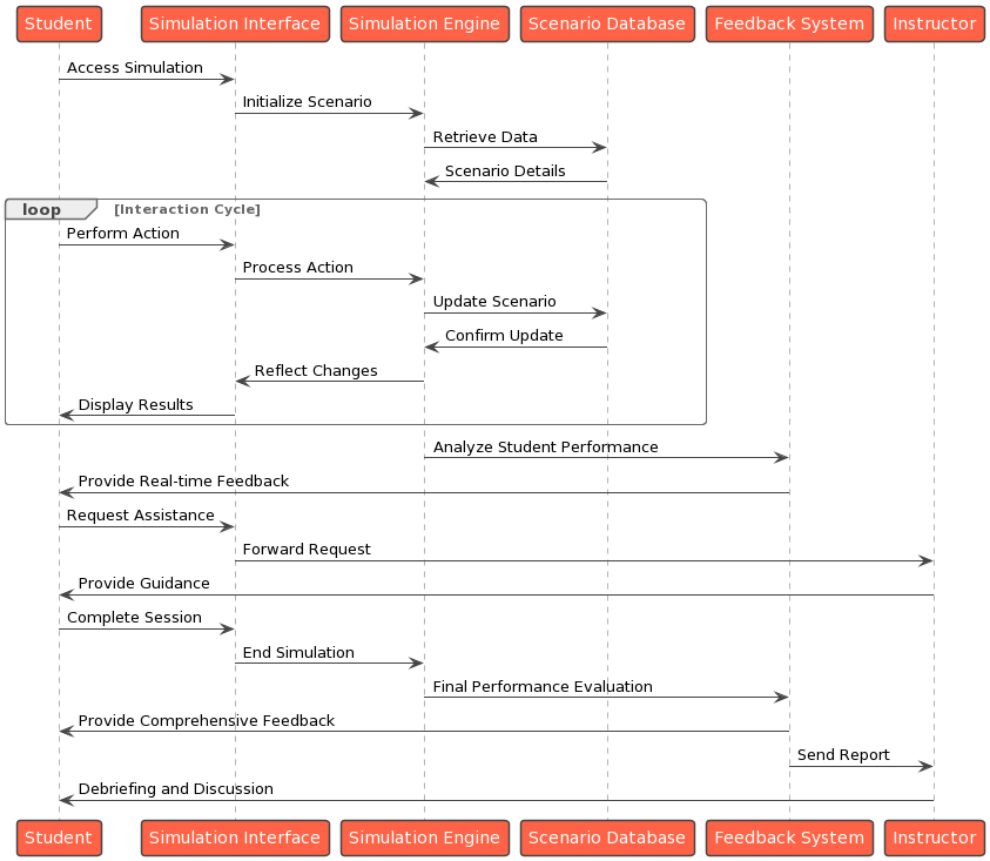

Figure 2. Interactions in Simulation World.

3.5.3. Educational Applications

Simulation World as a concept in education, refers to virtual environments that simulate real-world scenarios for learning purposes. These environments are particularly effective in fields where hands-on experience is crucial but difficult to obtain due to cost, safety, or logistical reasons. Below are some real-world examples of Simulation Worlds used in various educational contexts:

Medical schools often use virtual simulations to train students in surgical procedures, patient interactions, and emergency response. Platforms like 'Touch Surgery' offer detailed, interactive surgical simulations, allowing medical students to practice and refine their skills in a safe, controlled environment [108]. Aviation schools use flight simulators to train pilots. These simulators replicate the experience of flying an aircraft, including handling emergency situations, which are too risky or impractical to recreate in real life. Examples include the Microsoft Flight Simulator, which is also used for training purposes [109]. Business schools utilize simulation software to mimic market dynamics, allowing students

to experiment with business strategies, understand market trends, and learn about economic principles [110]. 'Capsim' is an example of such a simulation tool used in business education. Universities and research institutions use simulations to study environmental changes and ecological systems [111]. For example, 'EcoSim' is an ecosystem simulation where students can manipulate variables like rainfall, temperature, and vegetation to observe ecological changes. Historical Event Simulations are used in history and archaeology education, allowing students to explore historical sites or events in detail. For instance, the 'Virtual Rome' project lets students explore a 3D reconstruction of ancient Rome as it was in AD 320 [112]. Physics and Engineering Simulation tools like 'PhET Interactive Simulations' developed by the University of Colorado Boulder provide interactive simulations in physics, chemistry, biology, and more, helping students understand complex concepts through visualization and experimentation [113]. Virtual worlds, like 'Second Life', have been used for language learning, where students immerse themselves in a virtual environment that simulates real-life scenarios in a foreign language [114]. Industries like oil and gas, mining, and construction use VR simulations to train workers in safety protocols and emergency response in hazardous environments without associated risks [115].

3.5.4. Educational Affordances

Simulation World in an educational context refers to a virtual environment that replicates real-life scenarios or historical events, allowing students to interact with and learn from lifelike situations. These simulation environments offer a range of educational affordances that enhance learning by providing realistic, interactive, and immersive experiences [116,117]. Table 3 shows a summary of these affordances.

Table 3. Affordances of Simulation Worlds in Education.

Affordance	Description
Authentic Experiences	Simulation Worlds offer students the opportunity to engage in realistic scenarios that closely mimic real-world environments or historical contexts, providing a more authentic learning experience.
Contextualized Learning	By situating learning within a specific context, students can see the direct application and relevance of theoretical concepts, enhancing their understanding and retention.
Adaptive Learning	Simulation Worlds can adapt to individual learning styles and paces, offering personalized learning pathways. Some simulation worlds are equipped with AI to adapt to a student's learning pace and style, offering personalized educational experiences.
Experiential Learning	Students learn by doing, experiencing situations firsthand rather than reading or hearing about them. This hands-on approach can enhance understanding and retention.
Interactive Engagement	The interactive nature of Simulation Worlds fosters higher student engagement, as learners are actively involved in the learning process.
Increased Motivation	The immersive and often game-like elements of Simulation Worlds can increase students' motivation to learn and participate.
Practical Skills	Simulation Worlds allow students to practice and develop specific skills, such as surgical techniques in medical simulations or flying in flight simulators, in a safe and controlled environment.
Problem-Solving Skills	These environments often present complex problems, requiring students to apply critical thinking and problem-solving skills.
Decision-Making Skills	Many simulations require students to make decisions based on available information, mimicking real-life decision-making processes.
Iterative Learning	Students can try different approaches and learn from their failures, an essential aspect of the learning process.
Technological Literacy	Working within Simulation Worlds often enhances students' digital and technological skills.
Collaboration	Simulations can support collaborative activities, where students work in teams to solve problems or achieve goals, mimicking real-world collaborative environments.
Feedback Systems	Immediate feedback on actions and decisions help students understand the consequences of their choices, promoting reflective learning.

3.6. Creative World

3.6.1. Creative World: Definition and Key Elements

Creative World refers to a type of virtual learning environment, often described as a sandbox [118], where students have the freedom to build, create, and experiment. This environment is designed to foster creativity, innovation, and problem-solving skills among learners. The core elements of Creative Worlds are as follows:

- Open-Ended Environment: Unlike structured learning environments, a Creative World typically does not have predefined objectives. Students are encouraged to set their own goals and projects, fostering self-directed learning.
- Tools for Creation: Students are provided with a wide array of tools and resources that enable them to build and create virtually anything they can imagine. These tools might include building blocks, design software, art tools, coding platforms, and more.
- Interactive Platform: The world is highly interactive, allowing students to manipulate objects, change environments, and see the immediate impact of their actions.

Creative World represents an innovative approach to education, moving away from traditional, structured learning to an open, creative, and exploratory model. This approach not only engages students but also equips them with the skills necessary for the 21st century, such as creativity, collaboration, and technical proficiency [12].

3.6.2. Typical Interactions

In a Creative World, interactions are primarily focused on fostering creativity, innovation, and self-expression. These virtual environments are designed as open-ended platforms where users, often students or learners, can build, create, and experiment freely. Unlike more structured virtual worlds with predefined objectives or narratives, Creative Worlds offer a canvas for imaginative and exploratory learning. One of the core aspects of interaction in a Creative World is the construction and manipulation of elements within the virtual environment. Users are typically provided with a range of tools and materials that they can use to construct objects, structures, or entire landscapes. This process is highly intuitive and reflective of real-world building and artistic creation, albeit without the physical constraints. For instance, in an educational setting, students might use these tools to design models that illustrate scientific concepts, create art, or engineer solutions to hypothetical problems.

The collaborative potential of Creative Worlds also constitutes a significant aspect of user interaction. Many of these environments are designed to support multi-user engagement, allowing students to work together on joint projects. Such collaboration can range from constructing shared structures to brainstorming ideas and problem-solving. This collaborative process is instrumental in teaching teamwork skills, negotiation, and the value of different perspectives. Another key interaction in Creative Worlds is the ability to customize the environment itself. Users have the power to change aspects of the world according to their preferences or needs, such as altering terrain, adjusting weather conditions, or even programming specific behaviors into the world. This level of control enhances the immersive experience and allows users to experiment with different scenarios and outcomes. Creative Worlds often incorporate game-like elements, although these are usually more open-ended and less goal-oriented than in traditional game environments. These elements might include challenges or quests that prompt users to apply their creative skills to solve problems, but the emphasis remains on the process of creation rather than on achieving a specific end goal.

Creative Worlds are particularly effective in developing critical thinking and problem-solving skills. As students navigate these environments, they are often confronted with challenges that require innovative thinking. Whether it is designing a structure that can withstand certain forces or creating a digital story, students must apply knowledge and creativity to succeed. In addition to fostering creativity and collaboration, interactions in Creative Worlds also promote technological literacy [119]. Navigating and manipulating these environments requires a degree of digital competency. As such, students not only

learn about the subject matter at hand but also develop important digital skills that are increasingly valuable in a technology-driven world.

Figure 3 illustrates the interactions within a Creative World, highlighting the process of project creation, development, collaboration, feedback, and finalization. It covers the student's engagement with the creative interface, the use of creation tools, saving and sharing work through a project repository, collaborative interactions, and the role of instructors in providing guidance. This cycle of creation, collaboration, feedback, and improvement outlines a dynamic and creative educational experience in the virtual environment.

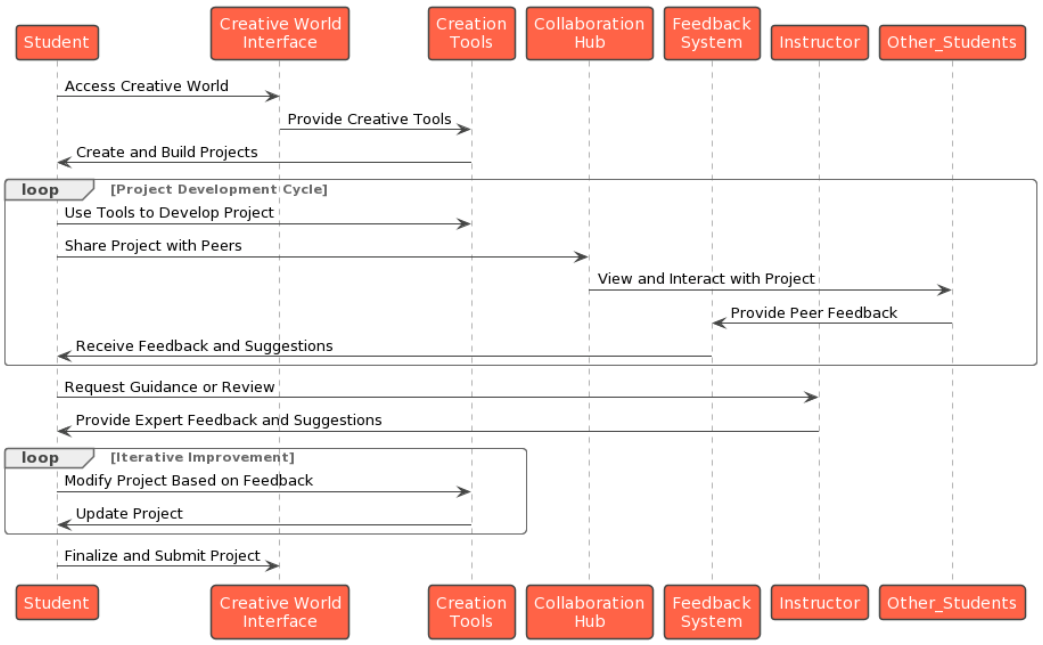

Figure 3. Typical interactions in Creative World.

3.6.3. Educational Applications

Creative World, in an educational context, refers to virtual environments or platforms where learners can engage in creative and constructive activities. These environments are designed to foster creativity, problem-solving, and collaborative skills. Here are some real-world examples of Creative Worlds used in education.

Roblox's [120] platform enables students to create and play games. It is used for teaching game design and programming skills. The immersive environment also allows for creative storytelling and digital art projects. Scratch [121] is a block-based visual programming language and online community targeted primarily at children. Users can create interactive stories, games, and animations, encouraging algorithmic thinking and creativity. LEGO Digital Designer allows students to build virtually with LEGO blocks. It is often used in engineering and design courses to teach concepts of structure, design, and spatial awareness [122]. Kerbal Space Program simulates space flight and has been used in physics and astronomy classes. Students learn about aerospace engineering, orbital mechanics, and physics through trial and error in building rockets and conducting missions [123]. SimCityEdu, an educational version of the popular city-building game SimCity, is designed to foster students' problem-solving and decision-making skills as they manage and grow virtual cities [124]. LittleBigPlanet allows players to create their own game levels. It's used in educational settings to teach concepts of physics, logic, and design [125].

3.6.4. Educational Affordances

Creative World in an educational context refers to a virtual environment that prioritizes creativity, innovation, and the construction of original ideas or projects. These environments are typically open-ended, offering a sandbox-like experience where students

have the freedom to explore, create, and experiment. The affordances of a Creative World in education are summarized in Table 4.

Table 4. Affordances of Creative Worlds in Education.

Affordance	Description
Creative Thinking	Creative Worlds provide an open platform for students to think imaginatively, encouraging them to come up with unique solutions and ideas.
Innovation through Experimentation	These environments allow students to experiment without fear of failure, fostering a mindset conducive to innovation.
Problem-Solving	By engaging in creative projects, students develop and refine their problem-solving skills, learning to tackle challenges in innovative ways.
Technical Skills	Depending on the tools and technologies available in the Creative World, students can acquire and enhance various technical skills, including coding, digital art, graphic design, 3D modeling, and more.
Artistic Expression	These worlds often provide tools for artistic creation, allowing students to express themselves through various mediums.
Collaboration	Many Creative Worlds encourage or require collaboration, helping students develop teamwork and communication skills.
Peer Learning	Students can learn from each other by sharing ideas, techniques, and feedback, fostering a community of learning.
Project-Based Learning	Creative World is ideal for project-based learning, where students undertake complex projects that require planning, execution, and revision.
Self-Directed Learning	Creative Worlds often allow students to pursue their interests, leading to higher motivation and a more personalized learning experience.
Interdisciplinary Learning	These environments can seamlessly integrate elements from various disciplines in STEM, encouraging students to apply a broad range of knowledge in their creative projects, and allowing for a holistic educational experience.
Connecting Theory and Practice	Students can apply theoretical concepts in a practical context, deepening their understanding and retention of academic content.
Digital Literacy	Interaction within Creative Worlds naturally improves digital literacy, a crucial skill in the modern digital age.
Increased Student Engagement	The freedom to create and the joy of seeing one's creations come to life can significantly boost student engagement.

Creative World environments in education offer a unique blend of creativity, skill development, collaboration, and engagement. They provide students with a platform to express themselves, explore interests, and develop a wide array of skills, from technical proficiency to creative thinking. However, the success of these environments depends on careful planning, resource allocation, and the presence of supportive facilitation to guide and maximize student learning outcomes.

3.7. Role-Playing World

3.7.1. Role-Playing World: Definition and Key Elements

Role-Playing World in an educational context is a simulated environment where students assume specific roles and interact within various scenarios [126]. This method of learning, often referred to as role-playing, is a form of experiential education that provides a rich, immersive experience, allowing students to explore different perspectives, develop empathy, and gain a deeper understanding of the subject matter.

Below are the core characteristics of the various aspects of a Role-Playing World:

- Immersive Scenarios: Role-Playing Worlds are designed to immerse students in realistic or accurate settings. These scenarios can range from re-enacting historical events to simulating modern-day situations or exploring hypothetical futures.
- Defined Roles: Each student assumes a specific character or role within the simulation. These roles are often based on real-life positions (e.g., a politician, a scientist, a nurse) or historical figures, and are designed to help students understand different viewpoints and the complexity of human interactions.
- Interactive Narrative: The environment typically has a narrative or storyline that evolves based on the actions and decisions of the participants. This narrative guides the learning experience and provides a context for the role-play.

3.7.2. Typical Interactions

In a Role-Playing World, interactions are central to the experience, offering a rich and complex blend of storytelling, character development, and social dynamics [127]. These virtual worlds are designed to allow users, often learners or players, to step into the shoes of characters in a simulated environment, embodying roles that differ from their real-life personas. The essence of these interactions is the immersive experience that comes from engaging with the narrative, other characters, and the world itself [128].

At the heart of a Role-Playing World is the narrative [129]. Players are often presented with a storyline that unfolds as they progress through the game. Interactions within this narrative context are crucial for driving the story forward. Players make decisions that influence the outcome of events, engage in dialogues that reveal more about the plot and characters, and undertake missions or quests that are integral to the storyline. The narrative is not just a backdrop but is actively shaped by the players' choices, making each player's experience unique.

Character interaction is another key aspect of these worlds. Players often interact with a range of NPCs, each with their own backstories, personalities, and roles within the narrative. These interactions can range from simple information exchanges to complex negotiations or conflicts, depending on the nature of the game and its storyline. Players also develop their characters over time, gaining skills, knowledge, and equipment, which in turn affects how they interact with the world and other characters.

Social interaction between players is also a significant component of Role-Playing Worlds, especially in multiplayer formats. Players often form groups or alliances to tackle challenges together, share resources, and strategize. This collaborative aspect mirrors real-life social interactions and requires players to develop communication, teamwork, and sometimes leadership skills. Moreover, these social interactions often extend beyond the confines of the game, fostering communities where players discuss strategies, share stories, and form lasting relationships.

Role-Playing Worlds can be powerful tools for learning. They provide a safe space for players to experiment with different roles, understand diverse perspectives, and practice skills in a simulated environment. The immersive nature of these worlds also makes learning more engaging and memorable. For instance, in an educational setting, students might role-play historical figures, engage in simulated business negotiations, or explore scientific concepts through character-based scenarios.

Figure 4 illustrates the complex interactions within a Role-Playing World. It encompasses the student's engagement with the role-playing interface, the scenario engine's role in managing the simulation, the character database's function in assigning roles, the instructor's involvement in providing guidance, and the feedback mechanism's role in evaluating performance and providing debriefing. This cycle of interaction, decision-making, and reflection encapsulates the dynamic and educational experience of role-playing in a virtual environment.

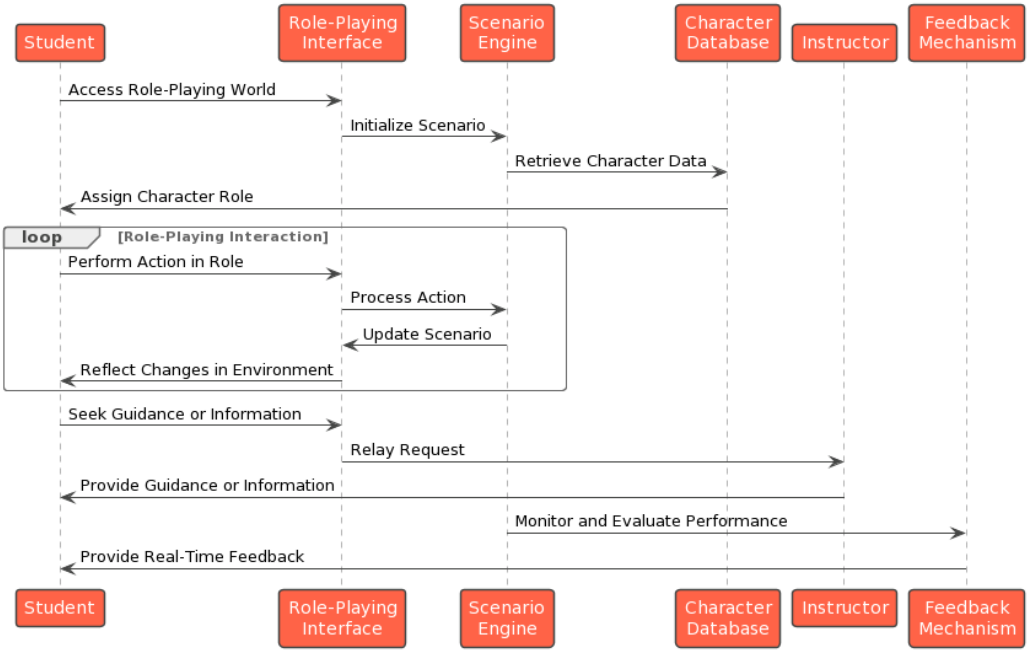

Figure 4. Typical interactions in Role-Playing World.

3.7.3. Educational Applications

Role-Playing World in an educational context refers to virtual environments where students assume specific roles and engage in activities or scenarios that mimic real-life situations, historical events, or fictional settings. This approach is widely used for experiential learning, where students learn by doing and reflecting on their experiences. Here, are some real-world examples of Role-Playing Worlds used in education:

Second Life has been used extensively in higher education for role-playing activities. For example, nursing students might role-play as healthcare providers in a virtual hospital to practice patient care [130], or language students might immerse themselves in a virtual environment where they must speak a foreign language [131].

Medical and nursing schools use role-playing simulations extensively. Students may role-play as doctors, nurses, or other healthcare professionals [132,133] to practice diagnosing and treating patients in a simulated environment, often with actors playing the roles of patients. Virtual History Field tools, like RobotLAB VR Expeditions 2.0 or BBC's Civilisations AR, enable students to take virtual trips to historical sites, where they can role-play as explorers or historical figures to learn about different cultures and eras.

3.7.4. Educational Affordances

Role-Playing World offers a unique set of affordances that can greatly enhance the learning experience. These affordances make it a powerful tool for teaching a wide range of subjects and skills. Table 5 presents a comprehensive discussion of these affordances.

Role-Playing World offers a dynamic and engaging way to learn, allowing students to actively participate in their learning process, understand different perspectives, and apply theoretical knowledge in practical, often complex, scenarios. This approach is particularly effective in fostering soft skills, critical thinking, and a deeper appreciation of various subjects. However, its effectiveness is contingent upon careful planning, resource allocation, and skilled facilitation.

Table 5. Affordances of Role-Playing in Education.

Affordance	Description
Contextual Learning	By situating learners in a specific context or scenario, role-playing helps in contextualizing the learning content, making it more relevant and easier to understand.
Empathy and Perspective-Taking	Assuming different roles allows students to see the world from varied perspectives, fostering empathy and understanding for different viewpoints.
Communication Skills	Role-playing scenarios often require students to communicate effectively, negotiate, and express their ideas clearly, which enhances their verbal and non-verbal communication skills.
Collaboration and Teamwork	Many role-playing activities require teamwork, teaching students how to work effectively in groups, resolve conflicts, and collaborate towards common goals.
Cognitive Skills	Role-playing often involves complex scenarios requiring analysis, decision-making, and problem-solving, thus enhancing cognitive skills.
Creative Thinking	The open-ended nature of many role-playing activities encourages creative thinking and innovation.
Emotional Intelligence	Participating in emotionally charged scenarios can help students in recognizing and managing emotions, both their own and others', thereby improving their emotional intelligence.
Interdisciplinary Learning	Role-playing can integrate various disciplines, allowing students to explore connections between different fields of study.
Adaptability to Learning Styles	This approach can be adapted to suit various learning preferences, whether visual, auditory, or kinesthetic.
Application of Theoretical Knowledge	Role-playing provides an opportunity for students to apply theoretical concepts in practical settings, bridging the gap between theory and practice.
Developing Soft Skills	Role-playing helps students develop communication, negotiation, leadership, and teamwork skills. It encourages active listening and empathy by requiring students to understand and portray different perspectives.
Understanding Complex Concepts	By acting out scenarios, students can better grasp complex social, political, economic, or scientific concepts. It allows them to see the practical implications of theoretical knowledge.
Engagement and Motivation	Role-playing activities captivate students' attention by immersing them in interactive and often emotionally engaging scenarios. This heightened engagement can lead to increased motivation and interest in the subject matter. It makes learning more dynamic and memorable.

3.8. Collaborative World

3.8.1. Collaborative World: Definition and Key Elements

Collaborative World, in an educational context, refers to a virtual environment designed to foster collaboration among students [134]. In these worlds, the emphasis is on group projects, teamwork, and collective problem-solving. This approach to learning leverages the power of social interaction and peer-to-peer engagement to enhance educational outcomes.

Key elements of a Collaborative World are as follows:

- Team-Based Structure: The fundamental structure of a Collaborative World is built around teamwork. Students are grouped into teams and must collaborate to achieve common goals.
- Shared Goals and Objectives: The tasks and challenges presented in these worlds require a collective effort to accomplish. Goals are designed in a way that they cannot be achieved by individuals working alone.
- Interactive and Shared Environment: The world provides an interactive space where students can communicate, share resources, and work together. This environment is often virtual, allowing for real-time collaboration regardless of physical location.

Collaborative World offers a dynamic and interactive platform for education, emphasizing teamwork, communication, and collective problem-solving. This approach is highly relevant in today's interconnected world, preparing students not only with academic knowledge but also with essential social skills and global perspectives.

3.8.2. Typical Interactions

In a Collaborative World, the nature of interactions is fundamentally anchored in cooperation, teamwork, and shared experiences [135]. These virtual environments are designed to foster collective effort, where participants, often learners or players, engage in activities that require collaboration to achieve common goals. This setting is ideal for educational and professional training purposes, as it mirrors real-life collaborative scenarios, providing a rich context for developing social and cognitive skills.

One of the primary modes of interaction in a Collaborative World is through group tasks or projects. Participants are usually required to work together to solve problems, complete tasks, or achieve objectives. These activities demand a range of collaborative skills, including effective communication, joint planning, and resource sharing. For instance, in an educational Collaborative World, students might work together on a scientific experiment, a historical research project, or a creative art piece. The success of these endeavors hinges on the ability of group members to coordinate their efforts, communicate clearly, and leverage each other's strengths [136]. As participants work together, they engage in continuous dialogue to share ideas, provide feedback, and make collective decisions. The exchange of ideas in such a collaborative setting can lead to deeper understanding and more innovative solutions than what might be achieved individually. These projects often require interdisciplinary knowledge, encouraging students to draw on different subject areas and integrate diverse skills. This interdisciplinary approach not only enriches the learning experience but also prepares students for the complexity of real-world problems.

Feedback and reflection are also integral to the collaborative process [137]. Participants receive feedback not only from the system or facilitators but also from their peers. This peer-to-peer feedback is valuable for learning and improvement, as it provides diverse perspectives and insights. Moreover, reflecting on the collaborative process helps participants understand the dynamics of teamwork, recognize the value of diverse contributions, and learn from both successes and challenges.

The use of digital tools and resources is another hallmark of Collaborative Worlds. These tools facilitate collaboration by allowing participants to share documents, create digital artifacts, and access a wealth of information [138]. The integration of these tools into the collaborative process enhances productivity and creativity, as participants can easily share and build upon each other's work.

Figure 5 illustrates the complex interactions within a Collaborative World. It covers the student's engagement with the collaborative interface, group collaboration system, communication tools, task management, and feedback systems. The diagram includes cycles of collaboration, individual contributions, project submission, and reflective practice, highlighting the dynamic and interactive nature of learning in a Collaborative World.

Collaborative Worlds offer a dynamic and interactive platform for cooperative learning and working. The interactions in these environments are characterized by teamwork, communication, negotiation, and shared problem-solving. Through these collaborative experiences, participants develop essential social and cognitive skills that are valuable in both academic and professional contexts. The use of digital tools and resources further enhances these interactions, making Collaborative Worlds an effective and engaging medium for collaborative education and training.

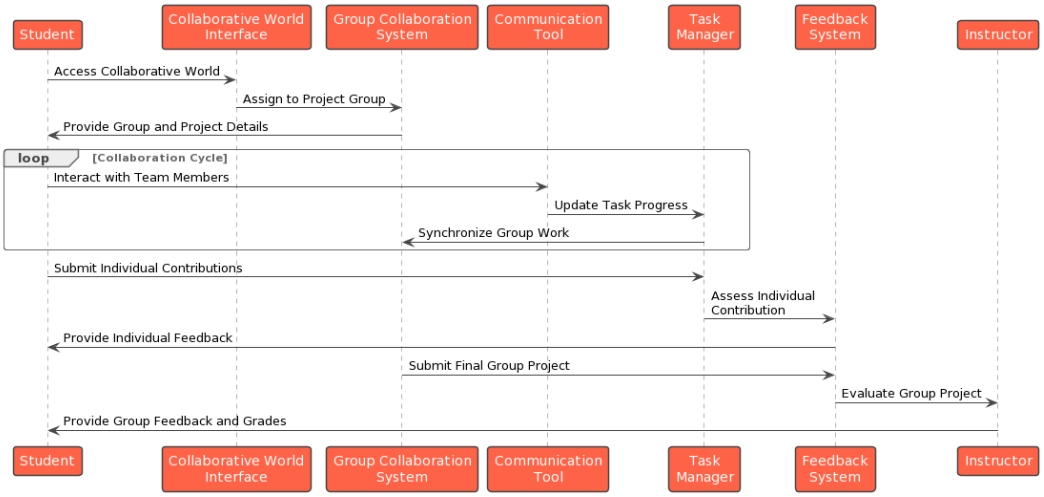

Figure 5. Typical interactions in Collaborative World.

3.8.3. Educational Applications

Collaborative World in an educational context, refers to virtual environments or platforms designed to foster collaboration among students. These worlds are increasingly being used in education to simulate real-world scenarios and to provide a dynamic space for group learning, problem-solving, and project-based activities. Here, are some real-world examples of Collaborative Worlds used in education:

Atlantis Remixed (formerly known as Quest Atlantis) is a 3D multi-user, alternate reality game that blends a fantasy narrative with educational tasks. It is designed to engage students in meaningful inquiry on a variety of topics. Collaboration is fostered through missions and quests that students complete together [139].

CivilizationEDU is an educational adaptation of the popular strategy game "Civilization". Students work together to build civilizations from the ground up, learning about history, geography, government, and economics in the process [140].

Foldit is an online puzzle video game about protein folding [141]. It involves players collaboratively solving puzzles to fold protein structures correctly. It is used in biology and biochemistry education, contributing to actual scientific research.

Another example is a digital puzzle game organized by the lecturers at Kaunas University of Technology (KTU), covering a section of the 'Mathematics 2' university course. The puzzles are designed to review all knowledge related to integrals, including indefinite integrals, definite integrals, improper integrals, and double integrals [142]. The objective is to complete all challenges and puzzles within 100 min. One puzzle example is presented in Figure 6.

Figure 6. Puzzle example gamified lecture at KTU.

3.8.4. Educational Affordances

Collaborative World in education refers to virtual environments specifically designed to facilitate collaboration among learners. These worlds offer unique affordances that support and enhance group-based learning activities. These affordances are summarized in Table 6.

Table 6. Affordances of Collaborative Worlds in Education.

Affordance	Description
Facilitates Group Communication	Collaborative Worlds offer platforms (like chat rooms, video conferencing, and shared digital workspaces) that enable seamless communication among students, essential for effective teamwork.
Supports Diverse Interaction Styles	These environments cater to different interaction styles, accommodating students who might be less inclined to participate in traditional classroom settings.
Social Learning	By encouraging discussion and exchange of ideas, these worlds foster social learning, where students learn from each other's experiences and perspectives.
Project-Based Learning	Collaborative Worlds are ideal for project-based learning, where students undertake complex projects that necessitate collaboration, planning, and execution.
Interdisciplinary Approach	These environments integrate various subjects and skills within a single project.
Distributed Leadership	Collaborative Worlds often allow for rotating leadership roles, giving students the opportunity to lead and follow in various contexts.
Peer-to-Peer Learning	These environments promote peer-to-peer learning, where students can mentor and support each other, often leading to deeper understanding and retention of knowledge.
Real-World Relevance	Many collaborative tasks are designed to mimic real-world challenges, making learning more relevant and engaging.
Critical Thinking	The need to evaluate information, discuss, and reach consensus promotes critical thinking skills.
Digital Literacy	Working in Collaborative Worlds naturally enhances students' digital literacy skills—an essential competence in the modern world.
Communication Skills	Effective communication is crucial in these worlds. Students learn to express their ideas clearly and listen to others' viewpoints.
Innovative Use of Technology	These environments often leverage cutting-edge technology, such as VR and AR, to create more immersive and effective collaborative experiences.
Overcoming Geographical Barriers	Collaborative Worlds enable students from different geographical locations to work together, broadening educational opportunities.
Teamwork Development	Students develop essential teamwork skills, including cooperation, negotiation, conflict resolution, and shared decision-making. They learn to work effectively in diverse groups and often rotate roles to experience different aspects of teamwork.
Problem-Solving	Collaborative Worlds present complex problems that require creative thinking and collective problem-solving skills.
Real-time Interaction	Advanced technologies enable real-time interaction and collaboration, enhancing the immediacy and impact of the learning experience.
Increased Engagement	The interactive nature of Collaborative Worlds can lead to higher levels of student engagement, as learners often find collaborative activities more enjoyable and rewarding.
Motivation through Community	Working in a team can create a sense of community and belonging, which can be a strong motivational factor for students.

Collaborative World in education provides a rich array of affordances that enhance learning through interaction, collaboration, problem-solving, and the use of technology. These environments prepare students for the collaborative nature of the modern workplace and a globally connected world. However, their success depends on effective facilitation, equitable participation, and robust technological infrastructure.

3.9. Comparison of the Worlds

To summarize, these worlds are grounded in their unique focus areas:

- Adventure World is defined by its narrative-driven entities and quest-based interactions.
- Simulation World is characterized by its realistic mimicry of real-world entities and processes.
- Creative World is distinguished by its emphasis on creativity and design in both entities and interactions.
- Role-Playing World is set apart by its role-specific entities and scenario-driven interactions.
- Collaborative World is defined by its focus on teamwork and cooperative entities and interactions.

4. Evaluation

For evaluation, we employ four frameworks: Theory of Inventive Problem Solving (TRIZ) [13], Concept-Knowledge (C-K) theory [14], Structure-behavior-function (SBF) modeling [15], Framework for 21st Century Learning (P21) [16] and Universal Design for Learning (UDL) [17].

4.1. TRIZ

TRIZ, or the Theory of Inventive Problem Solving, is a systematic approach developed to understand and solve complex problems and encourage innovation [13]. Originating from a comprehensive analysis of patents and inventions, TRIZ is based on the idea that the evolution of systems is governed by certain principles and patterns. Although TRIZ was initially developed for engineering and technological problem-solving, its principles are versatile and can be effectively applied to evaluate and enhance educational systems.

At the core of TRIZ is addressing and resolving contradictions without compromise, which in an educational context, could mean finding solutions that enhance learning outcomes without increasing workload or resource demands. For instance, the TRIZ principle of ideality, which focuses on maximizing the desired functions of a system while minimizing harmful or undesired effects, could be used to develop educational strategies that maximize student engagement and learning, while reducing stress and workload.

Another key aspect of TRIZ is the use of inventive patterns and analogies. This involves looking at solutions from other fields and adapting them to the current problem. In education, this could mean borrowing successful strategies from business management or technology to innovate teaching methods, curriculum design, or assessment models. TRIZ also emphasizes the prediction and anticipation of system evolution, allowing educators and administrators to foresee future challenges and opportunities in the education sector. This forward-thinking approach encourages the continuous adaptation and evolution of educational systems, ensuring they remain relevant and effective in the face of societal and technological changes.

Functionality is another TRIZ principle, focusing on understanding and improving each component's role within a system. Applying this to education could involve analyzing and enhancing various aspects of the learning process, such as instructional methods, learning materials, and student-teacher interactions, to improve the overall effectiveness of the educational system.

Table 7 outlines how each virtual world type aligns with key TRIZ principles, highlighting their unique features and educational advantages. The categories of Ideality, Contradiction Resolution, Functionality, and Adaptability provide a framework for comparing these virtual worlds in the context of inventive problem-solving and innovation, which are central to the TRIZ methodology.

Table 7. Comparison of Virtual World Types Using TRIZ Principles.

TRIZ Principle	Adventure World	Simulation World	Creative World	Role-Playing World	Collaborative World
Ideality	Engages students in story-driven quests for immersive learning	Simulates real-world environments for practical learning experiences	Encourages original creation and innovation in an open environment	Enables students to assume roles to understand different perspectives	Facilitates teamwork and group problem-solving in shared tasks
Contradiction Resolution	Balances narrative enjoyment with educational content	Merges realistic simulations with safe, controlled learning environments	Harmonizes free exploration with structured learning outcomes	Combines fictional role-play with real-world applicable skills	Aligns individual contributions with group objectives
Functionality	Offers contextual learning through guided adventures	Provides hands-on experience in lifelike scenarios	Fosters creativity and technical skills development	Enhances soft skills like empathy and communication	Promotes collaborative skills and peer-to-peer learning
Adaptability	Adjusts to varying narrative paths based on student choices	Tailors simulations to diverse educational fields	Supports a wide range of creative projects and disciplines	Adapts to different historical or fictional settings	Accommodates diverse team dynamics and project goals

4.2. C-K Theory

Concept-Knowledge (C-K) Theory, developed as a framework for innovation [14], primarily focuses on the interplay between two spaces: the concept space (C) and the knowledge space (K). In the realm of education, this theory can be instrumental in evaluating and enhancing educational systems. At its heart, C-K Theory posits that the concept space is where new ideas and possibilities are generated, regardless of their feasibility. These concepts challenge existing knowledge, leading to exploration and expansion beyond current understandings. In an educational context, this translates to encouraging students to think beyond the conventional curriculum, fostering creativity and innovation. Educators can use this space to introduce novel ideas or hypothetical scenarios that push students to think outside the box. The knowledge space comprises established facts, theories, and practices. It represents the current state of understanding in any given field. In education, this space is akin to the existing curriculum, teaching methods, and educational resources. The C-K Theory in education implies a dynamic interplay between teaching established knowledge and encouraging students to explore new concepts. The process of moving from the concept space to the knowledge space is where learning and innovation occur. When a novel idea in the concept space is explored and validated, it expands the boundaries of the knowledge space. This process is crucial in educational systems, as it encourages not just the acquisition of existing knowledge, but also the creation of new knowledge. It promotes a learning culture where students are not mere recipients of information, but active participants in knowledge creation [143].

Applying the C-K Theory to evaluate educational systems involves looking at how effectively these systems balance and transition between the concept and knowledge spaces. It requires an assessment of how well the curriculum encourages creative thinking and problem-solving, alongside imparting established knowledge. It also involves evaluating whether the educational environment provides opportunities for students to experiment with and validate their novel ideas, thereby contributing to the expansion of the knowledge space. C-K Theory can guide the development of teaching methodologies and curricula that are more adaptive and responsive to the changing needs of society. It supports a more

holistic approach to education, where the focus is not only on what is known but also on what could be known. This approach is particularly relevant in a rapidly changing world, where the ability to innovate and adapt is as crucial as the knowledge of established facts.

Table 8 outlines how each virtual world type aligns with key aspects of the Concept-Knowledge (C-K) theory, showcasing their unique approaches to learning and creative design. It provides a framework for comparing these virtual worlds in the context of concept development, knowledge integration, and learning facilitation, key components in the C-K theory.

Table 8. Comparison of Virtual World Types Using C-K Theory.

C-K Theory Aspect	Adventure World	Simulation World	Creative World	Role-Playing World	Collaborative World
Concept Expansion	Explores narrative-driven quests, expanding the concept of storytelling in learning	Simulates real-world scenarios, broadening the application of theoretical knowledge	Encourages original creation, expanding the boundaries of imagination	Engages in role assumption, diversifying understanding of perspectives	Focuses on group dynamics, enhancing the concept of teamwork and collaboration
Knowledge Integration	Integrates knowledge into a storyline, facilitating contextual learning	Applies theoretical knowledge to practical, simulated scenarios	Merges knowledge with creativity, fostering innovative thinking	Blends knowledge with empathetic understanding through role-play	Combines diverse knowledge sets within group projects for holistic learning
Creative Design	Designs engaging narratives that stimulate curiosity and exploration	Designs realistic simulations for hands-on learning experiences	Provides tools for creative expression and design freedom	Creates immersive roles and scenarios for experiential learning	Designs collaborative tasks that require collective creativity and problem-solving
Learning Facilitation	Facilitates learning through exploration and discovery in a guided narrative	Facilitates experiential learning through realistic practice and experimentation	Facilitates self-directed learning and creativity	Facilitates empathy and social learning through role immersion	Facilitates cooperative learning and knowledge sharing in group settings

4.3. Structure-Behavior-Function (SBF) Modeling

Structure-Behavior-Function (SBF) modeling [15] is an analytical framework primarily used to understand complex systems by decomposing them into their constituent parts. In the context of evaluating educational systems, SBF modeling offers a structured approach to analyze how various components of the educational system interact and contribute to its overall purpose.

The "structure" aspect of SBF refers to the physical and organizational elements of the educational system. This includes the infrastructure like classrooms, technological tools, curriculum content, and administrative organization. In evaluating an educational system, analyzing its structure involves looking at how these elements are organized and how they physically exist and operate within the system.

The "behavior" aspect pertains to the actions and processes that occur within the structure of the system. In education, this includes teaching methods, student interactions, learning activities, and administrative processes. Evaluating behavior in an educational system involves observing and understanding these actions and processes to determine how they contribute to or hinder the learning process.

The "function" aspect relates to the purpose or the outcomes of the system. In educational systems, the function is typically related to learning outcomes, student development,

skill acquisition, and the preparation of students for future endeavors. When evaluating an educational system using SBF modeling, the focus is on understanding how effectively the system achieves its intended functions. This involves assessing the success of the system in terms of student performance, skill development, and overall educational outcomes.

Using SBF modeling to evaluate educational systems allows for a comprehensive understanding of how well the system works. By analyzing the structure, it is possible to determine if the physical and organizational components are well-designed and conducive to learning. By examining the behavior, insights can be gained into the effectiveness of teaching methods and learning processes. Finally, by assessing the function, it can be determined whether the educational system is meeting its goals in terms of student learning and development. This holistic approach ensures that the evaluation of educational systems is not just focused on one aspect, like test scores or student satisfaction, but encompasses a broad view of how different elements within the system contribute to the overall educational goals. It allows educators, administrators, and policymakers to identify areas of strength and weakness within the system and to make informed decisions about where improvements can be made.

Table 9 uses the SBF model to analyze and compare various virtual world types. Each world's unique structure supports certain behaviors, which in turn, fulfill specific educational functions. This SBF perspective provides insights into how these virtual environments are designed and how they facilitate learning and skill development.

Table 9. Comparison of Virtual World Types Using SBF Modeling.

SBF Aspect	Adventure World	Simulation World	Creative World	Role-Playing World	Collaborative World
Structure	Story-driven environments with quests	Realistic replicas of real-world environments or scenarios	Open-ended, sandbox-like environments for creation	Character-driven scenarios with role-specific settings	Group-focused environments with shared goals and tools
Behavior	Exploration and interaction within a narrative	Practical application of skills in a simulated setting	Creativity, experimentation, and design	Assuming and acting out assigned roles	Collaboration, communication, and group problem-solving
Function	Enhances narrative understanding and contextual learning	Provides hands-on experience and practical skill development	Fosters innovation, creativity, and technical skill enhancement	Develops empathy, perspective-taking, and social skills	Promotes teamwork, cooperative learning, and collective intelligence

4.4. Framework for 21st Century Learning (P21)

The Framework for 21st Century Learning, developed by the Partnership for 21st Century Skills (P21), is a comprehensive model that outlines the essential skills and knowledge students need in the 21st century [16]. This framework is grounded in the recognition that education must evolve to prepare students for the complex challenges of today's global and digital world.

Central to P21's framework is the integration of four critical skill areas, referred to as the 4Cs: Critical Thinking, Communication, Collaboration, and Creativity. Critical Thinking involves problem-solving and decision-making skills, essential for navigating an increasingly complex world. Communication emphasizes the ability to effectively articulate and share ideas, a crucial skill in a globally connected environment. Collaboration focuses on the ability to work effectively with diverse teams, highlighting the importance of teamwork in a globalized society. Creativity encourages innovation and adaptability, skills that are becoming increasingly important as the pace of change accelerates. The framework also encompasses other key areas, including information, media and technology skills, and

life and career skills. It also emphasizes the importance of core subjects and interdisciplinary themes that reflect the interconnected nature of the modern world.

When used to evaluate educational systems, the P21 framework offers a holistic view of what constitutes a well-rounded, future-ready education. Rather than solely focusing on traditional academic achievements, this framework suggests assessing how well an educational system prepares students to be effective thinkers, communicators, collaborators, and creators. It advocates for curricula that not only cover core subjects, but also incorporate critical thinking, problem-solving, creativity, and digital literacy. Moreover, the framework emphasizes the importance of learning environments that support these skills. This includes evaluating whether schools provide opportunities for collaborative project-based learning, integrate technology in meaningful ways, and foster a culture of innovation and adaptability.

Applying the principles of the P21 framework to evaluate educational systems involves looking beyond standardized test scores to consider how well students are being prepared for the complexities of modern life and work. It means assessing whether students are gaining the skills they need to succeed in a world where change is the only constant, and where the ability to adapt, learn, and innovate is more critical than ever.

The P21 framework offers a comprehensive model for evaluating and guiding educational systems. It shifts the focus from traditional academic learning to a more holistic approach that prepares students for the demands and challenges of the 21st century. This approach is vital for developing learners who are not only academically proficient but also capable of thinking critically, working collaboratively, communicating effectively, and innovating continuously.

Table 10 uses the P21 Framework to analyze and compare various virtual world types in terms of how they support the development of critical 21st-century skills: Critical Thinking, Communication, Collaboration, and Creativity. This comparison provides insights into the unique educational benefits of each virtual world type, highlighting how they can be utilized to foster essential skills in learners for the 21st century.

Table 10. Comparison of Virtual World Types in Supporting 21st Century Skills.

21st Century Skill	Adventure World	Simulation World	Creative World	Role-Playing World	Collaborative World
Critical Thinking	Engages in problem-solving through quests	Develops analytical skills in realistic scenarios	Encourages innovative thinking in open-ended creation	Enhances decision-making in complex role-play scenarios	Promotes evaluative and strategic thinking in group tasks
Communication	Facilitates narrative understanding and expression	Requires precise communication in simulations	Supports articulation of creative ideas	Develops verbal and non-verbal communication in roles	Enhances collaborative communication skills in teams
Collaboration	Offers opportunities for teamwork in adventures	Encourages collaborative problem-solving in tasks	Supports co-creation and feedback sharing	Involves cooperative strategies in role enactment	Focuses on group dynamics and project management
Creativity	Stimulates imagination in story-based environments	Fosters inventive solutions to simulated challenges	Provides a canvas for artistic and innovative creations	Encourages imaginative role development	Inspires creative approaches to teamwork challenges

4.5. Universal Design for Learning (UDL)

The Universal Design for Learning (UDL) framework is a set of principles for curriculum development that gives all individuals equal opportunities to learn [17]. UDL is based on the insight that a one-size-fits-all approach to education often leaves out learners with unique needs and backgrounds. The framework addresses this by recommending flexible instructional materials, techniques, and strategies that empower educators to meet these varied needs. UDL is structured around three primary principles: Engagement, Representation, and Action and Expression (see Table 11).

Table 11. Comparison of Virtual World Types Using UDL Principles.

UDL Principle	Adventure World	Simulation World	Creative World	Role-Playing World	Collaborative World
Engagement	Engages students through narrative-driven exploration and quests	Provides hands-on, risk-free environments to engage with real-world scenarios	Fosters creativity and innovation through open-ended, sandbox-like environments	Engages students by taking on roles and navigating through character-driven scenarios	Promotes engagement through teamwork on common goals
Representation	Offers diverse storylines and characters to represent complex concepts	Uses realistic simulations to represent theoretical concepts and processes	Represents ideas through a variety of digital creation tools	Uses narratives and role-specific challenges to represent perspectives	Represents collaborative tasks and objectives within a shared virtual environment
Action and Expression	Allows students to choose paths and solve puzzles, offering multiple means of action	Supports experimenting and manipulation of variables for different outcomes	Encourages design, build, and share projects, offering diverse means of expression	Allows decision making and problem-solving through role-play, providing varied expression methods	Facilitates communication and collaboration tools for joint problem-solving

Engagement, the first principle focuses on motivating learners by offering diverse ways to capture interest and sustain effort and persistence across learning activities. This principle acknowledges that what excites and engages one learner might not work for another, emphasizing the importance of providing options that cater to different motivational drivers.

The second principle, Representation, is about presenting information and content in multiple formats to address the diverse ways learners perceive and comprehend information. This principle recognizes that learners vary in how they process information due to differences in sensory abilities, cultural and linguistic backgrounds, and learning styles. By offering information through various media (textual, visual, auditory, and interactive formats), educators can ensure that all students have equal opportunities to access and understand the content.

Action and Expression, the third principle, acknowledges that learners differ in how they navigate learning environments and express what they know. As such, UDL suggests providing multiple means for action and expression. This can include different tools for

composition, problem-solving approaches, and options for demonstrating knowledge, allowing learners to utilize their strengths and preferences in learning tasks.

Evaluating educational systems through the lens of UDL involves assessing how well these systems incorporate flexibility in engagement, representation, and action and expression to support the diverse needs of all learners. It entails looking at the curriculum, teaching methods, assessment strategies, and technologies used to ensure they offer multiple means of engagement, representation, and expression. An educational system that aligns with UDL principles is one that is accessible and inclusive, offering personalized learning paths and reducing barriers to learning for students with a wide range of abilities, backgrounds, and interests. This holistic approach not only supports learners with disabilities but also enhances the learning experience for all students, fostering a more inclusive and effective educational environment.

5. Findings and Discussion

5.1. Utilization of Virtual Worlds in Education

The utilization of virtual worlds in education has emerged as a transformative approach in recent years. These digital environments provide immersive, interactive platforms where learners can engage with content in a manner that traditional classrooms often cannot offer [144]. Virtual worlds range from highly structured simulations replicating real-world scenarios to more open-ended, creative spaces where imagination and innovation take the forefront. The versatility of these platforms allows for a wide range of educational applications, from teaching hard sciences through detailed simulations [19], to fostering soft skills like collaboration and empathy in role-playing settings [83]. These environments have been effectively used to simulate complex systems, visualize abstract concepts, and create engaging narratives for deeper learning experiences. Their use has been particularly beneficial in fields where hands-on experience is crucial but challenging to facilitate in a physical setting, such as medicine, engineering, and environmental sciences [145].

The emphasis on virtual worlds as a catalyst for innovative teaching and learning methodologies resonates with the findings of Díaz [18], who advocates for the integration of virtual worlds with hybrid and mobile learning models to enhance educational accessibility and engagement. Similarly, the role of virtual worlds in facilitating collaborative learning experiences is echoed in studies by Griol and Callejas (2017) [146], underscoring the versatility of virtual environments in nurturing creativity, collaboration, and problem-solving skills among learners.

In contrast, the work of An (2019) broadens the application of virtual worlds beyond the confines of the Metaverse, advocating for their potential to engender smart learning environments that are adaptive, engaging, and personalized [19]. Integrating the metaverse with natural language processing (NLP) and AI-powered chatbots for education represents a trend towards creating immersive, interactive learning environments that leverage NLP to provide personalized, engaging educational experiences in STEM [147]. This perspective is complemented by research from Gregory et al. (2015) and Dawson et al. (2019), which delve into the technological and pedagogical barriers to virtual world implementation in higher education, offering a pragmatic lens through which to view the challenges and opportunities presented by virtual learning environments [148,149].

5.2. Educational Outcomes

The educational outcomes associated with the use of virtual worlds have been notably positive. Studies have shown that students learning in these environments often demonstrate a deeper understanding of the subject matter, improved problem-solving skills, and enhanced memory retention [150]. In role-playing worlds, for instance, students exhibit a better grasp of historical events and social dynamics by experiencing them from the inside. Similarly, creative worlds have been found to significantly enhance students' creativity, technical skills, and ability to innovate. The simulation worlds offer a practical understanding of complex systems and processes, which is particularly valuable in techni-

cal and scientific education [72]. These varied learning experiences contribute to a more comprehensive educational outcome, equipping students with skills and knowledge that are relevant and transferable to real-world scenarios [19].

5.3. Student Engagement and Interaction

Engagement and interaction are key aspects where virtual worlds offer considerable advantages. The immersive nature of these environments captures students' attention and curiosity, motivating them to explore and learn actively. The interactive elements of virtual worlds, such as the ability to manipulate objects or navigate through different scenarios, encourage a more hands-on approach to learning [151]. Moreover, the social aspect of these worlds, especially in collaborative and role-playing formats, enhances peer interaction and teamwork. This social interaction is not just limited to within the classroom or institution; virtual worlds often connect learners from across the globe, fostering a more diverse and inclusive learning community [152].

5.4. Support for Student Learning Sustainability

Virtual worlds are a powerful educational tool, particularly for teaching concepts related to sustainability. These interactive environments enable students to visualize and interact with complex ecological and environmental systems in ways that traditional classroom settings cannot. For instance, students can simulate the impact of various actions on ecosystems, climate, and resources, gaining a deeper understanding of the cause-and-effect relationships inherent in sustainability issues. This experiential learning approach promotes active engagement, making abstract concepts tangible and relevant to the student's own experiences [153,154].

Virtual worlds foster a multidisciplinary approach to learning, integrating aspects of science, economics, and social studies to provide a holistic perspective on sustainability. This interdisciplinary method is crucial for understanding the interconnectedness of human actions and the environment. Students can experiment with different scenarios, such as implementing renewable energy sources or managing waste, and immediately observe the outcomes of these choices, which helps develop critical thinking and decision-making skills focused on long-term sustainability. The integration of knowledge from various fields through transdisciplinary co-production enhances the learning process by involving stakeholders in knowledge production, leading to a deeper understanding of sustainability issues [155]. Additionally, the transdisciplinary approach in sustainability research, combining complex systems theory with reflexive science, supports a deeper integration of diverse perspectives, crucial for addressing sustainability challenges [156].

Virtual worlds offer an inclusive and accessible learning environment, where students of diverse backgrounds and abilities can collaborate on sustainability projects, share perspectives, and develop solutions collectively. This aspect mirrors real-world processes and prepares students for future careers in sustainability fields, where teamwork and collaboration are essential. By engaging in virtual scenarios, students cultivate a sense of stewardship and responsibility towards the environment. The immersive nature of virtual worlds evokes emotional responses and builds empathy towards environmental issues, driving a more profound commitment to sustainable practices in their personal and professional lives. Studies [157,158] highlight how virtual worlds can foster inclusive and diverse learning communities, enhancing students' understanding and commitment to sustainability.

5.5. Challenges Encountered

Despite their advantages, the use of virtual worlds in education is not without challenges. One of the primary concerns is the digital divide; unequal access to technology can create disparities in educational opportunities [159]. Technical issues, such as software glitches and hardware limitations, can also hinder the learning experience. Additionally, developing high-quality virtual world content that is both educationally effective and

engaging can be resource-intensive. There is also the challenge of ensuring that the virtual interactions and activities are effectively integrated with the educational objectives and curriculum standards. Another concern is the potential for decreased face-to-face interaction, which some educators fear may impact social development and communication skills [160].

There are concerns regarding the optimal duration for immersion in virtual worlds, with factors such as cognitive load, physical comfort, and psychological impact which may have diverse learning effects due to differences in learner psychological types [161]. While specific time limits may vary depending on the individual and context, it is generally advised to moderate usage to prevent negative effects like virtual reality sickness, eye strain, or decreased real-world social interactions. Studies have highlighted various aspects of these challenges, including the adverse effects related to static balance and VR sickness [162], the influence of personality, sound, and content difficulty on VR sickness [163], and the effects of immersion and cognitive load on time estimation in VR environments [164]. Educational programs leveraging virtual worlds may recommend breaks and limit session lengths to ensure a balanced and healthy engagement. The educators should follow recommendations and guidelines issued by health professionals.

5.6. Implications for Teaching Practice

The integration of virtual worlds in education has significant implications for teaching practice. Educators must develop new pedagogical strategies that are suitable for virtual environments. This includes becoming proficient with the technology, understanding how to facilitate learning in a virtual space, and integrating virtual activities with traditional teaching methods. There is also an increased need for collaboration among educators, game designers, user eXperience (UX) designers and IT professionals to create effective and engaging learning experiences. Key studies highlight the importance of this multidisciplinary collaboration and pedagogical innovation in virtual worlds [72,165].

Game designers contribute by creating engaging and immersive virtual worlds, ensuring the content is both educational and captivating. UX designers play a pivotal role in ensuring that virtual environments are not only intuitive and engaging but also accessible to users with diverse needs and abilities. Their expertise in user-centered design principles enables the development of virtual worlds that are more inclusive, catering to a broad spectrum of user preferences and requirements, including those of learners with disabilities. This inclusion underscores our commitment to creating educational experiences that are universally accessible and beneficial to all users. The Unity Experiment Framework (UXF) is an example of a tool that bridges the gap between game designers and behavioral scientists, facilitating the creation of immersive educational content [166]. Additionally, the development of a role-playing game for software project management in a virtual world exemplifies the collaboration between educators, game designers, and UX designers to enhance experiential learning and simulate real-life scenarios [83].

Teachers must also be mindful of maintaining a balance between virtual and real-world interactions and ensuring that the use of technology enhances rather than detracts from the learning objectives. Furthermore, educators need to be aware of the diverse needs of their students, providing support for those who may struggle with the transition to virtual learning environments. This includes understanding the implications of the digital divide on access to technology and ensuring equitable educational opportunities. Collaborative efforts between educators, game designers, user experience (UX) designers, and IT professionals are crucial for creating effective and engaging learning experiences that cater to a broad spectrum of learner needs [167,168]. The focus on ensuring effective communication and interaction in virtual learning environments is also highlighted as a means to support student engagement and mitigate issues related to social isolation and decreased face-to-face interaction [151].

5.7. Support for Immersion in Learning

Immersive technologies like VR, AR, and MR significantly enhance learning experiences across different virtual worlds by altering interaction techniques, immersion levels, and availability (Table 12). VR offers deep immersion, making Adventure and Simulation Worlds more realistic and engaging. It allows learners to fully immerse themselves in the environment, facilitating active learning and retention [150]. AR enhances Creative and Role-Playing Worlds by overlaying digital information onto the real world, supporting interactive learning and engagement without full detachment from reality. MR combines the best of both, offering dynamic interactions in Collaborative Worlds by blending real and virtual elements, enhancing teamwork and problem-solving skills [169]. Each technology's unique capabilities cater to specific learning outcomes and accessibility needs, making them versatile tools for educational innovation.

Table 12. Impact of Different Technologies on Learning in Various Types of Virtual Worlds.

Technology	Adventure World	Simulation World	Creative World	Role-Playing World	Collaborative World
VR	High immersion, enhances narrative and exploration	Detailed simulations, realistic training scenarios	Creative freedom with 3D modeling and design	Immersive storytelling and character interaction	Enhanced team collaboration in a shared space
AR	Real-world integration, enhances discovery and engagement	Overlay simulations on real environments, practical learning	Augmented creativity, interactive designs in real space	Interactive stories in real-world settings	Real-world collaboration with digital overlays
MR	Combines real and virtual, dynamic interaction	Hybrid simulations, contextual learning experiences	Blended creativity, interactive with both digital and physical elements	Role-playing with a mix of real and virtual elements	Collaborative tasks using both real and virtual objects

5.8. Support for Inclusiveness and Accessibility

The design and deployment of various types of virtual worlds—Adventure World, Simulation World, Creative World, Role-Playing World, and Collaborative World—in education, necessitate a critical approach that foregrounds inclusivity and accessibility from the outset. Each type of virtual world offers distinct opportunities for learning and engagement, yet their effectiveness hinges on their ability to accommodate diverse learner needs. Adventure Worlds, with their exploratory narratives, must ensure navigational and sensory accessibility. Simulation Worlds require clear, adaptable interfaces to suit different learning styles and abilities. Creative Worlds should offer multiple modalities for expression to cater to various disabilities. Role-Playing Worlds must support diverse forms of communication and interaction, allowing all users to participate fully. Lastly, Collaborative Worlds need to facilitate universal access, ensuring that collaborative tools and platforms are accessible to everyone, including those with physical, sensory, or cognitive disabilities. Prioritizing these aspects from the design phase ensures that virtual worlds are truly inclusive, promoting equal learning opportunities for all students.

This approach ensures that these digital environments cater to a diverse array of learners, including those with various needs and disabilities. By prioritizing accessibility and inclusiveness, the development of virtual worlds can foster equitable learning opportunities, enabling all students to fully engage with and benefit from these innovative educational tools. This commitment to inclusivity not only enhances the learning experi-

ence for individuals with specific requirements but also enriches the educational landscape for all participants, promoting a more inclusive and accessible digital learning environment. Efforts like the Accessible Learning Objects [170], and the establishment of processes for accessible virtual campuses in higher education institutions in Latin America [171], exemplify the critical importance of inclusivity in the digital learning sphere.

A systematic literature review on the educational potential of three-dimensional multi-user virtual worlds for STEM education highlights the instructional and technological affordances of virtual worlds, influencing students' engagement and participation positively [72]. Additionally, the integration of virtual reality in K-12 and higher education emphasizes the potential and challenges of VR-supported instructional design strategies, focusing on students' outcomes and performance, alongside the benefits and challenges of VR technology concerning the analysis of visual features and design elements [172].

5.9. Limitations of the Methodology

The methodological limitations of this study, while inherent to the nature of a literature analysis, may have influenced the findings. Given the reliance on published sources, the research outcomes are subject to the availability, scope, and interpretive biases present within the existing body of work on virtual world environments. Furthermore, the narrative review approach, although comprehensive, may introduce a selection bias as it depends on the researcher's discretion in source selection. Such limitations potentially affect the generalizability of the results and the depth of analysis regarding emerging trends or less documented aspects of virtual world applications in education. This constraint emphasizes the need for future empirical research to validate, extend, and enrich the findings presented. The critical reflections on the limitations of digital mediums for teaching theoretical disciplines like philosophy by Ávila Cañamares [173] and the overview of spatial compression methods in virtual environments by Vasylevska and Kaufmann [174] provide insights into the methodological and technical challenges faced in virtual world education.

6. Conclusions

The exploration of virtual worlds in the realm of education has revealed a multitude of significant findings. Firstly, these environments offer unparalleled opportunities for immersive and interactive learning experiences. Students in virtual worlds can engage with content in ways that go beyond traditional educational settings, from participating in lifelike simulations to engaging in creative and collaborative projects. Such experiences cater to diverse learning styles and preferences, fostering a more inclusive and engaging educational landscape. The immersive nature of these environments, coupled with the interactive and often game-like elements, has been shown to capture students' attention more effectively than conventional teaching methods. This heightened engagement is crucial in facilitating deeper learning and retention of knowledge. Another key observation is the broad spectrum of skills that students develop in virtual worlds. These range from technical skills, such as coding and digital design in creative worlds, to soft skills like empathy, communication, and teamwork in role-playing and collaborative environments. This comprehensive skill development prepares students not only academically but also equips them with essential competencies for their future careers and personal lives. However, the use of virtual worlds in education is not without its challenges. The effectiveness of virtual worlds in achieving educational objectives depends largely on how well they are integrated into the broader curriculum and aligned with teaching goals.

Based on our findings, we provide the following answer to our research question: various types of virtual worlds significantly enhance learning experiences and outcomes by providing immersive, interactive platforms that foster a deeper understanding of subject matter, improve problem-solving skills, and enhance memory retention. Specifically, they support the development of critical 21st-century skills by offering environments where learners can engage in lifelike simulations, creative and collaborative projects, cater to diverse learning styles, and foster inclusivity. This comprehensive skill development

prepares students for future careers and personal life, demonstrating the potential of virtual worlds to revolutionize education with unique and engaging learning experiences.

Given the findings and the emerging nature of virtual worlds in education, several recommendations for future research can be outlined. First, there is a need for more comprehensive studies that investigate the long-term impact of learning in virtual environments. Research should focus on how skills and knowledge acquired in these settings translate into real-world applications and how they compare to traditional learning outcomes. Future research should also delve into the development of theoretical frameworks, pedagogical strategies and best practices for integrating virtual worlds into the existing curriculum [175]. This includes exploring methods for effective facilitation, assessment, and ensuring alignment with educational standards. As technology continues to evolve, ongoing research is needed to explore new possibilities and innovations in virtual world platforms. This includes the potential integration of emerging technologies such as artificial intelligence, and how they can further enhance educational experiences. Virtual worlds hold immense potential for revolutionizing education, offering unique and engaging learning experiences. However, realizing this potential requires careful consideration of the challenges and continued research to optimize these environments for educational use. As technology advances, so too must our understanding of how best to utilize these digital landscapes for the benefit of learners now and in the future.

Future works will include comprehensive investigations into the long-term impacts of learning within virtual environments. Key areas for future research include examining how skills and knowledge acquired in virtual settings translate to real-world applications and how they compare to traditional learning outcomes. Additionally, we will focus on the development of theoretical frameworks, pedagogical strategies, and best practices for integrating virtual worlds into existing curricula. This includes exploring effective facilitation, and assessment methods, and ensuring alignment with educational standards. As technology evolves, ongoing research is crucial to explore new possibilities and innovations in virtual world platforms, including the potential integration of emerging technologies such as AI to further enhance educational experiences. The overarching goal is to optimize these virtual environments for educational use, taking into account the challenges and continuously advancing our understanding to benefit learners now and in the future.

Author Contributions: Conceptualization, R.D. and T.S.; methodology, R.D. and T.S.; validation, R.D. and T.S.; formal analysis, R.D. and T.S.; investigation, R.D. and T.S.; writing—original draft preparation, R.D.; writing—review and editing, T.S.; visualization, R.D. and T.S.; supervision, R.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: We acknowledge the use of AI-powered tools to correct grammatical errors and improve our writing at the final stage of preparing the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Kye, B.; Han, N.; Kim, E.; Park, Y.; Jo, S. Educational applications of metaverse: Possibilities and limitations. *J. Educ. Eval. Health Prof.* **2021**, *18*, 32. [CrossRef]
2. De Felice, F.; Petrillo, A.; Iovine, G.; Salzano, C.; Baffo, I. How Does the Metaverse Shape Education? A Systematic Literature Review. *Appl. Sci.* **2023**, *13*, 5682. [CrossRef]
3. Sá, M.J.; Serpa, S. Metaverse as a Learning Environment: Some Considerations. *Sustainability* **2023**, *15*, 2186. [CrossRef]
4. De La Asuncion Pari-Bedoya, I.; Vargas-Murillo, A.; Palacios, R.; Guevara-Soto, F.; Ypanaque-Pereira, I. Smart Learning in Virtual Worlds: A Systematic Literature Review on the Usage and Applications of Metaverse in Education. *Int. J. Learn. Teach. Educ. Res.* **2023**, *22*, 85–101. [CrossRef]
5. Barab, S.A.; Hay, K.E.; Barnett, M.; Squire, K. Constructing virtual worlds: Tracing the historical development of learner practices. *Cogn. Instr.* **2001**, *19*, 47–94. [CrossRef]
6. Dickey, M.D. Brave New (Interactive) Worlds: A review of the design affordances and constraints of two 3D virtual worlds as interactive learning environments. *Interact. Learn. Environ.* **2005**, *13*, 121–137. [CrossRef]

7. Rubio-Tamayo, J.L.; Gértrudix-Barrio, M.; García, F. Immersive Environments and Virtual Reality: Systematic Review and Advances in Communication, Interaction and Simulation. *Multimodal Technol. Interact.* **2017**, *1*, 21. [CrossRef]
8. Young, G.W.; Stehle, S.; Yazgi Walsh, B.; Tiri, E. Exploring Virtual Reality in the Higher Education Classroom: Using VR to Build Knowledge and Understanding. *J. Univers. Comput. Sci.* **2020**, *26*, 904–928. [CrossRef]
9. Battal, A.; Taşdelen, A. The Use of Virtual Worlds in the Field of Education: A Bibliometric Study. *Particip. Educ. Res.* **2023**, *10*, 408–423. [CrossRef]
10. Díaz, J.; Saldaña, C.; Avila, C. Virtual world as a resource for hybrid education. *Int. J. Emerg. Technol. Learn.* **2020**, *15*, 94–109. [CrossRef]
11. Bainbridge, W.S. The Scientific Research Potential of Virtual Worlds. *Science* **2007**, *317*, 472–476. [CrossRef]
12. Wogu, I.A.; Misra, S.; Assibong, P.A.; Olu-Owolabi, E.F.; Maskeliūnas, R.; Damasevicius, R. Artificial intelligence, smart classrooms and online education in the 21st century: Implications for human development. *J. Cases Inf. Technol.* **2019**, *21*, 66–79. [CrossRef]
13. Dung, P. TRIZ: Inventive Creativity Based On The Laws of Systems Development. *Creat. Innov. Manag.* **1995**, *4*, 19–29. [CrossRef]
14. Hatchuel, A.; Weil, B. A new approach of innovative design: An introduction to C-K theory. In Proceedings of the International Conference on Engineering Design, ICED, Stockholm, Sweden, 19–21 August 2003; Volume DS 31.
15. Gero, J.S. Design Prototypes: A Knowledge Representation Schema for Design. *AI Mag.* **1990**, *11*, 26. [CrossRef]
16. Johnson, P. The 21st century skills movement. *Educ. Leadersh.* **2009**, *67*, 11.
17. Levey, S. Universal Design for Learning. *J. Educ.* **2021**, *203*, 479–487. [CrossRef]
18. Díaz, J.E.M. Virtual World as a Complement to Hybrid and Mobile Learning. *Int. J. Emerg. Technol. Learn.* **2020**, *15*, 267–274. [CrossRef]
19. An, Y. Creating Smart Learning Environments with Virtual Worlds. In *Foundations and Trends in Smart Learning*; Springer: Singapore, 2019. [CrossRef]
20. Naya, V.B.; Ibáñez, L.A.H. Evaluating user experience in joint activities between schools and museums in virtual worlds. *Univers. Access Inf. Soc.* **2015**, *14*, 389–398. [CrossRef]
21. Campbell, C.; Cameron, L. Scaffolding learning through the use of virtual worlds. In *Learning in Virtual Worlds*; AU Press: New York, NY, USA, 2016. [CrossRef]
22. Dreamson, N.; Park, G. Metaverse-Based Learning Through Children's School Space Design. *Int. J. Art Des. Educ.* **2023**, *42*, 125–138. [CrossRef]
23. Porat, E.; Shamir-Inbal, T.; Blau, I. Teaching prototypes and pedagogical strategies in integrating Open Sim-based virtual worlds in K-12: Insights from perspectives and practices of teachers and students. *J. Comput. Assist. Learn.* **2023**, *39*, 1141–1153. [CrossRef]
24. Li, Y.J.; Cheung, C.; Shen, X.L.; Lee, M. Promoting collaborative learning in virtual worlds: The power of "we". *Inf. Technol. People* **2023**, *36*, 2563–2586. [CrossRef]
25. Richter, S.; Richter, A. What is novel about the Metaverse? *Int. J. Inf. Manag.* **2023**, *73*, 102684. [CrossRef]
26. Masters, Y.; Gregory, S. Second life: A novice/expert teaching and learning tale. In Outlooks and *Opportunities in Blended and Distance Learning*; IGI Global: Hershey, PA, USA, 2013; pp. 204–218. [CrossRef]
27. Örnek, M.A.; Özer, E. VELaGradE: Utilizing open simulator as a virtual learning environment for basic landscape grading education. In Proceedings of the 51st World Congress of the International Federation of Landscape Architects, IFLA, Buenos Aires, Argentina, 5–7 June 2014.
28. Zafeiropoulos, V.; Kalles, D.; Sgourou, A. Adventure-style game-based learning for a biology lab. In Proceedings of the IEEE 14th International Conference on Advanced Learning Technologies, ICALT 2014, Athens, Greece, 7–10 July 2014; pp. 665–667. [CrossRef]
29. Sukhov, A. Educational dimension of "total war: Medieval ii". In Proceedings of the European Conference on Games-Based Learning, Sophia Antipolis, France, 4–5 October 2018; pp. 669–676.
30. Chang, M.; Chen, C.T.; Wu, K.H.; Yu, P.S. Conversation Quest in MEGA World (Multiplayer Educational Game for All). In *Foundations and Trends in Smart Learning*; Lecture Notes in Educational Technology; Springer: Singapore, 2019; pp. 77–82. [CrossRef]
31. Bravo, J.; García-Magariño, I. A methodology for elaborating activities for higher education in 3D virtual worlds. *J. Interact. Learn. Res.* **2015**, *26*, 23–38.
32. Maciuszek, D.; Martens, A. Construction spaces for the design of learning tasks in virtual worlds. In Proceedings of the European Conference on Games Based Learning, Berlin, Germany, 9–10 October 2014; Volume 1, pp. 330–338.
33. Gregory, S. Engaging classes in a virtual world. In *Serious Games and Virtual Worlds in Education, Professional Development, and Healthcare*; IGI Global: Hershey, PA, USA, 2013; pp. 126–144. [CrossRef]
34. Nocchi, S. Foreign language teaching and learning in virtual worlds: The construct of affordance. In *Virtual Worlds: Concepts, Applications and Future Directions*; Nova Science Publisher: New York, NY, USA, 2018; pp. 141–167.
35. Endicott-Popovsky, B.; Hinrichs, R.J.; Frincke, D. Leveraging 2nd life as a communications media: An effective tool for security awareness training. In Proceedings of the IEEE International Professional Communication Conference, Vancouver, BC, Canada, 15–17 July 2013. [CrossRef]

36. Riedmann, P.; Venable, J.R.; Chang, V.; Reiners, T.; Gütl, C. Rivale: A prototype realistic immersive virtual agent-based learning environment case study for learning requirements elicitation skills. In Proceedings of the AIS SIG-ED IAIM 2013 Conference, Milan, Italy, 13–15 December 2013.
37. Qassem, L.M.M.S.A.; Hawai, H.A.; Shehhi, S.A.; Zemerly, M.J.; Ng, J.W. AIR-EDUTECH: Augmented immersive reality (AIR) technology for high school Chemistry education. In Proceedings of the IEEE Global Engineering Education Conference, EDUCON, Abu Dhabi, United Arab Emirates, 10–13 April 2016; pp. 842–847. [CrossRef]
38. Cao, M.; Li, Y.; Pan, Z.; Csete, J.; Sun, S.; Li, J.; Liu, Y. Creative educational use of virtual reality: Working with second life. *IEEE Comput. Graph. Appl.* **2014**, *34*, 83–87. [CrossRef]
39. Czok, V.; Krug, M.; Müller, S.; Huwer, J.; Kruse, S.; Müller, W.; Weitzel, H. A Framework for Analysis and Development of Augmented Reality Applications in Science and Engineering Teaching. *Educ. Sci.* **2023**, *13*, 926. [CrossRef]
40. Gopalan, V.; Bakar, J.A.A.; Zulkifli, A.N.; Alwi, A. A review of augmented reality elements in science learning. *J. Telecommun. Electron. Comput. Eng.* **2018**, *10*, 87–92.
41. Sukhov, A.A. Gamification of the Middle Ages: Educational Discourse of "kingdom Come: Deliverance". In Proceedings of the ACM International Conference Proceeding Series, Yamanashi, Japan, 21–23 November 2022; pp. 59–66. [CrossRef]
42. Wozniak, M.P.; Lewczuk, A.; Adamkiewicz, K.; Józiewicz, J.; Malaya, M.; Ladonski, P. ARchemist: Aiding experimental chemistry education using augmented reality technology. In Proceedings of the Conference on Human Factors in Computing Systems , Honolulu, HI, USA, 25–30 April 2020. [CrossRef]
43. Tang, V.; Nassani, A.; Nanayakkara, S.; Billinghurst, M. Kiwrious AR: Exploring AR for Scientific Inquiry and Scaffolded Learning. In Proceedings of the Proceedings—2022 IEEE International Symposium on Mixed and Augmented Reality Adjunct, ISMAR-Adjunct, Singapore, 17–21 October 2022; pp. 911–912. [CrossRef]
44. Jamshidi, M.B.; Sargolzaei, S.; Foorginezhad, S.; Moztarzadeh, O. Metaverse and microorganism digital twins: A deep transfer learning approach. *Appl. Soft Comput.* **2023**, *147*, 110798. [CrossRef]
45. Iqbal, M.Z.; Mangina, E.; Campbell, A.G. Current Challenges and Future Research Directions in Augmented Reality for Education. *Multimodal Technol. Interact.* **2022**, *6*, 75. [CrossRef]
46. Fernandes, L.; Da Silva, A.P.; Da Silva, M.C.; Damasceno, E.F. A Brief Review of Immersive Virtual Environments for Teaching Microbiology. In Proceedings of the 2021 16th Latin American Conference on Learning Technologies, LACLO, Arequipa, Peru, 19–21 October 2021; pp. 435–437. [CrossRef]
47. Scorgie, D.; Feng, Z.; Paes, D.; Parisi, F.; Yiu, T.; Lovreglio, R. Virtual reality for safety training: A systematic literature review and meta-analysis. *Saf. Sci.* **2024**, *171*, 106372. [CrossRef]
48. Ventoulis, E.; Xinogalos, S. "AR The Gods of Olympus": Design and Pilot Evaluation of an Augmented Reality Educational Game for Greek Mythology. *Multimodal Technol. Interact.* **2023**, *7*, 2. [CrossRef]
49. Creed, C.; Al-Kalbani, M.; Theil, A.; Sarcar, S.; Williams, I. Inclusive Augmented and Virtual Reality: A Research Agenda. *Int. J. Hum. Comput. Interact.* **2023**. [CrossRef]
50. AlGerafi, M.A.M.; Zhou, Y.; Oubibi, M.; Wijaya, T.T. Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education. *Electronics* **2023**, *12*, 3953. [CrossRef]
51. Uriarte-Portillo, A.; Zatarain-Cabada, R.; Barrón-Estrada, M.L.; Ibáñez, M.B.; González-Barrón, L.M. Intelligent Augmented Reality for Learning Geometry. *Information* **2023**, *14*, 245. [CrossRef]
52. Jim, J.R.; Hosain, M.T.; Mridha, M.; Kabir, M.M.; Shin, J. Toward Trustworthy Metaverse: Advancements and Challenges. *IEEE Access* **2023**, *11*, 118318–118347. [CrossRef]
53. Hidayat, R.; Wardat, Y. A systematic review of Augmented Reality in Science, Technology, Engineering and Mathematics education. *Educ. Inf. Technol.* **2023**. [CrossRef]
54. Monteiro, R.; Rodrigues, N.F.; Martinho, J.; Oliveira, E. Sea of Cells: Learn Biology Through Virtual Reality. In *International Conference on Design, Learning, and Innovation*; Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST; Springer International Publishing: Cham, Switzerland, 2022; Volume 435 LNICST, pp. 141–155. [CrossRef]
55. Tsutsui, W.; Lopez-Parra, R.D.; Coutinho, G.S.; Mello, A.W.; Sangid, M.D.; Moore, T.J. The implementation of virtual labs in aerospace structures education. In Proceedings of the ASEE Annual Conference and Exposition, Virtual, 22–26 June 2020.
56. Paxinou, E.; Mitropoulos, K.; Tsalapatas, H.; Kalles, D. A Distance Learning VR Technology Tool for Science Labs. In Proceedings of the 13th International Conference on Information, Intelligence, Systems and Applications, IISA, Corfu, Greece, 18–20 July 2022. [CrossRef]
57. Hutson, J.; Lively, J.; Melick, E. Learning Communities in the Metaverse: Integrating High-Impact Practices and Durable Skills in a First-Year Experience Course Taught Entirely in a Virtual Learning Environment. *Int. J. Learn. High. Educ.* **2024**, *31*, 97–126. [CrossRef]
58. Shiradkar, S.; Rabelo, L.; Alasim, F.; Nagadi, K. Virtual world as an interactive safety training platform. *Information* **2021**, *12*, 219. [CrossRef]
59. Paxinou, E.; Panagiotakopoulos, C.T.; Karatrantou, A.; Kalles, D.; Sgourou, A. Implementation and Evaluation of a Three-Dimensional Virtual Reality Biology Lab versus Conventional Didactic Practices in Lab Experimenting with the Photonic Microscope. *Biochem. Mol. Biol. Educ.* **2020**, *48*, 21–27. [CrossRef]

60. Zafeiropoulos, V.; Anastassakis, G.; Orphanoudakis, T.; Kalles, D.; Fanariotis, A.; Fotopoulos, V. The V-Lab VR Educational Application Framework: A Beacon Application of the XR2Learn Project. In Proceedings of the 25th International Conference on Mobile Human-Computer Interaction, MobileHCI 2023 Companion, Athens, Greece, 26–29 September 2023. [CrossRef]
61. Golemati, O.N.; Zafeiropoulos, V.; Kalles, D. 3D Simulations in Civil Engineering Laboratory Education. In Proceedings of the ACM International Conference Proceeding Series, Athens, Greece, 20–22 November 2020; pp. 42–45. [CrossRef]
62. Griol, D.; Molina, J.; Callejas, Z. An approach to develop intelligent learning environments by means of immersive virtual worlds. *J. Ambient Intell. Smart Environ.* **2014**, *6*, 237–255. [CrossRef]
63. Morgado, L.; Paredes, H.; Fonseca, B.; Martins, P.; Almeida, Á.; Vilela, A.; Pires, B.; Cardoso, M.; Peixinho, F.; Santos, A. Integration scenarios of virtual worlds in learning management systems using the MULTIS approach. *Pers. Ubiquitous Comput.* **2017**, *21*, 965–975. [CrossRef]
64. Badilla-Quintana, M.; Sandoval-Henríquez, F. Students' immersive experience in initial teacher training in a virtual world to promote sustainable education: Interactivity, presence, and flow. *Sustainability* **2021**, *13*, 12780. [CrossRef]
65. Chesney, T.; Chuah, S.H.; Hoffmann, R.; Hui, W.; Larner, J. A study of gamer experience and virtual world behaviour. *Interact. Comput.* **2014**, *26*, 1–11. [CrossRef]
66. Cruz, G.; Costa, A.; Martins, P.; Gonçalves, R.; Barroso, J. Toward educational virtual worlds: Should identity federation be a concern? *Educ. Technol. Soc.* **2015**, *18*, 27–36.
67. Quinonez-Beltran, A.; Benitez-Correa, C.; Morocho-Cuenca, E. Implementation of Virtual Worlds to Promote Distance Practice Teachers' Participation in the English Learning Process. *Int. J. Learn. Teach. Educ. Res.* **2023**, *22*, 324–339. [CrossRef]
68. Hoter, E.; Nagar, I. Technical Support in Large Online Courses and MOOCs Using Virtual Worlds. *Int. J. Technol. Learn.* **2023**, *30*, 1–22. [CrossRef]
69. Maas, M.; Hughes, J. Virtual, augmented and mixed reality in K–12 education: A review of the literature. *Technol. Pedagog. Educ.* **2020**, *29*, 231–249. [CrossRef]
70. Wang, P.; Wu, P.; Wang, J.; Chi, H.; Wang, X. A Critical Review of the Use of Virtual Reality in Construction Engineering Education and Training. *Int. J. Environ. Res. Public Health* **2018**, *15*, 1204. [CrossRef]
71. Papanastasiou, G.P.; Drigas, A.; Skianis, C.; Lytras, M.D.; Papanastasiou, E. Virtual and augmented reality effects on K-12, higher and tertiary education students' twenty-first century skills. *Virtual Real.* **2018**, *23*, 425–436. [CrossRef]
72. Pellas, N.; Kazanidis, I.; Konstantinou, N.; Georgiou, G. Exploring the educational potential of three-dimensional multi-user virtual worlds for STEM education: A mixed-method systematic literature review. *Educ. Inf. Technol.* **2016**, *22*, 2235–2279. [CrossRef]
73. Calvert, J.; Hume, M. Immersing learners in stories: A systematic literature review of educational narratives in virtual reality. *Australas. J. Educ. Technol.* **2022**, *38*, 45–61. [CrossRef]
74. Sidekerskienė, T.; Damaševičius, R. Out-of-the-Box Learning: Digital Escape Rooms as a Metaphor for Breaking Down Barriers in STEM Education. *Sustainability* **2023**, *15*, 7393. [CrossRef]
75. Jamshidi, M.; Dehghaniyan Serej, A.; Jamshidi, A.; Moztarzadeh, O. The Meta-Metaverse: Ideation and Future Directions. *Future Internet* **2023**, *15*, 252. [CrossRef]
76. Kyrlitsias, C.; Michael-Grigoriou, D. Social Interaction with Agents and Avatars in Immersive Virtual Environments: A Survey. *Front. Virtual Real.* **2022**, *2*, 786665. [CrossRef]
77. Greenbaum, D. The virtual worlds of the metaverse. The Metaverse: And How It Will Revolutionize Everything Matthew Ball Liveright. *Science* **2022**, *377*, 377. [CrossRef] [PubMed]
78. Chen, X.; Zou, D.; Xie, H.; Wang, F.L. Metaverse in Education: Contributors, Cooperations, and Research Themes. *IEEE Trans. Learn. Technol.* **2023**, *16*, 1111–1129. [CrossRef]
79. De Felice, F.; Rehman, M.; Petrillo, A.; Baffo, I. A metaworld: Implications, opportunities and risks of the metaverse. *IET Collab. Intell. Manuf.* **2023**, *5*, e12079. [CrossRef]
80. Twining, P. Exploring the educational potential of virtual worlds—Some reflections from the SPP. *Br. J. Educ. Technol.* **2009**, *40*, 496–514. [CrossRef]
81. Warburton, S. Second Life in higher education: Assessing the potential for and the barriers to deploying virtual worlds in learning and teaching. *Br. J. Educ. Technol.* **2009**, *40*, 414–426. [CrossRef]
82. Bani-Salameh, H.; Al-Gharaibeh, J.; Jeffery, C.; Al-Sharif, Z.A. Collaborative education in a virtual learning environment. *Int. J. Bus. Inf. Syst.* **2017**, *25*, 474–489. [CrossRef]
83. Maratou, V.; Chatzidaki, E.; Xenos, M. Enhance learning on software project management through a role-play game in a virtual world. *Interact. Learn. Environ.* **2016**, *24*, 897–915. [CrossRef]
84. Bailey, C. Free the sheep: Improvised song and performance in and around a minecraft community. *Literacy* **2016**, *50*, 62–71. [CrossRef]
85. Ugaz, M.; Alva, A.B. Model for Effective Collaborative Learning in Virtual Worlds with Intelligent Agents. In *Handbook of Research on Interactive Information Quality in Expanding Social Network Communications*; IGI Global: Hershey, PA, USA, 2015.
86. Messinger, P.; Stroulia, E.; Lyons, K. A Typology of Virtual Worlds: Historical Overview and Future Directions. *J. Virtual Worlds Res.* **2008**. [CrossRef]
87. Reed, A.A.; Murray, J.; Salter, A. *Adventure Games: Playing the Outsider*; Bloomsbury Publishing New York, NY, USA, 2020.

88. De Castell, S.; Jenson, J.; Thumlert, K. From simulation to imitation: Controllers, corporeality, and mimetic play. *Simul. Gaming* **2014**, *45*, 332–355. [CrossRef]
89. Vaajakallio, K.; Mattelmäki, T. Design games in codesign: As a tool, a mindset and a structure. *CoDesign* **2014**, *10*, 63–77. [CrossRef]
90. Hébert, C.; Jenson, J. Teaching with sandbox games: Minecraft, game-based learning, and 21st Century competencies. *Can. J. Learn. Technol.* **2020**, *46*. [CrossRef]
91. Drachen, A.; Copier, M.; Hitchens, M.; Montola, M.; Eladhari, M.P.; Stenros, J. Role-Playing Games: The State of Knowledge. *Life* **2009**, *6*, 13.
92. Zagal, J.P.; Rick, J.; Hsi, I. Collaborative games: Lessons learned from board games. *Simul. Gaming* **2006**, *37*, 24–40. [CrossRef]
93. Poirier-Poulin, S. Adventure Games: Playing the Outsider, Aaron A. Reed, John T. Murray and Anastasia Salter (2020). *J. Gaming Virtual Worlds* **2022**, *14*, 340–344. [CrossRef]
94. Lindley, C.A. *Story and Narrative Structures in Computer Games*; Brunhild Bushoff: München, Germany, 2005.
95. Novak, E. A critical review of digital storyline-enhanced learning. *Educ. Technol. Res. Dev.* **2015**, *63*, 431–453. [CrossRef]
96. Howard, J. *Quests: Design, Theory, and History in Games and Narratives*; AK Peters/CRC Press: New York, NY, USA, 2022.
97. Hearn, R.A.; Demaine, E.D. *Games, Puzzles, and Computation*; A K Peters/CRC Press: New York, NY, USA, 2009; pp. 1–230. [CrossRef]
98. Hammady, R.; Arnab, S. Serious gaming for behaviour change: A systematic review. *Information* **2022**, *13*, 142. [CrossRef]
99. Llargues Asensio, J.M.; Peralta, J.; Arrabales, R.; Bedia, M.G.; Cortez, P.; Peña, A.L. Artificial Intelligence approaches for the generation and assessment of believable human-like behaviour in virtual characters. *Expert Syst. Appl.* **2014**, *41*, 7281–7290. [CrossRef]
100. Tonbuloğlu, B. An evaluation of game-based computer science course designs: The example of minecraftedu. *Educ. Inf. Technol.* **2023**. [CrossRef]
101. Asbell-Clarke, J.; Rowe, E.; Almeda, V.; Edwards, T.; Bardar, E.; Gasca, S.; Baker, R.; Scruggs, R. The development of students' computational thinking practices in elementary- and middle-school classes using the learning game, Zoombinis. *Comput. Hum. Behav.* **2021**, *115*, 106587. [CrossRef]
102. Bauer, W.J., Jr.; Huettl, M.; Phillips, K.M. Retracing The Oregon Trail. *Calif. Hist.* **2022**, *99*, 53–63. [CrossRef]
103. Deshpande, A.A.; Huang, S.H. Simulation games in engineering education: A state-of-the-art review. *Comput. Appl. Eng. Educ.* **2011**, *19*, 399–410. [CrossRef]
104. Cho, Y.; Park, K.S. Designing Immersive Virtual Reality Simulation for Environmental Science Education. *Electronics* **2023**, *12*, 315. [CrossRef]
105. Buzys, R.; Maskeliunas, R.; Damaševičius, R.; Sidekerskiene, T.; Woźniak, M.; Wei, W. Cloudification of virtual reality gliding simulation game. *Information* **2018**, *9*, 293. [CrossRef]
106. Barnabè, F.; Armenia, S.; Nazir, S.; Pompei, A. Critical Thinking Skills Enhancement through System Dynamics-Based Games: Insights from the Project Management Board Game Project. *Systems* **2023**, *11*, 554. [CrossRef]
107. O'Brien, M.P.; Costin, Y. Using Gamification to Develop Students As Strategic Thinkers: A Qualitative Perspective. In Proceedings of the 22nd European Conference on e-Learning: ECEL 2023. Academic Conferences and Publishing Limited, Pretoria, South Africa, 26–27 October 2023.
108. Ross, S.B.; Modasi, A.; Christodoulou, M.; Sucandy, I.; Mehran, A.; Lobe, T.E.; Witkowski, E.; Satava, R. New generation evaluations: Video-based surgical assessments: A technology update. *Surg. Endosc.* **2023**, *37*, 7401–7411. [CrossRef]
109. Smith, M.S. The Miracle of Flight Simulator: It was a wonder that the original video game worked at all. Decades later, it still enthralls millions. *IEEE Spectr.* **2023**, *60*, 36–41. [CrossRef]
110. Faria, A.J. The changing nature of business simulation/gaming research: A brief history. *Simul. Gaming* **2001**, *32*, 97–110. [CrossRef]
111. Costanza, R.; Chichakly, K.; Dale, V.; Farber, S.; Finnigan, D.; Grigg, K.; Heckbert, S.; Kubiszewski, I.; Lee, H.; Liu, S.; et al. Simulation games that integrate research, entertainment, and learning around ecosystem services. *Ecosyst. Serv.* **2014**, *10*, 195–201. [CrossRef]
112. Calori, L.; Camporesi, C.; Pescarin, S. Virtual Rome: A FOSS approach to WEB3D. In Proceedings of the 14th International Conference on 3D Web Technology, Web3D'09, Darmstadt, Germany, 16–17 June 2009. [CrossRef]
113. Perkins, K.; Adams, W.; Dubson, M.; Finkelstein, N.; Reid, S.; Wieman, C.; LeMaster, R. PhET: Interactive simulations for teaching and learning physics. *Phys. Teach.* **2006**, *44*, 18–23. [CrossRef]
114. Boulos, M.N.K.; Hetherington, L.; Wheeler, S. Second Life: An overview of the potential of 3-D virtual worlds in medical and health education. *Health Inf. Libr. J.* **2007**, *24*, 233–245. [CrossRef]
115. Wan, J.; Zheng, Y.; Li, Y.; Mei, H.; Lin, L.; Kuang, L. Oil depot safety inspection and emergency training system based on virtual reality technology. In *Proceedings of the IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2020; Volume 782, p. 042018.
116. Ke, F.; Pachman, M.; Dai, Z. Investigating educational affordances of virtual reality for simulation-based teaching training with graduate teaching assistants. *J. Comput. High. Educ.* **2020**, *32*, 607–627. [CrossRef]
117. Lainema, K.; Syynimaa, K.; Lainema, T.; Hämäläinen, R. Organizing for collaboration in simulation-based environments: An affordance perspective. *J. Res. Technol. Educ.* **2023**, *55*, 307–323. [CrossRef]

118. Rahimi, S.; Walker, J.T.; Lin-Lipsmeyer, L.; Shin, J. Toward defining and assessing creativity in sandbox games. *Creat. Res. J.* **2023**, 1–19. [CrossRef]
119. Rohmani, R.; Pambudi, N. A Critical Review of Educational Games as a Tool for Strengthening Digital Literacy. *Int. J. Multidiscip. Appl. Bus. Educ. Res.* **2023**, *4*, 1483–1493. [CrossRef]
120. Han, J.; Liu, G.; Gao, Y. Learners in the Metaverse: A Systematic Review on the Use of Roblox in Learning. *Educ. Sci.* **2023**, *13*, 296. [CrossRef]
121. Xie, Z.; Wong, G.K.; Chiu, D.K.; Lei, J. Bridging K–12 Mathematics and Computational Thinking in the Scratch Community: Implications Drawn From a Creative Learning Context. *IT Prof.* **2023**, *25*, 64–70. [CrossRef]
122. Xu, H.; Hui, K.H.; Fu, C.W.; Zhang, H. Computational LEGO technic design. *arXiv* **2020**, arXiv:2007.02245.
123. Rosenthal, S.; Ratan, R.A. Balancing learning and enjoyment in serious games: Kerbal Space Program and the communication mediation model. *Comput. Educ.* **2022**, *182*, 104480. [CrossRef]
124. Peggs, R. The Power of Technology in K-12 Education. In *Preparing Faculty for Technology Dependency in the Post-COVID-19 Era*; IGI Global: Hershey, PA, USA, 2022; pp. 232–245.
125. Fawcett, C. Creative Agency and Play in Design-Based Games. *Jeun. Young People Texts Cult.* **2021**, *13*, 315–325. [CrossRef]
126. Prager, R.H.P. Exploring the use of role-playing games in education. *MT Rev.* **2019**, *2*. Available online: https://mtrj.library.utoronto.ca/index.php/mtrj/article/view/29606 (accessed on 29 December 2023).
127. Gupta, S.; Tanenbaum, T.J.; Muralikumar, M.D.; Marathe, A.S. Investigating roleplaying and identity transformation in a virtual reality narrative experience. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, Honolulu, HI, USA, 25–30 April 2020; pp. 1–13.
128. Alrehaili, E.A.; Al Osman, H. A virtual reality role-playing serious game for experiential learning. *Interact. Learn. Environ.* **2022**, *30*, 922–935. [CrossRef]
129. Sweet, A.D. Diverging by Design: The Narrative Rhetoric of Choice-Based Role-Playing Games. Ph.D. Thesis, The Ohio State University, Columbus, OH, USA, 2022.
130. Barros Una, L.; Brangman, S.; Indelicato, A.; Krueger, A.; Ludwig, A.; Slutzky, A.R.; Stewart, T.; Germain, L.J. Using second life to teach health professions students about Alzheimer's Disease: A comprehensive review. *Gerontol. Geriatr. Educ.* **2023**, *44*, 243–253. [CrossRef]
131. Kruk, M. Dynamicity of perceived willingness to communicate, motivation, boredom and anxiety in Second Life: The case of two advanced learners of English. *Comput. Assist. Lang. Learn.* **2022**, *35*, 190–216. [CrossRef]
132. Maskeliūnas, R.; Damaševičius, R.; Kulikajevas, A.; Marley, J.; Larsson, C. Evaluation of MyRelief Serious Game for Better Self-Management of Health Behaviour Strategies on Chronic Low-Back Pain. *Informatics* **2022**, *9*, 40. [CrossRef]
133. Maskeliunas, R.; Damasevicius, R.; Paulauskas, A.; Ceravolo, M.G.; Charalambous, M.; Kambanaros, M.; Pampoulou, E.; Barbabella, F.; Poli, A.; Carvalho, C.V. Deep Reinforcement Learning-Based iTrain Serious Game for Caregivers Dealing with Post-Stroke Patients. *Information* **2022**, *13*, 564. [CrossRef]
134. Freeman, G.; Acena, D.; McNeese, N.J.; Schulenberg, K. Working together apart through embodiment: Engaging in everyday collaborative activities in social Virtual Reality. *Proc. ACM Hum.-Comput. Interact.* **2022**, *6*, 17. Available online: https://dl.acm.org/doi/10.1145/3492836 (accessed on 25 February 2024).
135. Knoll, T.; Liaqat, A.; Monroy-Hernández, A. ARctic Escape: Promoting Social Connection, Teamwork, and Collaboration Using a Co-Located Augmented Reality Escape Room. In Proceedings of the Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems, Hamburg, Germany, 23–28 April 2023; pp. 1–6.
136. Cooney, A.; Darcy, E. 'It was fun': Exploring the pedagogical value of collaborative educational games. *J. Univ. Teach. Learn. Pract.* **2020**, *17*, 4. [CrossRef]
137. Marougkas, A.; Troussas, C.; Krouska, A.; Sgouropoulou, C. Virtual reality in education: A review of learning theories, approaches and methodologies for the last decade. *Electronics* **2023**, *12*, 2832. [CrossRef]
138. Jin, Q.; Liu, Y.; Sun, R.; Chen, C.; Zhou, P.; Han, B.; Qian, F.; Yarosh, S. Collaborative Online Learning with VR Video: Roles of Collaborative Tools and Shared Video Control. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems, Hamburg, Germany, 23–28 April 2023; pp. 1–18.
139. Barab, S.; Thomas, M.; Dodge, T.; Carteaux, R.; Tuzun, H. Making learning fun: Quest Atlantis, a game without guns. *Educ. Technol. Res. Dev.* **2005**, *53*, 86–107. [CrossRef]
140. Bokolas, V.; Panagouli, D. Between "fortnite" and "civilization": Digital games and historical-cultural education. In Proceedings of the European Conference on Games-Based Learning, Odense, Denmark, 3–4 October 2019; pp. 74–81.
141. Milburn, C.; Buse, K.; Dhaliwal, R.S.; Wills, M.; Aldosari, R.; Camarador, P.; Miller, J.A.; Siegel, J. Join the Fold: Video Games, Science Fiction, and the Refolding of Citizen Science. *Des. Issues* **2023**, *39*, 70–87. [CrossRef]
142. Damaševičius, R.; Sidekerskiene, T. Designing metaverse escape rooms for microlearning in STEM education; In *Fostering Pedagogy Through Micro and Adaptive Learning in Higher Education: Trends, Tools, and Applications*; IGI Global: Hershey, PA, USA, 2023; pp. 192–211. [CrossRef]
143. Martí-Testón, A.; Muñoz, A.; Gracia, L.; Solanes, J.E. Using WebXR Metaverse Platforms to Create Touristic Services and Cultural Promotion. *Appl. Sci.* **2023**, *13*, 8544. [CrossRef]
144. Solanes, J.E.; Montava-Jordà, S.; Golf-Laville, E.; Colomer-Romero, V.; Gracia, L.; Muñoz, A. Enhancing STEM Education through Interactive Metaverses: A Case Study and Methodological Framework. *Appl. Sci.* **2023**, *13*, 10785. [CrossRef]

145. Reisoglu, I.; Topu, B.; Yilmaz, R.; Karakuş Yılmaz, T.; Göktas, Y. 3D virtual learning environments in education: A meta-review. *Asia Pac. Educ. Rev.* **2017**, *18*, 81–100. [CrossRef]
146. Griol, D.; Callejas, Z. Teaching and Learning Abstract Concepts by Means of Social Virtual Worlds. In *Virtual Reality in Education: Breakthroughs In Research And Practice*; IGI Global: Hershey, PA, USA, 2017. [CrossRef]
147. Zheng, W.; Lu, S.; Cai, Z.; Wang, R.; Wang, L.; Yin, L. PAL-BERT: An Improved Question Answering Model. In *Computer Modeling in Engineering & Sciences*; Tech Science Press: Henderson, NV, USA, 2023. [CrossRef]
148. Gregory, S.; Scutter, S.; Jacka, L.; McDonald, M.; Farley, H.; Newman, C. Barriers and Enablers to the Use of Virtual Worlds in Higher Education. *J. Educ. Technol. Soc.* **2015**, *18*, 3–12.
149. Dawson, M.E.; Davis, L.; Omar, M. Developing learning objects for engineering and science fields: Using technology to test system usability and interface design. *Int. J. Smart Technol. Learn.* **2019**, *1*, 140–161. [CrossRef]
150. Makransky, G.; Lilleholt, L. A structural equation modeling investigation of the emotional value of immersive virtual reality in education. *Educ. Technol. Res. Dev.* **2018**, *66*, 1141–1164. [CrossRef]
151. Christopoulos, A.; Conrad, M.; Shukla, M. Between virtual and real: Exploring hybrid interaction and communication in virtual worlds. *Int. J. Soc. Media Interact. Learn. Environ.* **2016**, *4*, 23–42. [CrossRef]
152. Nisiotis, L.; Kleanthous, S. The Relationship between Students' Engagement and the Development of Transactive Memory Systems in MUVE: An Experience Report. In Proceedings of the 2019 ACM Conference on Innovation and Technology in Computer Science Education, Aberdeen, UK, 15–17 July 2019. [CrossRef]
153. Su, C.H.; Cheng, T. A Sustainability Innovation Experiential Learning Model for Virtual Reality Chemistry Laboratory: An Empirical Study with PLS-SEM and IPMA. *Sustainability* **2019**, *11*, 1027. [CrossRef]
154. Vassigh, S.; Davis, D.; Behzadan, A.; Mostafavi, A.; Rashid, K.M.; Alhaffar, H.; Elias, A.; Gallardo, G. Teaching Building Sciences in Immersive Environments: A Prototype Design, Implementation, and Assessment. *Int. J. Constr. Educ. Res.* **2018**, *16*, 180–196. [CrossRef]
155. Polk, M. Transdisciplinary co-production: Designing and testing a transdisciplinary research framework for societal problem solving. *Futures* **2015**, *65*, 110–122. [CrossRef]
156. Popa, F.; Guillermin, M.; Dedeurwaerdere, T. A Pragmatist Approach to Transdisciplinarity in Sustainability Research: From Complex Systems Theory to Reflexive Science. *Futures* **2015**, *65*, 45–56. [CrossRef]
157. Guo-Brennan, L. Making Virtual Global Learning Transformative and Inclusive: A Critical Reflective Study on High-Impact Practices in Higher Education. *J. Teach. Learn.* **2022**, *16*, 28–49. [CrossRef]
158. Fonseca, P.; Julian, K.; Hulme, W.; Martins, M.; Brautlacht, R. The multi-disciplinary approach to an interdisciplinary virtual exchange. In *Virtual Exchange: Towards Digital Equity in Internationalisation*; Research-publishing.net: Dublin, Ireland, 2021. [CrossRef]
159. Spiteri, C.; De Raffaele, C.; Smith, S. Bridging the digital divide for e-learning students through adaptive VLEs. In Proceedings of the 2016 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), Bangkok, Thailand, 7–9 December 2016. [CrossRef]
160. Melchor-Couto, S. Virtual worlds and language learning. *J. Gaming Virtual Worlds* **2019**, *11*, 29–43. [CrossRef] [PubMed]
161. Sidekerskienė, T.; Damaševičius, R.; Maskeliūnas, R. Validation of Student Psychological Player Types for Game-Based Learning in University Math Lectures. In Proceedings of the Information and Communication Technology and Applications: Third International Conference, ICTA 2020, Minna, Nigeria, 24–27 November 2020; Revised Selected Papers 3; Springer: Berlin/Heidelberg, Germany, 2021; pp. 245–258.
162. Park, S.H.; Lee, G. Full-immersion virtual reality: Adverse effects related to static balance. *Neurosci. Lett.* **2020**, *733*, 134974. [CrossRef]
163. Widyanti, A.; Hafizhah, H.N. The influence of personality, sound, and content difficulty on virtual reality sickness. *Virtual Real.* **2021**, *26*, 631–637. [CrossRef]
164. Ghomi, M. The Effects of Immersion and Increased Cognitive Load on Time Estimation in a Virtual Reality Environment. Ph.D. Thesis, University of British Columbia, Vancouver, BC, Canada, 2018. [CrossRef]
165. Cunningham, T.D.; Lansiquot, R. Modeling Interdisciplinary Place-Based Learning in Virtual Worlds: Lessons Learned and Suggestions for the Future. In *Interdisciplinary Place-Based Learning in Urban Education*; Springer: Berlin/Heidelberg, Germany, 2018. [CrossRef]
166. Brookes, J.; Warburton, M.; Alghadier, M.; Mon-Williams, M.; Mushtaq, F. Studying human behavior with virtual reality: The Unity Experiment Framework. *Behav. Res. Methods* **2019**, *52*, 455–463. [CrossRef] [PubMed]
167. Santos, V.M.R.; Lima, T.; de Medeiros, F.P.A.; Rodrigues, N.; Lira, H.; Silvano, H.L. An Exploratory Analysis on the Perception of Teachers regarding the Monitoring of Interactions and Activities in the Collaborative Tools of Virtual Learning Environments. In Proceedings of the 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), Chaves, Portugal, 23–26 June 2021. [CrossRef]
168. Caprara, L.; Caprara, C. Effects of virtual learning environments: A scoping review of literature. *Educ. Inf. Technol.* **2021**. [CrossRef]
169. Tang, Y.M.; Au, K.; Lau, H.; Ho, G.; Wu, C.H. Evaluating the effectiveness of learning design with mixed reality (MR) in higher education. *Virtual Real.* **2020**, *24*, 797–807. [CrossRef]

170. Ingavélez-Guerra, P.; Robles-Bykbaev, V.; Perez-Muñoz, A.; Hilera-González, J.; Otón-Tortosa, S.; Campo-Montalvo, E. RALO: Accessible Learning Objects Assessment Ecosystem Based on Metadata Analysis, Inter-Rater Agreement, and Borda Voting Schemes. *IEEE Access* **2023**, *11*, 8223–8239. [CrossRef]
171. Sánchez Vásquez, F.; Pérez-Arriaga, J.C.; Contreras Vega, G.; Luján-Mora, S.; Otón Tortosa, S. Towards the Implementation Process of Accessible Virtual Campuses in Higher Education Institutions in Latin America. *Appl. Sci.* **2022**, *11*, 5470. [CrossRef]
172. Pellas, N.; Mystakidis, S.; Kazanidis, I. Immersive Virtual Reality in K-12 and Higher Education: A systematic review of the last decade scientific literature. *Virtual Real.* **2021**, *25*, 835–861. [CrossRef]
173. Ávila Cañamares, I. La clase virtual. Notas para una fenomenología de la presencia. *Ideas Y Valores* **2021**, *70*, 157–175. [CrossRef]
174. Vasylevska, K.; Kaufmann, H. Compressing VR: Fitting Large Virtual Environments within Limited Physical Space. *IEEE Comput. Graph. Appl.* **2017**, *37*, 85–91. [CrossRef]
175. Song, C.; Shin, S.Y.; Shin, K.S. Exploring the Key Characteristics and Theoretical Framework for Research on the Metaverse. *Appl. Sci.* **2023**, *13*, 7628. [CrossRef]