Developing a Virtual Worlds Framework for Early Childhood

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Abstract – In the past decade, there has been a significant shift from simply restricting children's access to technology toward actively monitoring and managing their interactions with it. The emphasis is now on creating safe, developmentally appropriate environments that allow children to engage with digital tools in meaningful ways. This paper introduces a new resource targeting an area with significant child usage but lacking proper oversight: virtual worlds. We propose the development of a Virtual Worlds Framework (VWF-ECE) tailored for early childhood, based on a conceptual framework approach, and informed by expert surveys in the field. The framework outlines 10 key criteria for evaluating a virtual world.

Introduction

The rapid integration of technology into daily life has fundamentally transformed how children interact with the world. For Generation Alpha (Gen Alpha), born between 2010 and the mid-2020s, technology is not merely a tool but an intrinsic part of their environment. They are true "digital natives." Unlike their Millennial or Generation Z parents and teachers who adapted to technology as it emerged, Gen Alpha seamlessly incorporates digital tools into their everyday routines. This generational shift has created a pressing challenge: how to support children in engaging responsibly and creatively with technology while ensuring their developmental needs are met [1]. Efforts to address this challenge have evolved from simply restricting technology access to actively guiding and managing children's interactions with digital tools. However, the rapid pace of technological adoption by Gen Alpha has outpaced the development of effective resources and strategies. This gap is particularly evident in early childhood education, where the focus traditionally has been on older students, leaving younger learners underserved. Parents and educators often struggle to bridge this divide, balancing the need for safety and structure with opportunities for fostering innovation and problem-solving skills in children [2].

To address these challenges, this paper is part of a broader research initiative aimed at developing comprehensive resources to support early childhood education. The goal of this research is to prepare young learners for the future by enhancing their problem-solving abilities, equipping them with tools to navigate an increasingly digital world, and ensuring their safety and developmental well-being. At the heart of this initiative lies the need for structured, evidence-based approaches that balance the immense opportunities offered by technology with the safeguards necessary for young children. A key component of this effort is the Virtual Worlds Framework, designed to establish essential criteria for the design and evaluation of virtual worlds tailored to early childhood education. This framework addresses the specific developmental needs of Gen Alpha and provides a structured approach to creating virtual environments that are safe, effective, and engaging. While the framework focuses on the needs of Gen Alpha, it lays a foundation with optionality for adapting to the characteristics of future generations. The emergence of a new generation in 2025 brings unknown challenges and opportunities, especially regarding technology usage and supervision. This paper emphasizes

the first step in this broader effort: building the theoretical foundation necessary to define the essential criteria for high-quality virtual worlds (VWF-ECE). By focusing on best practices and developmentally appropriate design principles, this work sets the stage for future phases of research, including real-world application. Through this foundational work, the research aims to provide strategies that empower young learners to thrive in the digital age while equipping parents and educators with the guidance needed to navigate an ever-changing technological landscape.

Background and Related Work

Early Generation Z

Gen Alpha (born from 2010 to the mid-2020s) is growing up in a digital-first world, surrounded by iPads, smart assistants, and social media platforms such as TikTok and Instagram. As "digital natives," they naturally integrate technology into their daily lives, using it to solve problems and complete tasks such as homework with the help of virtual assistants. Their proficiency with technology from a young age distinguishes them from previous generations and sets the stage for their future interactions with digital tools. According to xxx, key characteristics define this generation: (1) social media influenced: Social media significantly shapes their lives, behaviors, and interactions, with trends driving participation and sometimes even social pressures like bullying; (2) globally connected: This generation is highly aware of worldwide events and trends, quickly adopting global phenomena such as Pokémon GO; (3) virtually mobile: Gen Alpha is expected to thrive in virtual environments for work and education, allowing members to live and operate from anywhere; (4) visually oriented: They gravitate toward video-based platforms such as YouTube, consuming and creating visual content, with young influencers like Ryan of Ryan's World leading the way [3].

Method

Design

This paper employs Malallah's [4, 5] process, which combines the conceptual framework approach [6] with the Colaizzi Analysis technique [4], to systematically develop a comprehensive framework tailored to early childhood VWs. The research process, illustrated in Figure 1. Framework Design Process Steps, outlines a structured four-step design methodology:

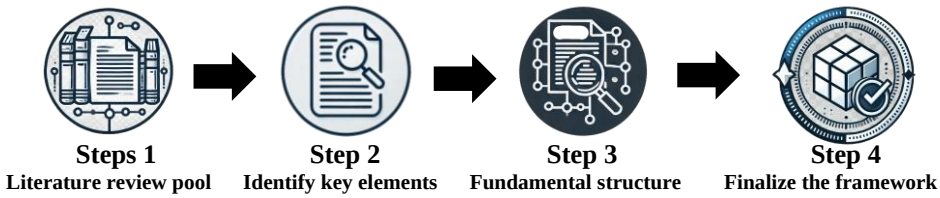

Figure 1. Framework Design Process Steps

Step 1 – literature review pool. The first step involves identifying and gathering qualitative data from intersecting domains to ensure the framework is based on existing knowledge and best practices. This comprehensive data pool serves as the foundational base for framework development.

Step 2 – primary key elements. Relevant elements are extracted from the data pool and organized into a preliminary structure. Colaizzi's analysis method is applied to the data through open coding to identify emerging themes and criteria. The analysis progresses through axial coding to establish relationships between these themes and is followed by selective coding to

refine and integrate the core categories. This ensures that the identified criteria are evidence-based and contextually grounded.

Step 3 – fundamental structure. The preliminary findings are refined and validated through expert feedback over two iterations. In the first iteration, elements are distributed via survey to gather expert input on the identified components. Experts evaluate each item, recommending whether to keep, remove, divide, or merge elements. Their feedback is analyzed and used to expand the structure, leading to the development of a second survey. The second iteration re-evaluates the elements based on the updated survey, further refining the structure.

Step 4 – finalize the framework. The feedback from the second iteration is analyzed to make final adjustments, resulting in a comprehensive and validated framework.

Data Collection

Data were gathered from two primary sources: a literature review conducted by researchers to identify key elements for the framework and expert feedback collected through a series of surveys.

Sample

A purposive sampling method was employed to select five experts based on their qualifications and willingness to contribute to the study. These experts were identified through professional connections (LinkedIn) to ensure their expertise aligned with the study's objectives and framework development process. The sample included a game designer with experience in virtual worlds, an early childhood educator, an early childhood educator with expertise in educational technology, a computer science educator, and a computer science specialist with a background in early childhood education.

Figure 2. Preliminary Survey – Demographic Information

Section 1: Demographic information

1. What is your professional background? (Select all that apply)
   - o Virtual world designer
   - o Early childhood educator
   - o Educational technologist
   - o Academic researcher
   - o Other (please specify): _____
2. How many years of experience do you have in the early childhood field?
   - o Less than 1 year
   - o 1–3 years
   - o 4–7 years
   - o 8+ years
3. How many years of experience do you have in virtual world/game design?
   - o Less than 1 year
   - o 1–3 years
   - o 4–7 years
   - o 8+ years
4. Have you ever played virtual worlds before?
   - o Yes
   - o No

Instrument – Survey

The study used a two-stage survey instrument, developed in a sequential process: the Key Elements Evaluation Survey (see Table 3) and the Full Structure Evaluation Survey (see Table 5). The results from survey 1 were analyzed and used to revise and create survey 2. Prior to this, a preliminary survey 0 was conducted to gather participants' demographic and professional information, ensuring their expertise and relevance to the study. Survey 1 focused on evaluating the initially identified framework criteria and elements. Participants were presented with elements and asked to assess whether each element should be removed, divided,

kept, or merged. They were also asked to provide open-ended feedback to refine the framework. Survey 2 included the revised elements with sub-elements for further validation. Participants evaluated these updated elements using the same method as in survey 1.

Keywords, Database, and Criteria

A combination of focused and interdisciplinary keywords was used, leveraging Boolean operators for precision. These keywords targeted three intersecting domains: virtual world frameworks, game theory, and technology best practices. The search string included (“guidelines” OR “”standards” OR “framework” OR “game theory,” “best practices”) AND (“immersive learning” OR “virtual world”) AND (“early childhood” OR “young learners” OR “preschoolers” OR “PreK”).

The search was conducted using the ERIC database and Google Scholar to access peer-reviewed sources. Materials reviewed included conference papers, journal articles, proceedings, and books written in English. Relevance was assessed by examining abstracts, introductions, titles, and content retrieved from search results and web pages. Because of the limited availability of related studies, the timeframe was extended to include publications from the past 20 years. Studies that did not meet the criteria or lacked a focus on technology use in early childhood education were excluded.

Results

The qualitative analysis was conducted using MAXQDA to process the data pool and expert feedback systematically. The research steps resulted in the creation of seven tables, which document the sequence of activities undertaken to develop the framework across the four methodological steps. In step 1, Table 1 was created to represent the size of the data pool and the qualitative key findings derived from the initial analysis. In step 2, Table 2 was generated to identify the key elements (themes) and their corresponding references, forming the foundation for the framework. In step 3, two tables were constructed to document the survey process. Table 3 detailed the content of survey 1, capturing the initial evaluation criteria. Table 4 summarized the expert feedback collected from survey 1, highlighting suggestions and refinements. Table 5 presented the content of survey 2, which was developed based on the analysis of the results from survey 1. Finally, in step 4, Tables 6 and 7 were created to represent the finalized elements and their descriptions. These tables define the comprehensive framework for evaluating a VW, outlining the criteria and their associated guidelines derived through the iterative research process.

Table 1. Data Pool and Key Findings from Qualitative Analysis

# Pool	Significant Sentences	Code	Themes
21	403	36	10

Step 1 and Step 2

Table 1 provides a summary of the Colaizzi analysis conducted during the initial phase of the study. The first column represents the final set of 21 identified documents, filtered down from an initial pool of 116 retrieved. Through analysis, 403 significant statements were extracted, consolidated into a single document, and systematically reviewed to identify recurring patterns and codes. This process generated 399 repeated coded segments, which were further refined to yield 36 distinct segments. From these distinct segments, 10 overarching themes were identified (see Table 2).

Table 2. Refine Key Element and the Corresponding References

Category/theme	Element/code	References
1 Accessibility and usability	Accessibility	[21], [9], [17], [19]
	Usability	[22], [20], [9]
	Dual-language support	[15], [12]
	Adaptive learning	[9], [13], [19]
	Time-limited activities	[13], [19]
2 Engagement and interaction	Engagement	[22], [21], [20], [17], [19]
	Interactive tools	[21], [22], [17]
	Play-based learning	[18], [12], [14]
	Multimodal interaction	[18], [19]
	Personalized learning	[9], [2], [10][11]
3 Safety and privacy	Safety and privacy	[13], [10][11], [15], [12]
	Safe spaces	[8], [10][11], [15]
	Rule enforcement mechanisms	[13], [15]
4 Collaboration and social development	Collaboration	[20], [7], [8], [17], [19], [14]
	Collaborative exploration	[18], [19], [14]
	Social skill development	[7], [8], [14]
	Leadership development	[8]
	Community representation	[10][11], [12]
5 Creativity and open-ended design	Creativity	[21], [20], [7], [8], [19], [10][11]
	Open-ended design	[19], [14]
	Iterative development	[20], [19]
	Resourcefulness	[7]
6 Cultural and historical contexts	Cultural relevance	[13], [12], [12]
	Historical contextualization	[20], [16], [12]
	Historical and cultural contexts	[20], [16], [12]
7 Developmental and educational appropriateness	Developmental appropriateness	[21], [17], [19], [12] [10][11]
	Alignment with educational standards	[9], [13], [19], [12]
	Gender-inclusive STEM practices	[13]
	Child-centered learning	[7], [13], [19]
8 Evaluation and feedback	Evaluation and feedback	[21], [20], [17], [19]
	Praxis-based learning	[13], [14]
9 Civic and ethical engagement	Civic engagement	[14]
	Respect for shared spaces	[15], [14],
10 Sensory and emotional stimulation	Sensory stimulation	[21], [17]
	Positive technological development	[13], [10][11], [14]

The 21 documents underwent review. Shaw et al. [7] explored immersive learning experiences in STEAM education, demonstrating the value of hands-on activities and participatory learning in fostering creativity and problem-solving. Javorsky [8] examined the integration of Minecraft in afterschool programs, emphasizing how collaborative tools and safe spaces promote leadership, teamwork, and critical thinking. Shadiev and Wang [9] reviewed technology-supported language learning, highlighting tools such as Google Docs and Moodle that facilitate collaboration, digital literacy, and communication skills. Bers and Cantrell [10] explored the Zora VW's impact on fostering peer relationships, psychosocial support, and collaborative creation for children with medical conditions, further illustrating the potential of VWs to enhance social development.

The alignment of virtual environments with developmental stages and cultural contexts is a recurring theme in literature. Beals and Bers [11] proposed a developmental lens for designing VWs, emphasizing purpose, communication, and play to support children's cognitive and emotional growth. Bers et al. [12] extended this focus by advocating for safe, inclusive environments that reflect diverse cultural narratives and foster identity exploration. Malallah [13, 14] introduced the "bes-T-ech" framework to integrate computational thinking into early childhood education, emphasizing gender-inclusive STEM practices, cross-cultural applicability, and alignment with educational standards. Similarly, Beals and Bers [12] highlighted the importance of tailored communication tools and cooperative play to align virtual activities with children's developmental needs.

VWs provide unique opportunities for fostering creativity, ethical decision-making, and civic engagement. Bers [15] explored the Zora VW as a praxis-based environment, demonstrating how open-ended tasks and interactive learning promote critical thinking and civic knowledge. Similarly, Beals and Bers [16] evaluated the ClubZora project, highlighting the role of user-driven design and safe spaces in fostering engagement and inclusivity. Malallah [13] emphasized purposeful design in VWs, integrating elements such as play-based learning, adaptive features, and evaluation mechanisms to support creativity and continuous

improvement. These findings highlight the need for virtual environments to balance structure with opportunities for innovation and personal growth.

Ensuring safety and accessibility is a fundamental consideration in virtual world design: Javorsky [8] and Malallah [13] stressed the importance of privacy safeguards, rule enforcement mechanisms, and inclusive design to create secure, child-friendly environments. Bers et al. [17] highlighted the significance of secure platforms in supporting peer networking and fostering a sense of community among young users. Inclusivity features such as dual-language support and adaptive learning tools are critical to making virtual environments accessible to diverse learners. Juárez Collazo et al. [9] emphasized user-friendly design and multimedia integration to accommodate varying student competencies, further demonstrating the importance of accessibility in VWs.

Interactive and immersive technologies are increasingly recognized for their ability to foster experiential learning in early childhood ages. Krueger [18] explored VW use in enhancing STEM engagement among middle school students, emphasizing its capacity for experiential learning and collaborative problem-solving. Keifert et al. [19] highlighted the role of MR environments in supporting embodied learning through iterative inquiry, where young learners use their bodies to model scientific concepts such as particle motion. Laranjeiro [20] examined the development of mobile learning applications for preschoolers using a design-based research approach. The findings underscore the importance of iterative development and pedagogical alignment in creating tools that promote creativity, collaboration, and multimodal interaction. These studies collectively highlight the potential of immersive technologies to engage young learners and enhance their understanding of complex concepts.

Some studies identify critical criteria for VW design, including interactive tools, collaboration, developmental appropriateness, and cultural responsiveness. Iterative design processes, as highlighted by Garcia [21] and Laranjeiro [20], underscored the importance of participatory feedback and co-design in creating relevant and effective tools. Evaluation mechanisms, such as those emphasized by Malallah [2], supported continuous improvement and alignment with educational goals. Aydoğdu [22] reviewed the use of augmented reality in preschool education. These findings underscore the importance of criteria such as interactive tools, sensory stimulation, creativity, and developmental appropriateness in designing virtual learning environments for preschool children. Similarly, Madanipour, investigated the integration of augmented reality in preschool education—examining its application across various domains such as early literacy, language learning, spatial skills, artistic activities, and musical skills—and suggested that criteria such as accessibility, interactive tools, technology integration, and play-based learning should be considered when developing VWs for early childhood education. [23].

Step 2 – Refinement Analysis and Construction of Survey 1

Table 3 represents the structure of survey 1, designed to refine and evaluate the identified elements. The first column lists the identified elements (themes) derived from the previous analysis. The second column provides a detailed description of each element to ensure clarity for participants. The third column prompts participants to take specific actions regarding each element, such as retaining, merging, eliminating, or modifying it. Finally, the fourth column is an optional feedback section, allowing participants to provide additional comments, suggestions, or further refinement.

Table 3. Content of Survey 1 (Evaluation Criteria)

Elements	Description	Action	Feedback (optional)
Engagement and motivation (EM)	Measures how well the VW sustains children's interest, curiosity, and active participation		
Communication and interaction (CI)	Ensures safe and effective communication tools and fosters positive interactions		
Collaboration and teamwork (CT)	Promotes teamwork, shared goals, and cooperative problem-solving among players		
Inclusivity and accessibility (IA)	Creates an inclusive environment accessible to diverse users, including those with special needs		
Data security and privacy (DSP)	Ensures compliance with child data protection standards and protects user privacy		
Design and environment (DE)	Evaluates sensory, navigational, and thematic elements for usability and appeal		
Creativity and problem-solving (CPS)	Encourages innovation, critical thinking, and exploration through open-ended challenges		
Ethics and decision-making (EDM)	Reinforces ethical behavior and critical thinking through in-game scenarios and dilemmas		
Facilitation and educator tools (FET)	Provides resources and tools for educators to guide, monitor, and assess learning outcomes		
Cultural responsiveness (CRR)	Reflects and respects cultural diversity, enabling children to see their identities represented		
Community building and empathy (CBE)	Focuses on fostering a sense of community, collaboration, and shared purpose		
Safety and technical security (STS)	Ensures a safe and secure environment for children's interactions and activities		
Monitoring, evaluation, and feedback (MEF)	Supports real-time tracking and continuous improvement of VW design and implementation		

Step 3 – Survey 1: Expert Feedback and Framework Refinement

The third step in the research process involved gathering expert feedback through survey 1 to refine the initial framework. The results were categorized based on the type of feedback provided and the actions taken to enhance the framework (see Table 4). Each feedback category was analyzed to identify overlaps, gaps, and opportunities for improvement, resulting in adjustments to the structure and content of the framework.

Table 4. Summary of Expert Feedback from Survey 1

Aspect	Refined framework
Structure	Groups elements into broader categories for clarity (e.g., engagement and motivation, inclusivity and accessibility). Lists specific elements (e.g., accessibility, safety, creativity).
Redundancy	Reduces overlap by merging similar elements (e.g., overlap in categories such as safety versus rule enforcement)
Educator role	Expands on tools/resources for educators under facilitation and educator tools (FET)
Cultural sensitivity	Combines into cultural responsiveness (CRR) for streamlined inclusion
Ethics and legal compliance	Introduces policy and ethics and expands safety into safety and technical security (STS)
Evaluation and feedback	Adds monitoring, evaluation, and feedback (MEF) with real-time and iterative processes

Based on expert feedback, the criteria's refinement resulted in an evolution from 10 categories to 13. After an additional round of clustering and refinement, the process involved analyzing overlapping and unique elements, consolidating similar concepts, and adding critical missing components. Key clusters were defined to provide clarity and ensure coherence among the criteria. Engagement and motivation emerged as a vital category, capturing how VWs sustain children's interest and curiosity through exploration, feedback, and personalization. Communication and interaction were grouped to emphasize safe, structured communication tools and fostering positive player interactions. Collaboration and teamwork were consolidated to address cooperative missions, shared goals, and the development of social skills. To enhance inclusivity, inclusivity and accessibility were combined to cover features such as adaptive

design, multilingual support, and accessible login options. Data security and privacy was retained as a distinct category, focusing on compliance with regulations while ensuring robust parental controls. Design and environment encapsulated sensory-friendly designs, cultural representation, and eco-friendly themes to create immersive and educational experiences. Creativity and problem-solving highlighted opportunities for innovation, critical thinking, and open-ended tasks through sandbox modes and STEAM-based missions. Additional clusters, such as ethics and decision-making, addressed the reinforcement of positive behavior and reflective practices. Facilitation and educator tools focused on resources to empower educators in guiding and monitoring student progress. Cultural responsiveness and representation underscored the importance of reflecting diverse narratives and traditions within the VW. Community building and empathy emphasized fostering shared purpose and collaboration, while safety and technical security addressed safeguarding children from technical risks and ensuring secure environments. Finally, monitoring, evaluation, and feedback provided mechanisms for tracking progress, generating reports, and refining the VW through feedback loops and audits.

Step 3 – Refinement Analysis and Construction of Survey 2

The next stage involved constructing survey 2, which focused on validating the revised elements and gathering additional insights for finalizing the framework. The content of survey 2 reflects the refined elements, their descriptions, and action prompts for participants to provide targeted feedback (see Table 5).

Survey 2 was designed to evaluate 38 specific elements categorized under broader themes that emerged during the refinement process. Each element was clearly described, with participants prompted to take specific actions such as confirming, modifying, or suggesting the removal of elements. Additionally, participants were encouraged to provide open-ended feedback, ensuring their expert perspectives could guide further adjustments.

Table 5. Content of Survey 2 (Refinements Based on Survey 1)

	Elements: description	Action	Feedback
1	The VW encourages open-ended exploration with guided hints fostering curiosity imagination and creativity.		
2	The VW integrates STEM-based missions and scenarios encouraging problem-solving and exploration of solutions.		
3	The VW provides a safe and exploratory sandbox mode for unstructured play while also offering timers or limited-time control features for structured activities.		
4	The VW includes multiplayer activities with structured collaboration and clear communication channels.		
5	The VW offers age-appropriate communication tools including emojis voice messages gestures and pre-set phrases for accessibility.		
6	The VW provides multilingual support to accommodate diverse users with adjustable font sizes, contrast options, and audio aids for accessibility.		
7	The VW ensures robust security measures including safeguards against breaches and regular updates to address vulnerabilities.		
8	The VW provides customization options for educators to tailor the environment while avoiding stereotypes and promoting positive depictions of all cultures.		
9	The VW provides real-time feedback and visual progress indicators to engage players and track achievements.		
10	The VW allows players to explore while encouraging imagination and curiosity.		
11	The VW uses interactive tasks to sustain engagement and motivation.		
12	The VW adapts difficulty levels based on the player's performance to keep them challenged but not frustrated.		
13	The VW encourages players to set goals and achieve milestones through playful interactions.		
14	The VW ensures all communication is moderated to promote safety and positive interaction.		
15	The VW features activities that promote sharing turn-taking and negotiation.		
16	The VW includes a structured tutorial to help children learn how to communicate within the platform.		
17	The VW allows facilitators or parents to monitor and guide player interactions in real time.		
18	The VW offers real-time support or tutorials for children who may need additional assistance.		
19	The VW offers customizable avatars that reflect diverse cultural gender and physical representations.		
20	The VW allows for offline accessibility or low-bandwidth modes to ensure inclusivity across technological constraints.		
21	The VW adheres to child data protection laws such as GDPR-K and COPPA.		

22	The VW provides clear and understandable privacy policies for parents and educators.		
23	The VW provides comprehensive parental control options for managing settings and privacy.		
24	The VW conducts regular third-party audits to ensure compliance with security and privacy standards.		
25	The VW offers intuitive navigation with clear instructions and easy-to-follow pathways.		
26	The VW uses age-appropriate visuals, animations, and layouts to match developmental stages.		
27	The VW incorporates scenarios that allow players to reflect on the consequences of their decisions.		
28	The VW promotes empathy through activities that encourage understanding others' perspectives.		
29	The VW includes ethical dilemmas appropriate for young children to develop problem-solving skills.		
30	The VW rewards positive behaviors such as helping others or sharing to reinforce ethical actions.		
31	The VW discourages harmful actions by providing constructive feedback when players make unethical choices.		
32	The VW ensures decision-making tasks are age-appropriate and free of complex moral ambiguity.		
33	The VW provides session reports and saves artifacts for assessment and reflection.		
34	The VW avoids stereotypes and promotes positive depictions of all cultures.		
35	The VW hosts virtual events that bring players parents and educators together.		
36	The VW includes content filtering to block inappropriate language and behavior in real time.		
37	The VW provides real-time monitoring tools for facilitators to observe gameplay and interactions.		
38	The VW includes tools for saving and reviewing player artifacts such as creations or completed tasks.		

Step 3 – Survey 2: Expert Feedback

Based on expert feedback, the transformation of the original framework (Table 5) into the revised version (Table 6) involved refining and consolidating elements to create a more concise and practical structure. The modifications aimed to eliminate redundancy, streamline categories, and emphasize core functionalities while maintaining alignment with best practices in VW design for children. Several elements in the original framework were merged to reduce overlap and to improve clarity. For instance, elements focusing on fostering imagination and creativity were integrated with STEM-based activities. Originally, the framework included "The VW encourages open-ended exploration with guided hints fostering curiosity, imagination, and creativity" (element 1) and "The VW allows players to explore while encouraging imagination and curiosity" (element 10). In the revised framework, these were consolidated into a single category under STEM-focused missions and scenarios, emphasizing problem-solving and exploration while retaining creative elements. Similarly, accessibility and communication tools were combined. The original framework featured distinct elements for age-appropriate communication tools (element 5) and accessibility features such as multilingual support and adjustable visual aids (element 6). These were merged into a single category in the revised framework (element 4: "The VW supports communication with age-appropriate tools and accessibility features") to create a more comprehensive description of communication and inclusivity.

Expert analysis highlighted redundancies in the original framework. For example, cultural sensitivity was addressed in multiple elements, such as "The VW avoids stereotypes and promotes positive depictions of all cultures" (element 34) and "The VW provides customization options for educators to tailor the environment while avoiding stereotypes and promoting positive depictions of all cultures" (element 8). These were unified in the revised framework as "The VW offers customizable avatars that reflect diverse cultural, gender, and physical representations" (element 10), simplifying the framework while preserving its intent.

Elements related to gameplay structure were also revised. The original framework included "The VW provides a safe and exploratory sandbox mode for unstructured play while also offering timers or limited-time control features" (element 3). Feedback suggested that sandbox modes were less critical to the framework's goals, leading to their removal. Instead, the original framework focused on the structured aspect of gameplay by retaining the timer feature (element 2: "The VW offers timers or limited-time control features for structured activities").

The original framework addressed player engagement and ethical behavior across multiple elements, such as "The VW provides real-time feedback and visual progress indicators to engage players and track achievements" (element 9) and "The VW rewards positive behaviors such as helping others or sharing to reinforce ethical actions" (element 30). In the revised framework, these were combined into "The VW provides real-time feedback and visual progress indicators to engage players. It rewards positive behaviors and discourages harmful actions through constructive feedback" (element 19), ensuring a holistic view of engagement and ethical development.

Certain elements in the original framework, such as "The VW provides real-time monitoring tools for facilitators" (element 37) and "The VW includes tools for saving and reviewing player artifacts" (element 38), were omitted in the revised framework. These features were deemed less essential and were integrated into broader categories. For example, facilitator monitoring and artifact review were summarized under "The VW provides session reports and saves artifacts for assessment and reflection" (element 20).

Additionally, the element inclusivity and accessibility (IA) has been expand to include the age age-appropriate criteria to become inclusivity, accessibility and age-appropriate (IAA). Researchers also integrated empathy into ethics and decision-making (EDM) and refined community building (CB) to focus on encouraging children to think about benefiting their communities.

Step 4 – Survey 2: Expert Feedback and Final Framework

Based on the results of survey 2, the final structure of the framework represents the culmination of expert feedback and iterative refinements (see Table 6). The framework consists of 21 items, each addressing at least one of the 13 identified elements, as outlined in the second column of the table. The third column lists the sub-items associated with each element; remaining columns illustrate the relationships between the items and the elements they satisfy. The intersections between items and elements indicate which aspects of the framework are addressed by each item. For instance, item 1 satisfies multiple elements, including engagement and motivation (EM), community building and empathy (CBE), and creativity and problem-solving (CPS). This mapping highlights the multidimensional nature of the items and their contributions to the overarching framework. In addition to the structural overview provided in Table 6, Table 7 offers detailed definitions and descriptions of the final 13 elements. These descriptions were developed following the final analysis and aim to provide a clear understanding of each element's purpose, scope, and role within the virtual world evaluation framework. For example, engagement and motivation (EM) focuses on sustaining interest and curiosity through exploration and personalized feedback, while community building and empathy (CBE) emphasizes fostering social responsibility and collaboration among users.

The final framework represents a comprehensive tool for evaluating virtual worlds, integrating diverse expert perspectives and addressing critical aspects such as inclusivity, safety, creativity, and ethical considerations. By clearly defining the relationships between items and elements and providing detailed descriptions, the framework ensures clarity and usability for researchers, educators, and developers alike.

Table 6. Final Identified Elements for Virtual World Evaluation

		EM	CT	CI	IAA	DSP	DE	EDM	MEF	FET	CRR	CBE	STS	CPS
1	The VW integrates STEM-based missions and scenarios encouraging problem-solving and exploration of solutions.	1										1		1
2	The VW offers timers or limited-time control features for structured activities.				1		1							
3	The VW includes multiplayer activities with structured collaboration and clear communication channels.	1	1	1									1	
4	The VW supports communication with age-appropriate tools (emojis, voice, pre-set phrases) and accessibility features (multilingual, adjustable fonts, contrast, audio).			1	1						1			
5	The VW adapts difficulty levels based on the player's performance to keep them challenged but not frustrated.	1			1		1							1
6	The VW features activities that promote sharing, turn-taking, and negotiation.													
7	The VW includes a structured tutorial to help children learn how to communicate within the platform.		1											
8	The VW allows facilitators or parents to monitor and guide player interactions in real time.									1				
9	The VW offers support or tutorials for children who may need additional assistance.				1		1							
10	The VW offers customizable avatars that reflect diverse cultural, gender, and physical representations.				1						1			
11	The VW allows for low-bandwidth modes to ensure inclusivity across technological constraints.				1									
12	The VW adheres to child data protection laws and safeguards the environment by filtering inappropriate content and offering real-time monitoring tools for facilitators.			1		1							1	
13	The VW provides clear and understandable privacy policies for parents and educators.									1			1	
14	The VW provides comprehensive parental control options for managing settings and privacy.												1	
15	The VW conducts regular third-party audits to ensure compliance with security and privacy standards.												1	
16	The VW uses age-appropriate visuals animations and layouts to match developmental stages.				1									
17	The VW incorporates scenarios that allow players to reflect on the consequences of their decisions.							1						
18	The VW fosters empathy through activities that encourage understanding and includes age-appropriate ethical dilemmas to support moral development in young children.													
19	The VW provides real-time feedback and visual progress indicators to engage players and track achievements. It rewards positive behaviors and discourages harmful actions through constructive feedback.						1	1	1					
20	The VW provides session reports and saves artifacts for assessment and reflection.								1	1				
21	The VW hosts virtual events that bring players parents and educators together.									1		1		

Table 7. Descriptions of Final Elements for Virtual World Evaluation

Engagement and motivation (EM) The features that captivate players' attention and sustain their interest. These include mechanisms such as real-time feedback, visual progress indicators, goal setting, and reward systems to	**Collaboration and teamwork (CT)** Fostering cooperative experiences within virtual environments. Like multiplayer activities to promote shared responsibilities, turn-taking, and negotiation, encouraging players to solve challenges collectively and build social skills.	**Creativity and problem-solving (CPS)** Activities that inspire innovation, critical thinking, and active participation. Virtual worlds should provide tools and opportunities for children to be creators rather than passive consumers. This includes features such as customizable

maintain players' enthusiasm and encourage active participation.		content creation, interactive building tools, and open-ended exploration tasks.
Communication and interaction (CI) Enabling players to engage effectively using age-appropriate tools. These tools may include emojis, pre-set phrases, voice messaging, and gestures to ensure clear and accessible communication within diverse user groups.	**Inclusivity, accessibility and age-appropriate (IAA)** Cater to a diverse audience by supporting multiple languages as well as providing adjustable font sizes, contrast options, and audio aids ensuring that all features are age-appropriate and inclusive.	**Design and environment (DE)** Creating an intuitive, visually appealing, and developmentally appropriate virtual space. This includes interactive animations, age-appropriate visuals, and user-friendly navigation to support exploration and engagement.
Data security and privacy (DSP) Measures to protect user information and ensure compliance with digital safely regulations. Features include clear privacy policies, safeguards against data breaches, real-time monitoring tools, and regular audits to maintain a secure environment.	**Safety and technical security (STS)** Protective measures to ensure players interact in a secure environment. Features such as real-time content filtering, communication moderation, and robust safeguards are implemented to prevent harmful interactions and technical vulnerabilities.	**Evaluation and feedback (MEF)** Provide players with meaningful insights into their progress through features such as real-time feedback, visual progress indicators, and session reports. Help track achievements and encourage self-reflection and growth.
Cultural responsiveness (CRR) Cultural responsiveness ensures that virtual worlds reflect and respect cultural diversity. This includes avoiding stereotypes, promoting positive depictions of various cultures, and offering customizable avatars that represent different genders, cultures, and physical characteristics.	**Community building (CB)** Inspiring children to think about how their actions can benefit their communities within and beyond the virtual world. Activities and interactions are designed to foster collaboration, leadership, and a sense of responsibility. Players are encouraged to participate in community-driven projects, share resources, and engage in meaningful ways that promote collective well-being and social impact.	**Facilitation and educator tools (FET)** Facilitation and educator tools offer functionalities for parents, teachers, or facilitators to monitor and guide player interactions. Customizable settings allow the environment to align with specific educational goals while ensuring safety and control.
Ethics, empathy, and decision-making (EDM) Helping children understand the consequences of their actions and fostering moral and ethical development. Virtual worlds should incorporate scenarios that encourage players to reflect on their decisions, promote empathy by understanding others' perspectives, and reward positive behaviors such as helping and sharing. Constructive feedback discourages harmful actions, while ethical dilemmas appropriate for their age support the development of critical thinking and moral reasoning.		

Discussion

The results identified 21 items representing 13 key elements that should be considered when evaluating or designing a VW for young children. These items serve as a framework to assess or guide the development of a VW. Tables 6 and 7 serve as a comprehensive rubric to assess the quality, functionality, and suitability of a VW designed for children. First, use the 13 categories to analyze the VW systematically. Then, evaluate whether each category is adequately represented in the VW. Assign a numerical scale for each element within the categories (e.g., 1–5, where 1 = poor and 5 = excellent). Next, evaluate how well the VW implements features such as engagement, accessibility, security, etc. Add the scores for all elements within a category and calculate the overall performance of the VW. Use the Final Score Interpretation table to classify the VW's quality (e.g., exceptional, strong, satisfactory, etc.).

The total rubric score is calculated by evaluating all elements across the categories in Table 6. Each category's performance is assessed using a scoring system (e.g., 1–5 scale for each element). The sum of the scores is compared against the total possible score to assign a qualitative interpretation.

Final Score Interpretation:

- **90%–100%**: Outstanding VW, excellent for early childhood development
- **75%–89%**: Very good VW, meets most criteria with minor enhancements needed
- **60%–74%**: Adequate VW, addresses many criteria but needs significant improvements
- **50%–59%**: Subpar VW, lacks critical features for effective early childhood use
- **Below 50%**: Not suitable as a VW for early childhood

To comprehensively evaluate a VW, facilitators, parents, and educators must look beyond the structured rubric and actively immerse themselves in the platform. Imagine stepping into the VW not as an evaluator but as a participant, exploring its features and functionality from the child's perspective. This immersive approach allows facilitators, parents, and educators to identify risks or limitations that the rubric might overlook, such as hidden complexities, unaddressed accessibility needs, or subtle design flaws. Observing how children naturally interact with the VW—how they navigate its spaces, engage with its challenges, and communicate within it—offers invaluable insights into the platform's usability and potential shortcomings. As they delve deeper into the evaluation, the process must extend beyond the platform's surface. Reviewing privacy policies, terms of use, and the latest updates is crucial to ensure the VW adheres to child safety standards and best practices. Technology evolves rapidly; every update brings new features and potential vulnerabilities. A thorough evaluation requires staying informed about these changes and reassessing how well the VW aligns with its intended goals. Collaborating with a network of parents, educators, and experts can enrich this process, as shared observations often reveal gaps or opportunities for improvement that might not be apparent to a single evaluator. Also, consider the unique benefits of joining a child in their virtual journey. Playing alongside them and monitoring their interactions can uncover nuances that static evaluation cannot. For example, how intuitive are the controls? Are the challenges appropriately scaled to the child's abilities? Does the VW foster meaningful engagement or unintentionally introduce risks? This hands-on approach not only enhances the evaluator's understanding but also creates a shared learning experience, helping to build trust and provide immediate guidance to the child.

Finally, even with rigorous evaluation, technology will never be entirely safe. Virtual worlds, like all digital environments, present evolving risks that cannot be fully eliminated. The partnership between parent and child becomes the most reliable safeguard.

Limitations

Many elements in the rubric, such as engagement, inclusivity, or ethics, rely on subjective judgment by the evaluator. The interpretation of whether a feature is effective or meets the required standard may vary depending on the evaluator's experience, perspective, or familiarity with the technology. Also, the rapid evolution of technology introduces new features, updates, and potential risks. The rubric, being a static tool, may not account for these changes in real time, requiring continuous adaptation to remain relevant and effective. While the rubric includes categories such as data security, privacy, and accessibility, it does not provide detailed technical benchmarks (e.g., encryption standards, latency limits) for assessing compliance with these criteria. Facilitators may have limited technical knowledge or insufficient time to fully explore the VW or may provide incomplete or inconsistent assessments.

Conclusion

This research aimed to develop a comprehensive framework for evaluating and designing virtual worlds (VWF-ECE) tailored to young children. Through a systematic methodology involving expert feedback, qualitative analysis, and iterative refinement, the study produced a robust framework consisting of 21 items across 13 distinct elements. Each element addresses critical aspects such as engagement, inclusivity, creativity, safety, ethics, and facilitation, ensuring that virtual worlds meet developmental, educational, and safety standards.

The process began with an extensive literature review and data collection, followed by coding and theme development to identify the foundational elements. Expert feedback from two surveys played a pivotal role in refining the framework, consolidating overlapping concepts, and introducing key missing components. The final structure provides a clear and actionable guide for evaluating virtual worlds, highlighting the relationships between individual items and their contribution to the overarching elements.

Future Work

Future work includes testing the rubric in diverse real-world settings to evaluate its applicability and reliability. This will include assessing virtual worlds designed for children across various age groups, cultural backgrounds, and socio-economic contexts. Additionally, efforts will focus on developing quantitative metrics to complement the rubric, enabling more objective and measurable evaluations. These initiatives aim to refine the rubric and ensure its adaptability to the evolving landscape of virtual environments.

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