

Learners in the Metaverse: A Systematic Review on the Use of Roblox in Learning

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Abstract: The development of the Metaverse has drawn much attention in education. Roblox, as an important platform in the Metaverse, attracts millions of young users, which raises the question of how its effectiveness as a learning environment can be maximized. This study aims to synthesize the available evidence to provide an overview of the current research on learning in Roblox by exploring its benefits, challenges, and existing gaps. In line with PRISMA and assisted by LDA topic modeling, we included 40 studies that were analyzed to answer our questions. The research findings show that: (1) Roblox could be combined with social interactive learning or collaborative learning environments, provide a VR environment that supports learning, and be of benefit to programming in STEM education; (2) the use of Roblox in learning has the advantages of attracting a large number of student users, eliciting the positive attitudes of students, and promoting students' cognitive and noncognitive learning abilities; and (3) there are also challenges such as cyberbullying, cybersecurity, lack of adequate teaching design, etc. Empirical studies on this topic have only begun to emerge, and more future research is needed into different pedagogical scenarios to explore the effects, factors, outcomes, designs, etc.

Keywords: learning in Metaverse; systematic review; latent Dirichlet allocation; benefits; challenges



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1. Introduction

1.1. The Metaverse in Education

The year 2021 was a significant inflection point for the Metaverse. The use of virtual reality (VR) has been universally considered the gateway to the Metaverse [1]. Facebook, the world's largest social network company, also changed its brand name to Meta. Studies have been conducted to review previous Metaverse studies in education, and these studies shed light on what has been done and future directions of the Metaverse in education. For example, Tlili et al. [2] conducted a systematic review of the literature of the Metaverse in education, including 81 articles. Their findings showed that using the Metaverse in education has evolved over generations and that the implementation of the Metaverse can expand educational opportunities to explore environments that have historically been inaccessible due to space, time, and cost barriers. In terms of future research, the study suggested that more studies should be conducted using the Metaverse with disabled students. Meanwhile, future studies need to pay more attention to the threats that the Metaverse has presented. Parmaxi [3] reviewed 26 scholarly manuscripts about the educational use of VR. The study concluded that VR has provided many opportunities in the field of language learning and teaching, and using VR is a necessary skill and ability for 21st century learners, as it helps them cultivate teamwork, autonomy, and cultural awareness. In addition, future researchers will focus on aligning VR with a pedagogical background and seek to better combine the enlightenment of these tools with teaching methods and learning directions to achieve solid implementation in teaching methods. To learn the applicability of Minecraft, Nebel, Schneider, and Gunter Daniel Rey [4] examined studies on the use of games in

education. They discussed the benefits of using Minecraft in educational videogames and instructional psychological research; for example, these transformational games can go beyond the limits of the original content. On the other hand, Minecraft has some limitations in the field of teachers, players, and technical challenges. They also pointed out that using Minecraft in education and research will be influenced by social factors, technical barriers, and future potential.

1.2. Roblox

With the rapid development and expansion of the Metaverse [5], Roblox, as one of the most famous platforms of the Metaverse, is defined as a sustainable and shared 3D virtual space in the virtual universe [6]. In recent years, Roblox has also been developing dramatically, with its number of users growing from 12 million in 2018 to 42.1 million in 2021. Park & Kang [7] built a ranking of applications based on the frequency, time used, and other parameters. In this ranking, Roblox rose from 47th in January 2020 to 29th in August 2020. According to 2021 statistics, Roblox had 150 million monthly active users and 40 million daily users [8]. The majority of users of the Metaverse are children and primary and secondary school students, and it is extremely popular among children who are 5–16 years old [9,10]. Users under 13 years old account for 54.86% of the total number of Roblox users [11]. In the United States, more than 55% of Generation Z (Gen Z: born in 1997–2012) children registered with Roblox. Roblox has become an important Metaverse platform used by children of Gen Z and Gen Alpha (born after 2012), and they spend much more time in Roblox than in other platforms [10]. They spend 2.6 h on average using Roblox every day, three times as much as they do on YouTube and seven times as much as they do on Facebook [8].

Roblox is the world's largest multiplayer game community in which players can create a sandbox game online, and its platform includes virtual worlds, leisure communities, and self-built content. Roblox provides a programmable environment in which users can create their own world [1]; therefore, users can build games and interactive worlds in Roblox according to their own needs. Roblox already contains virtual worlds and games built by hundreds of thousands of users [12]. Users interact socially or play games together in Roblox [10], exchange nearly 60 billion messages [13] in Roblox every day, and can also meet, trade, and build social networks in the 3D visual environment [14]. Roblox has eight key features of the Metaverse: identity, friends, immersive, anywhere, low friction, variety of content, economy, and safety [6], which attract young users.

2. Research Gap and Study Objectives

To begin conducting a large empirical study about social interactive learning in the Metaverse, the present study first carried out a systematic review to understand the application of the Metaverse in learning by combing previous research. We found that some studies have systematically reviewed Minecraft [4], the Metaverse [5], VR in language learning [3], and VR in social learning [15]. In recent years, with the rapid development of Roblox and the increasing number of users, the application of Roblox in learning has received increasing attention. Some research is currently exploring learning or learners in Roblox, but there is a lack of relevant review research at this stage. Consequently, no review of the literature was conducted to summarize the use of Roblox in learning and shed light on the future directions of integrating Roblox in learning. Review research can help us comprehend the research development, application, challenges, and development trends in this subject so that future research can make greater contributions to known fields [16]. Considering the potential advantages of the use of Roblox in learning and the increasingly important role of the Metaverse in CSCL learning, there is a need to summarize related research to examine how Roblox is used in learning in order to contribute to relevant research and to inform pedagogical practices in an underexplored learning environment (Roblox).

Therefore, to address the identified research gaps, this research aimed to summarize previous studies concerning learners in Roblox regarding its applications, benefits, and

challenges. We confirmed the existing gaps to date and discussed which areas need deeper exploration in the future. Specifically, this study raises the following research questions (RQs):

RQ1: How is Roblox used in learning?

RQ2: What are the main benefits of using Roblox in learning?

RQ3: What are the main challenges of Roblox learning settings?

RQ4: What are the existing gaps in the use of Roblox in learning and research?

3. Materials and Methods

3.1. Search Strategy

Because learning in Roblox is a relatively new research area, relevant academic research is limited [1]. Considering that the purpose of this study is to explore the advantages and challenges of applying Roblox to learning, we referred to any type of research that explores the integration of Roblox and learning. We did not limit the literature search to the field of education only because we consider that as long as learners are in the environment of Roblox, any exploration of learning in Roblox, such as students' attitudes and ideas about Roblox, students' use experiences in Roblox, and instructional design in Roblox, is relevant to our research. We believe that these studies may appear in computer science, public health, psychology, and other fields. The study systematically searched the following databases: Web of Science (WoS), Scopus, and ProQuest. We limited our search to peer-reviewed English articles. Considering that this is a relatively new field, we also included conference papers and dissertations. WoS is the most widely used and authoritative research database in the world; Scopus is a comprehensive research database across a wide variety of disciplines; and ProQuest is a collection of many databases, including academic journals, dissertations, and other publications. To more extensively understand the research related to learning in Roblox, we did not restrict the research field, and we only set Roblox as the search keyword. Two research assistants downloaded all the articles found in full text. This research does not include human participants.

3.2. Data Analysis

The study used a checklist and a flow diagram from PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta Analyses) to help us improve the quality of systematic reviews. Based on the PRISMA statement, we constructed the procedures for the literature search and selection (see Figure 1). In the three databases, the study searched 114 related articles in total, including 14 duplicates. After duplicate removal, the 100 articles were downloaded in full and screened independently by two researchers on the research team. The first author of this study made the final decision on the different opinions generated in the process. Sixty studies were excluded because they did not meet the selection criteria. The main reason is that in these studies, Roblox did not have any connection with learning. For example, there is a study taking Roblox as an example to discuss the development opportunities for the food retail industry in the Metaverse [17]. This kind of research is excluded because it has neither a learner involved in Roblox nor does it use Roblox as a learning case. Finally, 40 papers were analyzed to answer the four research questions of this study. The researchers read and analyzed these 40 articles thoroughly. The coding scheme aimed to ensure that the study did not miss relevant information to answer the RQs. In addition, the study adapted the suggested coding categories for the types of focus on theme with a narrow scope [18]. The coding scheme of the present study included context, participants, aims and scopes, key functionalities, and key findings.

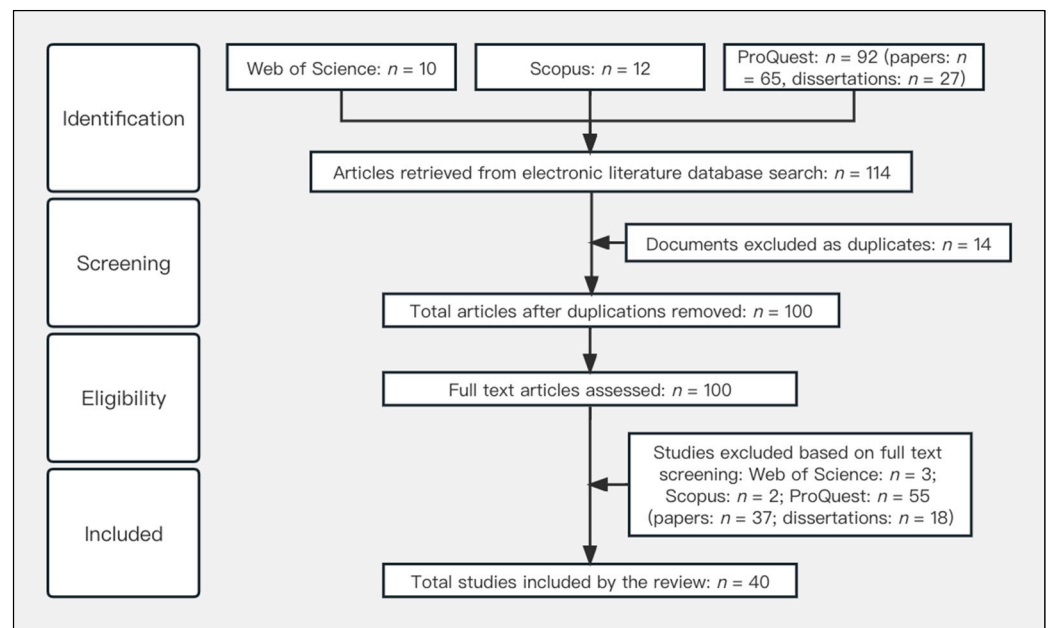


Figure 1. Overview of the search conducted in September 2022 based on the PRISMA statement.

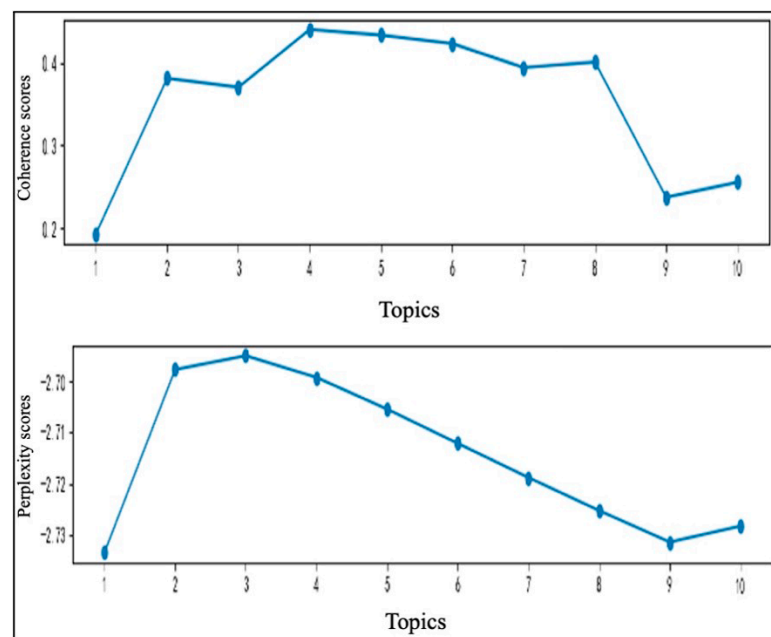
At the same time, latent Dirichlet allocation (LDA) topic modeling, coherence scores, and perplexity scores were conducted for the abstracts of these 40 studies to help the study analyze and elaborate research themes and trends. In the field of natural language processing, topic modeling is widely used in text clustering and topic detection and evolution [19]. LDA is a document theme generation model, and the unsupervised LDA model can obtain the topic distribution. It can cluster by calculating the similarities between themes and trends, which has obvious advantages in the calculation accuracy and clustering effect [20]. The study analyzed the abstracts of 40 articles in total. Because these data cannot be applied to topic modeling directly, we cleaned the data first: (1) stop words, such as “the”, “a”, “by” and “through”, were removed; and (2) single roots for many words were filtered out. Some words have similar meanings, but the computer confirmed that they were different words, such as student and students. (3) Some words that appear in the abstract frequently but do not play a significant role in topic classification were removed, such as “this research” and “the study”. Subsequently, the study calculated the coherence scores and perplexity scores (as shown in Figure 2), which could be used to determine the optimal topic. For this research, six topics were selected to model the topics of these studies, and the Python Gensim Library was used to conduct LDA topic modeling, forming the probability distribution of topic words (as shown in Table 1). The researchers read and summarized the selected articles in full. The purpose of using topic modeling is to help the researchers analyze data more comprehensively and provide corresponding support.

Table 1. LDA topic modeling.

Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6
Bible 0.009	Child 0.011	Metaverse 0.020	Social 0.010	Game 0.017	Education 0.013
Education 0.008	Use 0.009	Game 0.009	Child 0.009	Social 0.010	Game 0.012
Use 0.008	Cyberbullying 0.009	Use 0.008	Use 0.008	Use 0.009	Use 0.011

Table 1. *Cont.*

Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6
Metaverse 0.007	Game 0.006	Spatial 0.007	Education 0.007	Online 0.009	Metaverse 0.008
Spatial 0.007	School 0.005	Training 0.005	Metaverse 0.006	Child 0.006	Social 0.008
Skills 0.006	Children 0.005	Skill 0.005	Student 0.005	People 0.005	Experience 0.005
Student 0.006	Digital 0.005	World 0.005	Digital 0.004	Children 0.004	Student 0.005
Learning 0.006	Elementary 0.005	Online 0.004	Sexual 0.003	Serious 0.004	Learning 0.004
Child 0.006	Education 0.005	Student 0.004	Data 0.003	Education 0.004	Child 0.004
Game 0.006	Behavior 0.004	Education 0.004	Solving 0.003	Spatial 0.004	Online 0.004

**Figure 2.** Coherence scores and perplexity scores.

4. Results

4.1. How Roblox Is Used in Learning

To answer RQ1, the study analyzed the full text of each article and summarized its (1) context, (2) participants, (3) aims and scopes, (4) key functionalities, and (5) key findings related to Roblox (see Table 2). To further excavate research topics, the study used LDA topic modeling to analyze the abstracts of 40 articles.

Table 2. Overview of studies included based on a systematic search.

No.	Study	Context	Participants	Aims and Scopes	Key Functionalities	Key Findings
1	Seo [21]	Church education.	N/A	To explore the implementation of Bibliodrama.	-Construct relevant scenarios and events.	-Recommended building environments in Roblox.
2	Du et al. [22]	Play in virtual worlds.	Childhood and early adolescence.	To analyze key design features.	-Text/voice chat. -Social interaction.	-Recommended for users over the age of 10. -A high degree of freedom for those over 13 years old. -A new way of social interaction.
3	Lee et al. [14]	Social interaction skills training.	Children aged 7–12 years diagnosed with ASD.	To develop training programs for children with ASD.	-Social skills training. -Using wearable devices to collect real-time biometric information.	-Enhancing the social interaction skills of children with ASD.
4	Toh & Lim [23]	Parent–child co-play in Roblox.	Four adults and four children.	To learn how digital co-play provides opportunities for children to learn.	-Children cooperate with their parents to play games.	-The interaction in the process helps children learn. -Learning through communicating, making, modeling, teaching, and leading.
5	Park & Kim [5]	Roblox as a case of an important Metaverse platform to be analyzed.	N/A	To explore the taxonomy, constituent elements, applications and challenges of the Metaverse.	-Simple hardware. -Users can create game scenarios and stories by themselves. - The requirements for identification, rendering, and development are lower.	-Ideal for primary school students. -Children can learn to program. -Children can make friends. -User misconduct grows as it scales up. -Hard to check and monitor users.
6	Meier et al. [24]	Plastic, Visual and Audiovisual Education.	53 secondary school fourth graders.	To introduce the experience of using Roblox Studio to simulate the urban environment.	-Design virtual spaces and integrate sculptures into virtual spaces.	-Students had a better understanding of the local sculptural heritage. -Students felt empowered to create their own interactive worlds. -Broadened students' horizons for career options. -Easy to use and effective in helping students learn. -A good complement to traditional teaching methods. -Students would like to see more of this type of activity incorporated into future teaching interactions.
7	Dwivedi et al. [25]	Roblox as a case of an important Metaverse platform to be analyzed.	N/A	To examine the topics such as education and health in the Metaverse by combining informed narratives from experts on the many aspects of the Metaverse and its transformative impact.	-Roblox allows users to create virtual characters in their own virtual universes and interact with other players. -Roblox allows the sale of virtual products to users.	-Roblox is representative of the Metaverse. -Roblox encountered hacking attacks influencing virtual currency and users' information. -The use of Roblox requires attention to the issues of digital twins, NFTs, cyberbullying, privacy, and sustainable development. -Need academic analysis of Roblox.

Table 2. Cont.

No.	Study	Context	Participants	Aims and Scopes	Key Functionalities	Key Findings
8	Han et al. [26]	Roblox videos.	46 empirical studies are selected.	To explore how Generation Alpha children use the Metaverse and shape cultures in an ethnographic approach.	-Exploring maps and playing games with partners. -Completing a task together. -Customizing and developing some game content.	-Users like to personalize their settings. -Users prefer to invest in game content. -Roblox's task setting emphasizes challenges and partnership.
9	Abel [9]	Documents related to guardian in Roblox.	Caregivers, parents, and caregiver–child dyads from diverse backgrounds.	To explore how parents view their children's development and creation in virtual space.	-Children's development and creation in virtual space.	-Roblox sets out a "perfect" rule for parents to support children in creating in the virtual world, such as setting privacy, parental controls, etc. -Parents not being able to support their child due to a lack of time, technical skills, etc.
10	Hollensen et al. [27]	The virtual space of the Roblox–Nike collaboration in Roblox.	A case analysis.	To explore the key building blocks for creating value from interactions.	-Experience default or customized games. -Dress up avatars. -Buy virtual items. -Virtualize Nike' headquarters.	-Users could transfer real-world actions to Roblox. -Users like to complete any challenges.
11	Istiono & Waworuntu [28]	Educational games.	53 preschool and primary school children.	To explore how much children are interested in these educational games.	N/A	-14 children (27%) like Roblox games; higher than Minecraft (18%).
12	Charmaraman, Hodes, & Richer [29]	Roblox was used as a topic in a questionnaire comparing sexual minorities with their heterosexual peers.	1033 early adolescents.	To explore how sexual minorities in secondary school use social media.	-Roblox as social media. -Social interactions.	-A Roblox group is a common interest or identity shared by sexual minorities.
13	Jaramillo-Alcázar et al. [30]	A serious educational game in Roblox.	10 people without disabilities.	To test some users and collect information about the serious Roblox game and the accessibility features it contains.	-Players must work through different elements of the computer to solve challenges, respond to challenges, and answer questions to assess the knowledge gained in the serious online game.	-To support the learning process of people with disabilities. -60% of users believe that they have increased their knowledge and interest in computers. -70% felt it seemed appropriate to enhance the course construction with fun tools such as serious games in Roblox.
14	Suh & Ahn [11]	Educational virtual world.	336 Korean primary school students.	To analyze learners' experiences and attitudes toward the educational virtual world.	N/A	-Students found the virtual world interesting because they were exposed to games such as Roblox. -97.9% of the primary school students have had experience with the virtual world, and 95.5% of them believe that the virtual world is closely related to their daily lives.

Table 2. Cont.

No.	Study	Context	Participants	Aims and Scopes	Key Functionalities	Key Findings
15	Linares et al. [31]	Massively multiplayer online game.	268 questionnaires were obtained through social networks.	To understand the relationship between continuous use of games and social well-being.	N/A	-Discussed the types of large-scale games users play, with 28.4% of users using Roblox.
16	Martzoukou [32]	Students were asked about their favorite online games and social media.	30 students from a secondary school.	To examine the development of children's digital literacy and citizenship in the online environment.	-Online game. -Social media.	-Students reported that Roblox is a frequently used online game and form of social media.
17	Pursell & Iiyoshi [33]	Two scholars discussed the characteristics and development of the online education scenarios.	Two well-known scholars.	To discuss field and space in online education and express opinions on its significance.	-Interactive features. -Play with friends.	-Roblox is more interactive than Lego in this virtual world in which students not only can play Lego in Roblox but can also play with friends. -Educators can consider the choice of different learning styles.
18	Park & Kim [34]	Five virtual game worlds.	7000 visitors.	To determine the gaming experience that world types in the Metaverse provide for users.	-Users can interact with other players. -Interact with the environmental factors. -Compete with other users.	-Taking a game in Roblox as an example, with 70,000 users in a short period of time, users can improve their social interaction experience, motivation, and sustainable learning.
19	Kent & Pauzé [35]	Children's 10 favorite websites.	N/A	To evaluate the effectiveness of the Canadian Children's Food and Beverage Advertising Initiative in restricting advertising of unhealthy food and beverages on websites preferred by children.	-Advertisements on Roblox.	-Roblox is the most popular website in Canada for children aged 2–11. -In 2015–2016, 5,400,3425 food ads appeared on Roblox, which accounted for the majority (80.4%) of ads viewed on all websites. -The study found that children may be exposed to alcohol ads.
20	Charmaraman, Richer, & Moreno [36]	The risk level of video games for middle school students.	1472 middle school students.	To explore how the risk level of video games is related to behavioral health, social impact, and online social interaction.	-Online social interactions. -Spending money on gaming. -Influencing behavioral health.	-Students who play high-risk games report higher depressive symptoms and problematic online behaviors, sleep less, spend more time playing games, and view social media more frequently. -Roblox's risk level is 2, of which the violence level is 4/5, the substance use level is 0/5, the sex level is 0/5, and the language level is 1/5.
21	Jawad & Tout [37]	Develop game-based teaching themes. Apply the themes in the two courses.	61 college students.	To explore whether the teaching of computer science based on games can promote the effectiveness of teaching.	-Coding game.	-Roblox is introduced as a coding game to help learners learn, and Roblox proves the feasibility of game-based teaching.

Table 2. Cont.

No.	Study	Context	Participants	Aims and Scopes	Key Functionalities	Key Findings
22	Hwang & Lee [38]	Use music content in the Metaverse to fit the SPICE model and analyze customer satisfaction.	422 questionnaires were received.	To verify the effectiveness of the Metaverse by providing a framework for content creators.	N/A	<ul style="list-style-type: none"> -29.1% of participants used Roblox. -The monthly usage time of Roblox is 3 billion hours. -The Metaverse is not limited by time and space, which is conducive to a non-contact era. -The virtual experience provided by Roblox has a high sense of immersion and connectivity, thus enhancing the sense of the experience.
23	Citlali & Estrella [39]	The online content featuring Nike, Vans, Hyundai, and Escada in Roblox was analyzed.	300 college students.	Explore the relationship between the Metaverse and game advertising.	<ul style="list-style-type: none"> -Customization. -Rewards. -Short game time. 	<ul style="list-style-type: none"> -The majority of players are willing to accept this content and think it is very innovative. -Roblox considers that the features attracting users include customization, rewards, and shortened game time.
24	Pangrazio & Gaibisso [40]	Roblox was studied as a form of social media.	276 participants aged 7–12.	Understand the social media used by students and conduct network security education for students.	-Social media.	<ul style="list-style-type: none"> -Roblox is a way for children to expand their social media use. -In addition to mainstream social media, Roblox is an important form of social media used by teenagers.
25	Choi et al. [41]	Analyze the characteristic of Roblox.	N/A	To describe the design features, framework and model of the Metaverse platform serving the IT operating environment.	<ul style="list-style-type: none"> -Persistence. -Connect real life with the virtual world. -Customization. -Economy system. 	<ul style="list-style-type: none"> -Roblox has the characteristics of persistence, mass concurrency, economy system, etc. -It can also connect real life with the virtual world and customize its own content.
26	Cho & Wong [42]	The electronic software used by these children.	40 children aged 8–14.	This study examined the experiences of children in need in the economic and material aspects, social relations and participation, and psychological and emotional health.	-Games.	-A child responded that Roblox was one of the modern games he often played.
27	Bolger [12]	The technology and platform in the Metaverse are analyzed.	Roblox is one of the cases.	To discuss the essence of the Metaverse.	<ul style="list-style-type: none"> -Social media. -Create content. 	<ul style="list-style-type: none"> -Roblox is not a single game, but thousands of games created by users. -Roblox is similar to social media. -It does not create content itself but provides tools for users to create content.

Table 2. Cont.

No.	Study	Context	Participants	Aims and Scopes	Key Functionalities	Key Findings
28	Oxarart & Houghton [43]	A conceptual model is proposed by combing the literature and concepts.	Roblox is one of the cases.	To explore the relationship between gamification, self-leadership, and workplace value results.	-Customization. -Economy system.	-Roblox users spend a lot of time and money customizing their characters and buying clothes for their characters. -Their characters' appearance and actions are very important, representing their real or ideal selves in the game situation.
29	Aladsani et al. [44]	Distance education in the pandemic period. Roblox is one of the cases.	600 participants in K-12.	To understand the impact of distance education (especially K-12 education) in the pandemic period.	-Games.	-A student responded that her friend uses Roblox every day.
30	Anakwe et al. [45]	Integrating technology into meaningful educational activities during COVID-19.	11 African American families.	To discuss the experience of African American parents in using technology to enable their children to participate in meaningful activities (such as online learning) during COVID-19.	-Playing games. -Watching videos. -Interactions with friends.	-Parents say that children often use Roblox, which is the first app for children. -Parents have engaged their children in technology-based activities, including Roblox. -Parents believe that children have high engagement in Roblox.
31	Belda-Medina & Calvo-Ferrer [46]	Students interacted with three conversational agents.	176 undergraduates.	To investigate the knowledge, satisfaction, and perception level of future educators in integrating conversational AI in language learning.	-Chatbots. -Having conversations with video calls. -Video games.	-Various forms of chatbots have been embedded in Roblox.
32	Wauck et al. [47]	STEM education in Roblox.	20 children.	To explore which features in the game can affect the effectiveness of space skills required in STEM activities and encourage students with low spatial skills to play games. To design more effective and motivating spatial skills training interventions.	-Construction games: allow players to collect materials to build objects in a virtual world.	-Most of the boys ($n = 7$) can play construction games (such as Roblox), while only a few of the girls ($n = 3$) can play such games. -Girls used fewer strategic behaviors in experimental games.

Table 2. Cont.

No.	Study	Context	Participants	Aims and Scopes	Key Functionalities	Key Findings
33	Elmore [48]	Math education.	A sixth-grade child and a Latino mother.	To discuss how to improve students' understanding, verification, and evaluation of various mathematical knowledge bases established in family mathematics practice.	-Math practices.	-Many students played Roblox at home. -Students would use a lot of mathematical knowledge unconsciously in the process of playing Roblox. -The use of mathematics in Roblox games needs to be pointed out clearly. -Parents and teachers have the responsibility to help children clearly realize the use and practice of mathematical knowledge in the game.
34	Lewis [49]	Online violence on the internet.	436 primary school participants.	To supplement the limited information about online bullying and bystander behavior of primary school children.	-Video games.	-Most participants pointed out that they saw the highest frequency of online violence in video games, and nearly 10% of them believed that Roblox was the online game with the most online bullying behaviors.
35	Hurter [50]	Roblox was studied as an activity that students would choose when sitting for a long time.	74 fifth-grade students.	To explore and develop new and existing methods to evaluate children's sedentary behavior.	-Online games.	-The main activity of some students when they are sedentary is to play Roblox. -Most participants mention their sedentary activities without hesitation, but four of them thought that they spent too much time playing Roblox, which they played for 2 h every day.
36	Geibel [51]	The research was carried out among adult family members of disabled students in urban school districts with low socio-economic levels.	Six educator participants and three family member participants.	To identify the barriers to participate in meetings and explore strategies to improve the attendance rate of Individualized Education Plan meetings.	-Game playing with friends.	-The children enjoyed playing Roblox with their friends. -Roblox can mobilize students' motivation and enthusiasm.
37	Devine [52]	Math education.	10 fourth-grade students.	To provide supporting data for teachers, administrators, and educational decision-makers to integrate the Metaverse and other Web 2.0 tools into K-6 math classes.	-Designing your homepage in games; maybe picking colors.	-The previous experience is also very important for students and affects their ability to solve unconventional mathematical problems. -Some participants were affected by Roblox and other projects, and these past experiences are conducive to the development of their Glogs.

Table 2. Cont.

No.	Study	Context	Participants	Aims and Scopes	Key Functionalities	Key Findings
38	Deliman [53]	By observing and analyzing the performance of different courses, the author explores the significance of students' and teachers' self-positioning under various backgrounds.	12 students. 2 teachers.	To discuss the significance of children and teachers' self-positioning in various social backgrounds.	-Video games: culture gaming platforms.	-A student pointed out that she often linked her ideas about role playing and imaginative work with video games such as Roblox. -Games such as Roblox can bring creativity and inspiration to students and help them use this inspiration in projects.
39	Curtice [54]	The use of technology from non-schooling education.	10 non-schooling education families.	To understand how non-schooling children use technical equipment.	-Internet multiplayer game. -Children are conversational with their friends in Roblox.	-Roblox is one of the most time-consuming games for participants. -Children use personal computers mainly for playing video games. -Roblox is popular with younger children (<12) because it can be used only by visiting the game website. -Although Roblox can be learned quickly, it is hard to master.
40	Melton [55]	Children's social network and communication in peer interaction.	45 to 60 children.	To investigate how children interact to create cultural knowledge and practice jointly.	-Games.	-When boys played Roblox, they talked about the content of the game and the control of the players and cheered each other. -When a robot exploded or fell off a cliff in the game, they also laughed at him, and the game was full of competition and initiative. -Girls are in a passive position when playing competitive games on Roblox.

Based on Tables 1 and 2, the results showed that there are few educational empirical studies using Roblox at the current stage. Studies have explored the relationship between Roblox and education from the perspectives of design and development, theoretical exploration, student health, and user experience. Although current studies cannot provide empirical data for the present study, they can be an important reference for the application of Roblox in education. The subject domains include Bible education, social interaction skills training, family education, programming/STEM education, math education, gamification learning, simulated environments, peer interactions, students' views and perspectives, students' health, and students' psychology. The specific functions of Roblox in learning can be summarized into the following six features: interaction, active creation, game-based learning, personalized development and customization, strong sense of immersion, and simulation experience. The study summarized three main areas of using Roblox in learning in this study, including social interactive learning and collaborative learning, VR environment-supported learning, and programming/STEM education. The key findings of the research include the advantages and challenges of Roblox, which include (a) helpful cognitive and noncognitive abilities, (b) advantages in gamification learning, (c) connection with real life, (d) positive user attitude, and (e) a large number of users. The challenges include cybersecurity, cyberbullying, and lack of effective teaching design and guidance. We discuss this in detail in the following subsections.

4.1.1. Social Interactive Learning and Collaborative Learning in Roblox

Social interactive learning in Roblox is an important embodiment of how Roblox applies to learning, which acts in cooperation with Topic 4 in LDA topic modeling. In this topic, the most commonly used words representing social interactive learning were "Social", "Child", "Use", "Education", "Metaverse", "Student", and "Digital". Some research notes that Roblox provides a new way for learners to socialize [5,22]. First, the functions of Roblox can support learners' social interaction and collaborative learning (Figure 3 as an example). Roblox has simple hardware requirements, and it does not require a pressure sensor or tactile versatility [5]. Since Roblox supports text and voice communication [22], it is convenient for learners to collaborate. Han et al. [26] pointed out that task settings in Roblox emphasize challenges and cooperation, so learners must cooperate to successfully complete a task. In Roblox, learners can interact with other users and environmental factors and compete with peers. These factors enhance users' interactive experience, motivation and interest and promote sustainable learning [34].

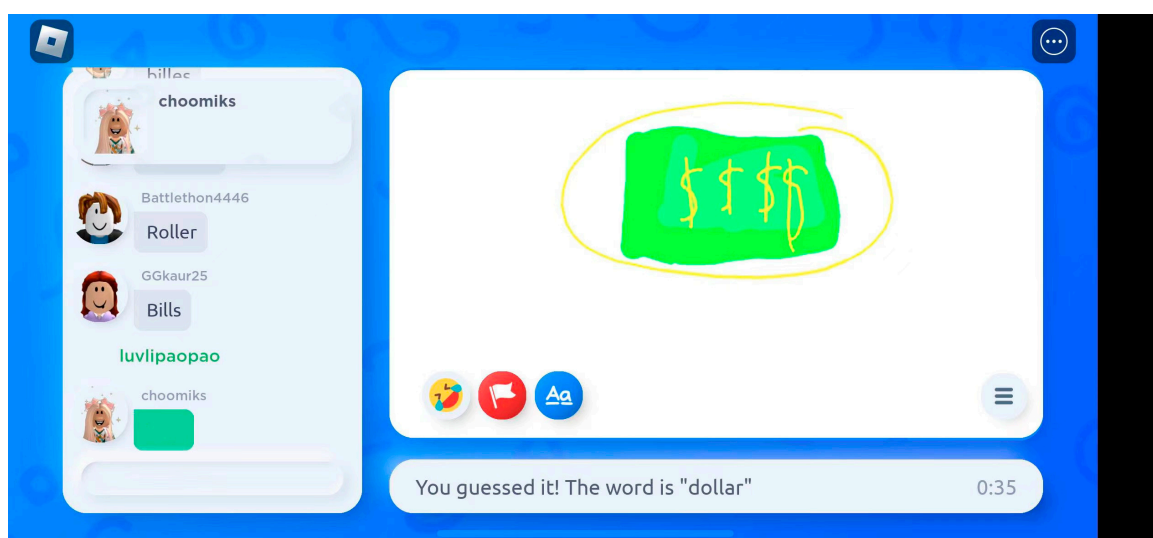


Figure 3. Social interactive learning in second language learning. (Cited from "Draw It").

Second, teenagers regard Roblox as social media. Pangrazio & Gaibisso [40] found that students expanded social media to include Roblox after investigating 276 students aged 7–12 and showed that Roblox has become an important social platform for teenagers in this research. Bolger [12] pointed out that the function of Roblox is more like a social platform because Roblox does not create content, but users usually create content themselves. Park & Kim [34] supported adolescents in building a virtual world through collaborative programming cooperation in Roblox and making friends in this process. Third, adolescents' social interaction and collaborative learning are reflected not only in the interaction between peers but also in the interaction between teenagers and their parents. Toh & Lim [23] studied two groups of fathers and sons and two groups of parents using Roblox together and found that it is possible to realize parent-child cooperative learning in Roblox. In interactions with parents, teenagers can learn through imitation and communication. As Rospigliosi [1] stated, the transformation of Facebook into Meta indicates that teenagers in school are currently changing; therefore, future learning will also change.

4.1.2. VR Environment-Supported Learning

Building virtual scenarios is another important application of Roblox in teaching and learning. Users can create their own scenarios and stories [5] and customize and develop the content [56]. The largest and most attractive feature of Roblox is that users can build virtual scenarios [39]. This function allows users to transfer real-life scenes to virtual spaces [41], such as interacting characters [25], shopping, and trying on clothing [27]. In Roblox, users have high flexibility to build the required virtual learning scenarios and resources, which echoes the analysis of Topic 1. In Topic 1, the most commonly used words representing VR environments supporting learning were "Bible", "Education", "Use", "Metaverse", "Spatial", "Skills", "Student", "Learning", "Child", and "Game". Applying Roblox to build virtual historical scenarios and buildings, as well as important historical events, is extremely suitable for Bible study. For example, Seo [21] applied Roblox to Bible study in his research. He said that in Roblox, we can build scenarios and environments related to important events in the Bible, which will help students learn and understand the contents of the Bible. Therefore, through this conclusion, we can see that this method can be effectively transferred to history or geography education.

4.1.3. Programming and STEM Education

Rospigliosi [1] defines Roblox as a sandbox game that allows users to create and shape the environment. Roblox provides a more programmable environment to enable users to create their own worlds in the platform (Figure 4 as an example). Some research considers Roblox as a tool for programming, STEM, and maker education. Wauck et al. [47] conducted research among 20 teenagers to explore the factors that affect students' spatial ability in STEM activities by using Roblox to implement STEM teaching, and the research conclusion showed that Roblox is a constructive game that is preferred by boys. Park & Kim [5] pointed out that teenagers can learn programming knowledge through Roblox, and they will participate in Roblox programming classes and summer camps. Jawad & Tout [37] explored whether a computer science curriculum based on game development can effectively improve teaching quality and found that Roblox, as a coding game, can help students learn. Meanwhile, their research also proved the feasibility of game teaching. Elmore [48] interviewed sixth-grade students in the research, and these students pointed out that they could unconsciously learn and use some mathematical knowledge when using Roblox. Thus, programming and STEM education are important subject areas in which Roblox may be applied to learning. The role of content creators demonstrated that using Roblox is a valuable approach in programming and STEM education. In addition, creating worlds and applying domain knowledge from multiple disciplines provided learners with good opportunities for social interactive and collaborative learning.

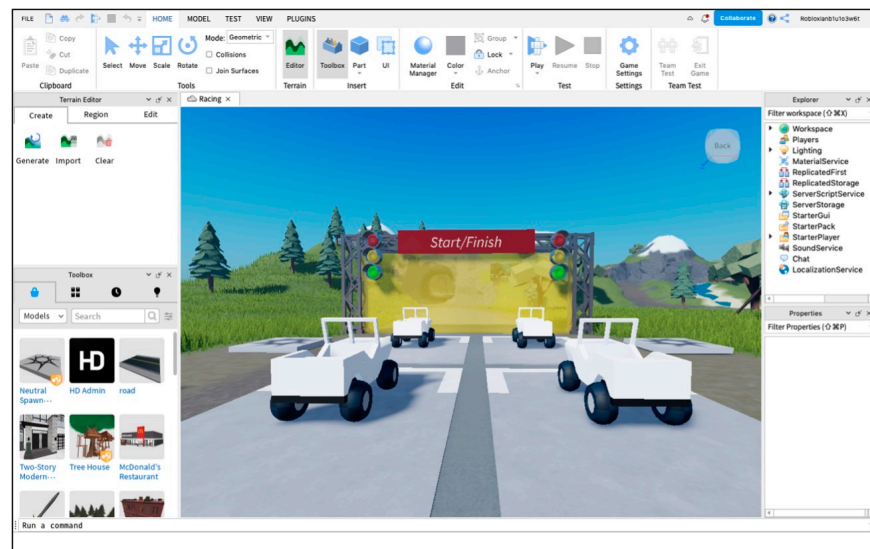


Figure 4. Coding and game design with Roblox studio. (Cited from “Roblox Studio”).

4.2. What Are the Main Benefits of Roblox Used in Learning?

Through a detailed analysis of the contents related to Roblox in these studies, we identify some benefits of Roblox used in learning. First, some studies have applied Roblox to teaching, and the results indicate that this method can improve students’ cognitive or noncognitive abilities in some way (Figure 5 as an example), which corresponds to Topic 3 in LDA topic modeling. The most used words in this topic are “Metaverse”, “Game”, “Use”, “Spatial”, “Training”, “Skill”, “World”, “Online”, “Student”, and “Education”. In terms of cognition, students’ creativity [53], curriculum knowledge [24], spatial skills [47], mathematics [48], color selection skills [52], and connection ability [53] can be improved. For example, Meier et al. [24] asked students to use Roblox to design the visual space of historical buildings in secondary school courses. The students said that this learning activity gave them a better understanding of the local sculpture heritage, enabled them to create their own interactive worlds with Roblox, broadened their career choice vision, and promoted their development in fields that they were unfamiliar with before. Elmore [48] interviewed sixth graders who used Roblox at home. In the interview, he found that these students unconsciously used much mathematical knowledge when using Roblox. In terms of noncognition, it can improve students’ social interaction ability [5,14], learning interest [30], learning motivation [51], and learning engagement [45]. For example, Lee et al. [14] set up a training program in Roblox and other Metaverse platforms. Their research indicated that this method could effectively improve the social interaction skills of teenagers with ASD. A case in Deliman [53] showed that Roblox can bring creativity and inspiration to students and help them find inspiration in the process of developing projects.

Roblox is defined as an educational game, and it is thought that Roblox reflects some benefits in learning associated with educational games [1,24]. This is consistent with the keywords of LDA Topic 6, “Education”, “Game”, “Use”, “Metaverse”, “Social”, “Experience”, “Student”, “Learning”, “Child”, and “Online”. The task setting in Roblox emphasizes challenge and cooperation [56], which is helpful to cultivate students’ cooperation ability and stimulate students’ interest in learning. Some users believe that by completing various challenges through human–computer interaction and answering some knowledge questions set in the game, Roblox has improved their computer knowledge and interest [30]. Jawad & Tout [37] stated that Roblox is a programming education game. Their research demonstrated that computer science and programming teaching could be carried out through Roblox, and their research conclusions proved the effectiveness of game-based teaching. Other studies have discussed why Roblox is conducive to learning mainly from the perspective of its functions. First, Roblox is easy to operate. Roblox’s

operation design is simple and comfortable, and its hardware tends to be simpler, which is suitable for teenagers in primary school [5,22]. Second, it can be personalized and customized [39,41]. For example, Citlali & Estrella [39] interviewed 300 college students and found that the most attractive point about Roblox is that users can customize content. Third, Roblox is connected with real life [27,43]. For example, Hollensen et al. [27] noted that the most valuable function of Roblox is that users can transfer real-life scenarios to Roblox. Fourth, the design of the functions encourages social interactions. From the perspective of social interaction theory, social interaction plays an important role in learning, and Roblox emphasizes social interaction. For example, various forms of voice interaction software can access Roblox [46], and many students expand Roblox into a form of social media [40].



Figure 5. Learning math with Roblox. (Cited from “Tower of Math”).

Another benefit of using Roblox in learning is that Roblox has many student users, and most users have a positive attitude toward Roblox. One kind of research primarily discusses users’ responses and numbers in Roblox. The research on user responses mainly shows a positive attitude. For example, Citlali & Estrella [39] surveyed 300 students, most of whom noted that they were willing to accept the content and thought it was very innovative. In the research of Hwang & Lee [38], users pointed out that a Metaverse such as Roblox is not limited by time and space, so the virtual experience provided has a high sense of immersion and connectivity. Suh & Ahn [11] surveyed 336 Korean primary school students, and 95.5% of them believed that Metaverse platforms such as Roblox were closely related to their daily lives. From the perspective of user usage, Roblox has become the most commonly used platform for teenagers. Roblox, whose number of users is greater than that of the educational game Minecraft [28], is the favorite game of Canadian children aged 2–11 [35]. Some parents believe that Roblox is the first app used by children [45] and has become one of the main social platforms for teenagers [40].

4.3. The Main Challenges of Roblox Learning Settings

Through a systematic review of these studies, we find that cyberbullying is one of the challenges of applying Roblox to education. This works in concert with Topic 2 of the LDA topic modeling analysis. The keywords of this topic include “Child”, “Use”, “Cyberbullying”, “Game”, “School”, “Children”, “Digital”, “Elementary”, “Education”, and “Behavior”. In adolescent groups and higher education, the development of cyberbullying is a disturbing trend [57]. The longer students spend time on online learning and working,

the more likely they are to be exposed to cyberbullying [58]. Among them, the types of cyberbullying most encountered by students are curses, insults, and humiliation [59], and cyberbullying can lead to truancy, depression, insomnia, suicidal thoughts [60,61], social anxiety [62], fear, and anger [63]. Previous research has discussed that the environment of Roblox is conducive to cyberbullying: with the rapid growth of the scale of Roblox use, users' misconduct is also growing, and it is difficult to check and monitor users in Roblox [5]. Melton [55] observed the behaviors of 45–60 students from kindergarten to the fifth grade of primary school when using Roblox, and the results showed that boys often use aggressive language in the game. For example, several boys cheered and shouted "beat him" together; when seeing a robot falling off a cliff, children laughed at the robot. Lewis [49] investigated cyberbullying among 436 students, and Roblox was a part of the questionnaire. The survey results showed that 62.6% of the participants said they had seen cyberbullying, and 10% of the students said they often saw cyberbullying behaviors in Roblox. Roblox has now expanded into social media [40], which is an important platform for daily online communication among young people. Therefore, studies should pay attention to the problem of cyberbullying in Roblox [25].

Cybersecurity is another challenge. With the spread of technology, the internet has penetrated every aspect of our daily life, and network security, which is very important for individuals and countries, has also emerged as a concern. Cybersecurity can protect the security of user property and prevent security risks in the network environment [64], but both students and teachers lack the understanding and knowledge of online security [65]. A lack of cybersecurity awareness may lead to attacks on mailboxes, accounts, personal information, etc., resulting in serious losses [66]. First, there are many young users in Roblox [5], and children over 13 have a high degree of freedom [22]. Younger users have not received systematic education on cybersecurity, so their cybersecurity awareness is relatively low [67], which makes them vulnerable to becoming victims of cyber fraud and scams [68]. Second, Roblox has a complete economic system [41]. Roblox has an in-game virtual currency (Robux), where businesses can sell virtual goods to users [25]. At the same time, users can pay to dress up their virtual characters and buy various goods for virtual characters [27]. Some users are pleased to invest in Roblox [56]. Thus, a lack of cybersecurity may lead to serious financial loss. Third, Roblox has the characteristics of high stature and immersion, which makes it a social network for young people. Students closely associate real life with virtual life [41], so they may be at risk of having their personal information stolen. Using ransomware, hackers can infect the Roblox system or personal computer system, blackmail students in virtual currency, and even expose sensitive pictures and information [25]. Therefore, it is necessary to pay close attention to the cybersecurity of teachers and students when they carry out learning activities in Roblox.

The third main challenge is that the lack of effective teaching design and guidance in Roblox may lead to students' addiction to games. This idea corresponds with Topic 5 in LDA topic modeling, whose keywords are "Game", "Social", "Use", "Online", "Child", "People", "Children", "Serial", "Education", and "Spatial". Excellent electronic games can cultivate excellent learning ability, which is closely dependent on game design [69]. A well-designed video game is a visual experience centered on problem solving that enables students to learn and master knowledge in a fun way, thus enhancing deep learning [70]. Smith et al. [71] also noted that games can motivate learning to achieve better results, but the key premise is that teachers must carry out effective teaching design and guidance. The research on Roblox that we combined also verified this theory. Abel [9] explored the relationship between parents and children in Roblox. Through parental supervision and support, Roblox provides a perfect platform for parents to support children in creating a virtual world. However, it should be noted that many parents have no time to supervise their children. Meier et al. [24] used Roblox to teach students to make virtual buildings, helping students have a better understanding of local historical buildings. Elmore [48] mentioned that students unconsciously encounter much mathematical knowledge when using Roblox, but they are not aware of what they have learned due to the lack of timely guidance from

parents and teachers. Without teaching guidance, Roblox may cause students to indulge in game playing. Curtice [54] pointed out that Roblox is the most time-consuming application for participants, while Hurter [50] also noted that students spend two hours on Roblox each day. Aladsani et al. [44] tracked 600 students for seven months and found that some students played Roblox every day. Some students will use Roblox for entertainment [11] if they do not acquire teaching and guidance from teachers and parents. In sum, Roblox is a double-edged sword. Through effective teaching design and guidance, students' interest in learning, participation, and performance can be improved effectively. In contrast, if it is not used in teaching, it may cause students to spend too much time in games for entertainment, thus leading to game addiction.

4.4. The Existing Gaps of Roblox in Learning and Research Identified by Selected Studies

In this section, we mainly describe the existing gaps in Roblox learning and research mentioned in the included studies. These results provide us with some insights for implications for future research. In the Discussion section, we will consider the implications for future research found after sorting out the research on Roblox in learning.

Some existing gaps have been proposed in the process of applying Roblox to learning from the perspective of teaching and research. From the existing gaps in teaching, first, future studies should consider various teaching methods. Pursell & Iiyoshi [33] proposed that compared with other Metaverse platforms (e.g., Lego), Roblox has higher interactivity, and learners can collaborate in games. Therefore, teachers need to consider different teaching methods in the future. Meier et al. [24] mentioned in their research that to improve learning motivation, students hope that teachers can better integrate Roblox into future teaching and create more learning activities in Roblox. Second, teachers, parents and students need to pay attention to cyberbullying and cybersecurity in the process of learning [25], which is consistent with the challenges mentioned above. Roblox provides a space with a high degree of freedom, and only by maintaining a good sense of mutual trust and a safe atmosphere in the learning space can the sustainable development of learning activities be ensured. Third, teachers and parents need to guide students to learn in Roblox. Elmore [48] noted that when students use Roblox for learning activities, they usually do not know the points of knowledge, so teachers and parents need to help them clearly notice, understand, use, and practice the knowledge they have gained in Roblox.

From the existing gaps in the research field, the role of Roblox in education needs to be further understood through academic research. For example, Dwivedi et al. [25] said that academic analysis of Roblox can enable researchers to better understand and question the role of the virtual world in application, governance, and interaction. In addition, it is necessary to explore the influencing factors of learning in Roblox through academic research. For example, gender impacts learning strategies [47] and learning styles [55] in Roblox. In addition, other influencing factors need to be considered. Finally, technologies related to Roblox will become increasingly widespread. Learning languages requires using well-organized taxonomy to separate threads and form a group of experts in each field [5].

5. Discussion

Given that studies on Roblox in learning are relatively new, this study aimed to synthesize the best available evidence worldwide to provide an overview of the current studies on how Roblox is used in learning. This systematic review involved investigating the benefits and challenges of Roblox in learning. The research has sorted out three types of learning used in Roblox: social interactive learning, VR environment-supported learning, and programming for STEM education. Roblox emphasizes the characteristics of social interaction, which helps it attract an increasing number of young users and gradually develop into an important social platform for young people. Just as Facebook and Twitter can provide effective support for social interactive learning as social platforms [72,73], Roblox also provides opportunities for social interactive learning. The Metaverse has the characteristics of high immersion, high flexibility, and high fitness [74,75], and it has a

great advantage in supporting learning by creating virtual scenes [76,77]. Roblox, as a representative of the Metaverse, also has such characteristics. Moreover, since Roblox provides a development platform for designers to develop components in it (designers do not need to develop the platform themselves) [5], they can create virtual scenes more flexibly, and a larger variety of scenes will provide more effective support for learning. Students' design and development of Roblox scenes, components, and human-computer interaction functions through Roblox Studio also enrich STEM and maker education. STEM education has been proven by many studies to improve students' computing literacy [78], problem solving ability [79], and cooperation ability [80]. Meanwhile, students' abilities in programming, mathematics, engineering, and other disciplines can also be cultivated through Roblox. The benefits of Roblox also contribute to its application in learning. First, Roblox has had many user groups until now, and its convenient design makes it easy for children to operate. Second, Roblox can motivate students to learn in highly liberal ways, customizable characters and content, and rich resources. Third, most of the students have a positive attitude toward Roblox, which eliminates the learning obstacles caused by unfamiliarity with a certain platform.

In sum, Roblox is a multiplayer online game/content creation platform that allows users to design, develop, and play their own games/content, which offers a variety of interactive features that can be applied in learning. Avatar customization allows users to reflect their identities and preferences. Social interaction features allow users to interact with each other through live chat, group activities, and so forth, which could promote social learning and collaboration. Active creation and gamification learning provide opportunities for learners to work together. Simulated environment features allow learners to have group virtual field trips to places that may be difficult to access in real life.

This study also found some challenges in the application of Roblox to learning. Cyberbullying has negative effects on learners, which are caused by anonymity, psychological needs, bad relationships between children and adults, social dominance theory (such as older students tending to dominate over younger students), interpersonal problems, and other factors [57]. Roblox is an important space for social interaction among teenagers; however, in this space, there is a risk of the factors mentioned above resulting in cyberbullying. Therefore, it is necessary to strengthen the interaction of reporting and monitoring in Roblox learning. Cybersecurity is a significant issue that needs to be considered. To protect learners' personal information, privacy, learning data, currency, etc., in Roblox, it is urgent to improve students' cybersecurity awareness through education so that students know how to deal with cyberattacks. Another challenge that needs special attention is the combination of Roblox and teaching. Teachers need to use appropriate teaching theories and methods to build appropriate teaching activities in Roblox, and curriculum designers also need to design and develop relevant teaching resources under the guidance of teaching methods. Furthermore, parents are responsible for supervising and guiding children's use of Roblox and preventing students from using Roblox only as a tool for entertainment.

Based on our review of previous studies and the challenges we found, we propose the following implications for future research. Our research also echoes the statement of Rospiglios [1]; that is, there is not much academic research focusing on Roblox in teaching and learning at this stage, so we need to use empirical studies, which include large and diverse samples, to explore the effects of using Roblox in learning. We need to explore the factors affecting Roblox by using empirical and long-term data with participants and propose strategies for improvement. Through qualitative research, we will explore students' ideas, views and attitudes when using Roblox to better understand the factors that affect students' application. We will focus on teaching design, explore how to design and carry out teaching activities in Roblox effectively, and investigate the effect under different pedagogical scenarios by testing students' outcomes. We will pay attention to cyberbullying and cybersecurity in Roblox and study how to reduce cyberbullying and prevent cyberattacks. Additionally, we will concentrate on teachers' use of Roblox,

including training teachers to use Roblox, designing and developing teaching activities, and interaction with students, etc.

6. Conclusions

This study combined 40 studies related to Roblox used in learning, a relatively new learning environment in the Metaverse. The findings indicate that there are three main ways to combine Roblox with learning at this stage: socialized teaching, learning environments supported by virtual reality, and programming for STEM education. The research found that the use of Roblox learning has the advantages of being available to a large number of students, attracting the positive attitude of students, and promoting students' learning motivation; however, there are also challenges such as cyberbullying, cybersecurity, and a lack of adequate teaching design. The findings also shed some interesting light on the implications for future studies. Research should focus on large-scale empirical research involving more learners, collect empirical and long-term data, use qualitative research to deepen our understanding of learning in Roblox, pay attention to the teaching design of Roblox, emphasize cyberbullying and cybersecurity in Roblox, and pay attention to the use of Roblox by teachers in the future. Continued research will help us to further understand how to apply Roblox to teaching and learning effectively.

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