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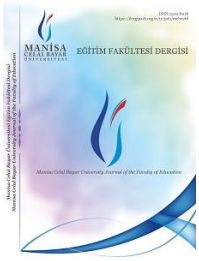

The EVRIM Framework: Guiding Ethical and Inclusive Virtual Reality Integration in Education

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Abstract

This study introduces the EVRIM Framework (Ethical Virtual Reality Integration Model), designed to meet the growing need for the ethical and effective integration of Virtual Reality (VR) technology in education. As VR technology continues to transform educational practices, a structured approach is essential to maximize its benefits while adhering to ethical standards and promoting inclusivity. The EVRIM Framework is divided into five stages: Discovery, Design, Development, Deployment, and Impact. The Discovery stage involves identifying educational needs, selecting appropriate technologies, and ensuring alignment with educational goals and ethical standards. The Design stage focuses on creating immersive, interactive, and inclusive VR content, emphasizing user experience and accessibility. The Development stage encompasses the technical creation and rigorous testing of VR applications, ensuring data privacy, content accuracy, and cultural sensitivity. The Deployment stage involves practical implementation, including training educators and students, integrating VR content into curricula, and providing ongoing technical support. Finally, the Impact stage assesses the effects of VR on student performance and learning outcomes, collecting and analyzing data to continuously improve VR experiences. The EVRIM Framework aims to revolutionize education by enhancing learning outcomes, promoting inclusivity, and adhering to ethical principles, providing a valuable tool for educators, designers, and policymakers. It serves as a comprehensive guide for leveraging VR technology responsibly and effectively in education. Future research should focus on longitudinal studies to assess long-term impacts, further development of accessibility features, and the creation of comprehensive guidelines for the ethical use of VR in education. By continuously refining and expanding the EVRIM Framework, VR technology can be used to its fullest potential, fostering an inclusive and innovative educational landscape.

Keywords
1. Virtual Reality
2. Ethical Principles
3. Tech Integration
4. Pedagogical Design
5. EVRIM

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INTRODUCTION

Virtual Reality (VR) technology has profoundly transformed various fields, offering immersive and interactive experiences that were previously unimaginable. In the educational sphere, VR possesses the potential to revolutionize conventional teaching methods by creating hands-on, engaging learning environments. Ke, Pachman, and Dai (2020) and Kustandi, Fadhillah, Situmorang, Prawiladilaga, and Hartati (2020) have demonstrated that VR, by simulating real-world scenarios, allows students to explore complex concepts and practice skills in a safe and controlled setting, thus enhancing student motivation, retention, and comprehension of the subject matter. This technology allows for experiential learning, which is crucial in fields that require practical skills and real-world application such as medicine, engineering, and the sciences (Madathil et al., 2017; Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020). Furthermore, Sadek, Baldwin, Gray, Khayyat, and Fotis (2023) asserts that the capability of VR to simulate and interact with intricate systems and environments renders it a powerful tool for fostering a deep understanding and mastery of subjects.

The integration of Virtual Reality (VR) in education serves as a vital bridge between theoretical knowledge and practical application. In this study, for example, students receive IoT training in a VR environment where they learn about various IoT components, construct virtual circuits, and use block-based coding to activate these circuits. Subsequently, they are provided with real-life circuit elements, allowing them to transfer the knowledge gained in the VR setting into real-world applications, thereby demonstrating the effectiveness of VR in bridging the gap between virtual learning and hands-on experience (Geriş & Özdener, 2024). In medical training, VR can simulate surgeries and patient interactions, allowing students to practice and refine their skills without the risks associated with real-life procedures (Riva, Wiederhold, & Mantovani, 2021; Sadek et al., 2023). In engineering, VR can be used to model and test designs, providing a dynamic platform for experimentation and innovation (Freina & Ott, 2015). The recreation of historical events in VR provides students with immersive experiences that significantly enhance their understanding and engagement with historical content, as noted by Savir et al. (2023). These applications not only make learning more engaging but also prepare students for real-world challenges by providing experiential learning opportunities. For students, VR enhances problem-solving skills, spatial awareness, and collaboration while increasing engagement through interactive, immersive experiences. For teachers, it offers innovative methods to visualize complex concepts and implement interactive learning strategies. Moreover, VR's ability to create immersive and interactive learning environments supports various pedagogical approaches, such as situated learning and constructivist learning, which emphasize active, context-rich educational experiences (Lie, Helle, Sletteland, Vikman, & Bonsaksen, 2023; Mikropoulos & Natsis, 2011).

Despite its transformative potential, integrating VR into educational settings presents significant challenges. As VR technology becomes more prevalent, serious concerns about its ethical implications and overall impact on human flourishing (eudaimonia) have emerged. Issues such as data privacy, user consent, accessibility, and the potential for addiction or negative psychological effects necessitate careful consideration (Carter & Egliston, 2020; Lee, Wong, & Fung, 2010). The ethical use of VR in education requires a comprehensive framework that addresses these concerns while maximizing the benefits of this technology (Shahriari & Shahriari, 2017; Tusher, Nazir, & Mallam, 2022). Recent studies, such as those by Mahling et al. (2023) and Savir et al. (2023), emphasize the dual nature of VR, where it can either enhance learning and empathy or lead to risks such as addiction and data exploitation if not properly managed.

The ethical considerations in VR use are multifaceted. Data privacy is a paramount concern, as VR systems often collect vast amounts of personal data, including biometric information, which must be protected from misuse and unauthorized access (Madary & Metzinger, 2016; Phan, Ali, Labou, & Foster, 2022). Ensuring data security in VR environments involves implementing robust encryption methods and strict access controls to prevent data breaches and misuse. Furthermore, transparency about data collection practices is essential to build trust among users and stakeholders, as noted by Szcyrek and Stewart (2022). User consent is another critical issue; students must

be fully informed about the data being collected and the purposes for which it is used, ensuring that their participation is voluntary and informed (Flammini & Marrone, 2023; Slater & Sanchez-Vives, 2016). This involves clear communication about the nature of the VR activities, the types of data being collected, and the specific educational benefits of these activities. Accessibility is also crucial, as VR technology should be inclusive, providing equal learning opportunities to all students, including those with disabilities, according to Bailenson (2018) and Walker (2022). This includes designing VR content and interfaces that accommodate various physical and cognitive abilities, ensuring that all students can fully participate in and benefit from VR-enhanced learning experiences.

Moreover, the potential for VR-induced addiction and negative psychological effects, such as cybersickness and disorientation, poses additional ethical challenges. Prolonged use of VR can lead to symptoms similar to motion sickness, negatively impacting students' health and learning experience (Oh & Son, 2022). Cybersickness can disrupt learning by causing discomfort and distraction, while long-term exposure to VR environments may lead to issues like addiction and social isolation, as highlighted by Kourtesis, Papadopoulou, and Roussos (2024). Thus, guidelines for safe and responsible VR use, including time limits and monitoring of students' health, are necessary to mitigate these risks (Venkatakrishnan et al., 2023). Educators and designers must be vigilant in monitoring the effects of VR use on students, adapting practices to minimize adverse outcomes while maximizing educational benefits, as Usmani, Sharath, and Mehendale (2022) and Geris, Cukurbasi, Kilinc, and Teke (2024) suggest.

There is a growing need for a framework that combines practical applications with ethical and eudaimonic principles to guide the effective and responsible integration of VR in education. Such a framework should ensure that VR is used in ways that are ethical, inclusive, and supportive of human well-being. It should provide guidelines for educators and designers to create VR experiences that are not only educationally effective but also ethically sound and conducive to human flourishing (Burns et al., 2022; Iio, Hasegawa, Iizuka, Hayakawa, & Tsujioka, 2021). The development of such a framework requires interdisciplinary collaboration, drawing on insights from education, psychology, ethics, and technology to address the complex challenges associated with VR integration Sanfilippo et al. (2022). This holistic approach ensures that VR-enhanced education not only meets academic goals but also supports the overall well-being and development of students, as Hua and Wang (2023) argue.

Despite the increasing adoption of Virtual Reality (VR) technologies in educational contexts, there remain critical gaps that hinder its effective and responsible integration. Existing literature predominantly addresses the technical and pedagogical aspects of VR implementation yet falls short in establishing comprehensive frameworks that encompass ethical considerations, data privacy, accessibility, and long-term educational impacts. These deficiencies pose significant barriers to the equitable, safe, and inclusive use of VR in learning environments. The EVRIM Framework is thus developed to fill these gaps by providing a structured, ethical, and inclusive guide for the integration of VR technologies in education. By addressing these limitations, the framework aims to ensure that VR is leveraged not only to enhance learning outcomes but also to uphold ethical standards and foster a more inclusive and responsible educational landscape.

This paper introduces the EVRIM Framework (Ethical Virtual Reality Integration Model), developed to guide the integration of VR technology in educational environments by emphasizing ethical considerations and the principles of eudaimonia. The principles of eudaimonia, which focus on fostering human flourishing and holistic well-being, are integrated throughout the EVRIM Framework to ensure that VR experiences contribute positively to students' academic, emotional, and social development. By embedding these values, the framework not only enhances learning outcomes but also promotes a learning environment where students can thrive both personally and intellectually (Carneiro et al., 2023; Tusher et al., 2022). The EVRIM Framework consists of five main stages: Discovery, Design, Development, Deployment, and Impact. Each stage incorporates ethical elements to ensure the responsible and effective use of VR in education. By following this framework, educators and designers can create VR experiences that are not only pedagogically effective but also ethically sound, ultimately benefiting students, educators, and society (Lie et al., 2023; Munafo, Diedrick, & Stoffregen, 2017). This framework is innovative and essential for navigating the complexities of VR integration, ensuring that the use of VR in education is both effective

and responsible, and promoting a holistic approach to learning and well-being (Gondomar & Mor, 2021; Kouame, Davis, & Smith, 2023; Singer, 2017).

By addressing these critical issues, such as data privacy, accessibility, inclusivity, and learner autonomy, through the EVRIM Framework, this study aims to provide a robust structure for integrating VR in education. For example, data privacy concerns Carneiro et al. (2023) are addressed by ensuring that user data is collected and managed transparently, while accessibility is emphasized to create inclusive environments for diverse learners (Tusher et al., 2022). Similarly, the framework incorporates strategies to promote learner autonomy and ethical use of VR technologies, which are critical for maintaining student engagement and ensuring equitable access to educational resources (Harfouche & Nakhle, 2020). These considerations are essential to ensure that VR implementations are not only technologically advanced but also ethically sound, creating a balanced and supportive learning environment that fosters holistic human flourishing.

METHODOLOGY

The development of the EVRIM Framework was carried out through a multi-phase research design, encompassing a combination of systematic literature review, theoretical modelling, expert consultations, and iterative validation. Each stage of this process was meticulously planned to ensure that the resulting framework is both comprehensive and practically applicable within educational contexts. The first phase involved a comprehensive literature review to identify existing frameworks and models related to Virtual Reality (VR) integration in educational settings. This review aimed to map out the strengths and limitations of current approaches, focusing on key elements such as ethical principles, pedagogical strategies, inclusivity, and accessibility. Databases such as Scopus, Web of Science, and Scopus were searched using keywords like "Virtual Reality in Education," "Ethical Integration of VR," and "Inclusive Pedagogical Models." Relevant studies were systematically reviewed to extract data on the ethical considerations and challenges of VR usage in education. This phase highlighted critical gaps, particularly the lack of a holistic framework that simultaneously addresses ethical use, data privacy, long-term educational impacts, and inclusivity.

Based on the findings from the literature review, the core structure of the EVRIM Framework was conceptualized. The development followed a theoretical approach, incorporating insights from education, technology, and ethics to establish a guiding structure. The initial framework was divided into five key stages—Discovery, Design, Development, Deployment, and Impact—each tailored to address the identified gaps in the literature. This stage involved defining the objectives, ethical principles, and specific strategies for each phase of the framework. To validate the relevance and applicability of the framework, a series of consultations were conducted with domain experts, including educators, VR technology developers, and ethicists. Semi-structured interviews were held to gather feedback on the preliminary framework and to identify any missing components or potential limitations. Expert insights were used to refine the framework, ensuring it was aligned with both pedagogical goals and ethical considerations. This step also included cross-referencing with similar models in the fields of digital ethics and instructional design.

The feedback from experts was systematically incorporated into the framework through an iterative process. Each iteration was followed by internal and external reviews to evaluate the framework's robustness and comprehensiveness. Several rounds of refinement were conducted, focusing on enhancing the usability, clarity, and inclusiveness of the framework. A small-scale pilot study was also conducted with educational practitioners to test the framework's applicability in real-world scenarios. The results from these evaluations informed further modifications, ensuring that the final version of the EVRIM Framework is both theoretically sound and practically viable. The final version of the EVRIM Framework was consolidated based on the iterative feedback and validation processes. Implementation guidelines were developed to support educators, policymakers, and VR designers in adopting the framework within diverse educational contexts. These guidelines include detailed recommendations

for each stage of the framework, highlighting key ethical considerations, practical steps, and potential challenges to be addressed during the integration of VR technologies in education.

Ethics Statement

This study did not involve human participants, animals, or any personal data, and therefore, no ethical approval was required.

THE EVRIM FRAMEWORK

The Ethical Virtual Reality Integration Model (EVRIM) Framework is designed to guide the ethical and effective integration of VR technology in education, providing a structured approach to ensure that all aspects of VR implementation—from planning to evaluation—are aligned with educational and ethical standards. The framework is divided into five stages (Discovery, Design, Development, Deployment, and Impact) to comprehensively address the key phases of VR integration. Each stage serves a specific purpose: Discovery focuses on identifying learning needs and ethical considerations; Design ensures that the VR experience is aligned with pedagogical and ethical objectives; Development involves creating and adapting content; Deployment oversees implementation in real educational settings; and Impact evaluates learning outcomes and long-term effects. This multi-stage structure ensures a systematic approach to VR integration, addressing both practical and ethical concerns at every phase. Also, each stage incorporates ethical considerations, pedagogical efficacy, and practical implementation strategies to ensure that VR technologies are utilized responsibly and effectively. The framework is visually represented in Figure 1, which illustrates the five stages and their interconnections, providing a clear overview of the structured approach of EVRIM.

The EVRIM Framework begins with the Discovery stage, which involves identifying the educational needs and objectives that VR can address. This stage is crucial for understanding the specific contexts in which VR will be implemented and the characteristics of the target audience, ensuring alignment with educational goals and ethical standards through comprehensive needs analysis and stakeholder engagement Radianti et al. (2020). Next, the Design stage focuses on creating VR content and environments that are pedagogically sound and ethically robust. This involves collaboration between educators, VR developers, and ethicists to design immersive experiences that enhance learning outcomes while ensuring data privacy, user consent, and inclusivity (Madary & Metzinger, 2016).

The Development stage encompasses the technical creation and rigorous testing of VR content and applications, including software development, 3D modeling, and the integration of educational content into VR environments. Developers conduct extensive testing to ensure functionality, usability, and safety, addressing ethical considerations such as safeguarding user data, preventing cyber sickness, and ensuring content is free from biases and stereotypes (Makransky, Terkildsen, & Mayer, 2019). The Deployment stage involves the practical implementation of VR technologies in educational settings, which includes training educators and students on effective VR tool use, providing technical support, and integrating VR experiences into the curriculum. Continuous monitoring and evaluation are essential to address any emerging issues, ensuring alignment with educational objectives and ethical standards (Freina & Ott, 2015).

Finally, the Impact stage focuses on assessing the outcomes of VR integration in education, evaluating the effectiveness of VR in enhancing learning outcomes, student engagement, and overall educational experiences. Ethical impact assessments ensure that VR use does not inadvertently harm students or exacerbate existing inequalities. Feedback from students and educators is crucial for continuous improvement, making the VR integration process dynamic and responsive to the educational community's needs (Cowie & Alizadeh, 2022; Slater & Sanchez-Vives, 2016). All these stages are explained in detail under specific subheadings, providing a comprehensive understanding of each phase and its ethical considerations. This structured approach ensures that the integration of VR in education is not only effective and responsible but also aligned with ethical standards and the principles of human flourishing.

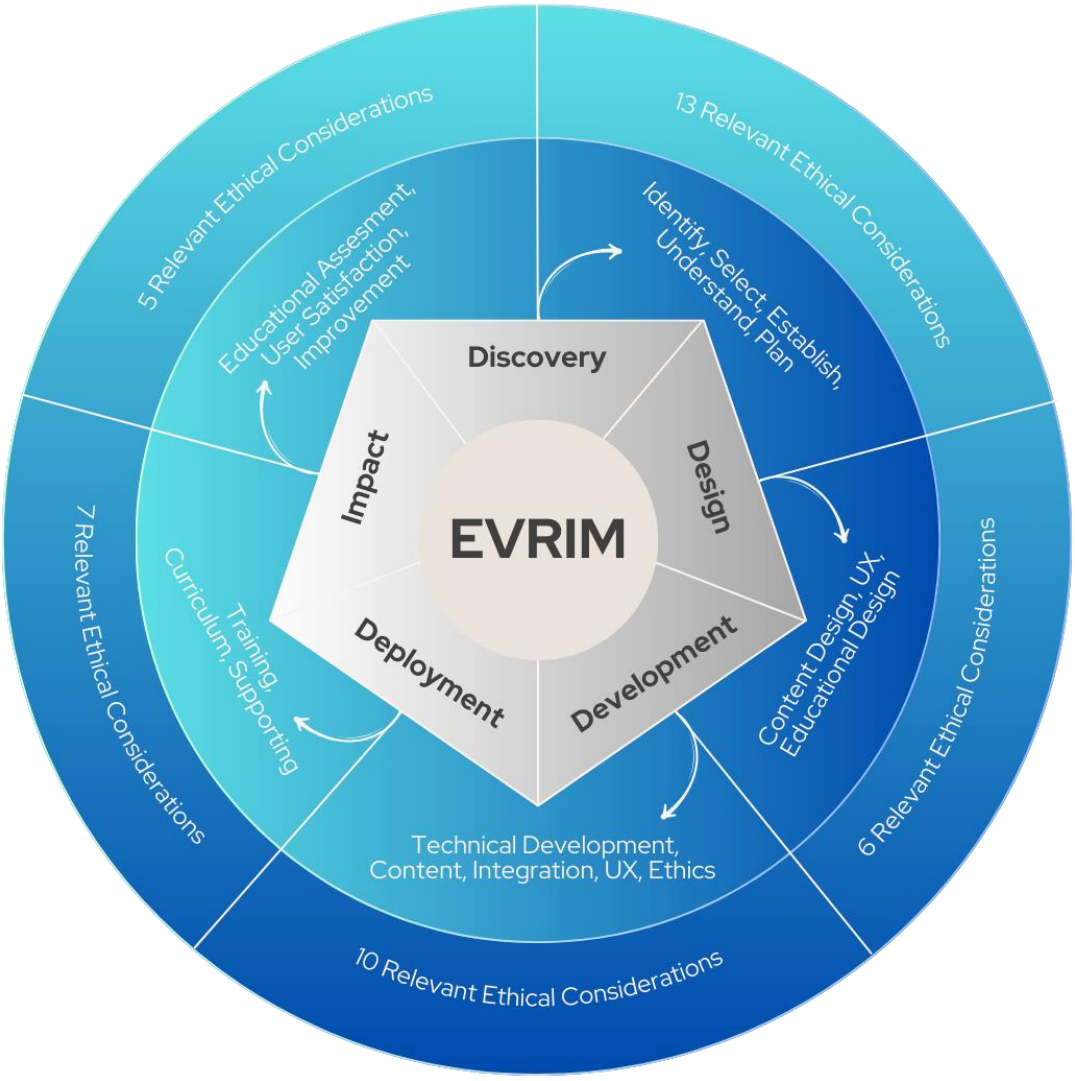

Figure 1. The EVRIM framework

The EVRIM Framework is designed to serve a broad spectrum of educational contexts, ranging from primary and secondary schools to higher education institutions. It primarily targets educators, instructional designers, and educational administrators who are seeking to integrate Virtual Reality (VR) in a manner that is not only pedagogically effective but also ethically sound and inclusive. A key component of the framework is its emphasis on accessibility and inclusivity, ensuring that VR experiences are adaptable for students with diverse needs, including those with disabilities. To this end, the framework incorporates guidelines for creating accessible content such as alternative interaction methods, adaptive hardware support, and compliance with established accessibility standards (e.g., WCAG 2.1). The EVRIM Framework aims to support the creation of VR-based educational experiences that are accessible and adaptable for all learners, thereby fostering an inclusive learning environment that takes into account diverse needs and promotes equitable opportunities for engagement.

Discovery Stage

The Discovery stage is foundational in the EVRIM Framework, establishing the groundwork for the successful integration of VR technology into educational environments. This stage involves several critical steps: identifying educational needs and objectives, selecting appropriate technologies, establishing ethical principles, understanding student demographics, and planning budgets and resources. Each step is crucial to ensure that VR implementation aligns with educational goals, is ethically sound, and is accessible to all students. The details of each step in the Discovery stage are summarized in Table 1.

Table 1. Summary of Discovery Stage Components and Ethical Considerations

Steps	Relevant Ethical Considerations
Identifying Educational Needs and Objectives	Fair and Inclusive Participation, Transparency and Accountability (Alizadeh & Cowie, 2022; Carter & Egliston, 2020; Susser, Roessler, & Nissenbaum, 2019)
Selecting Appropriate Technologies and Environments	Technology Neutrality, Accessibility (Bailenson, 2018; Heffernan & Rolfe, 2023; Zhao et al., 2018)
Establishing Ethical Principles	Data Privacy and Security, Informed Consent, Fair Use and Inclusivity (Bye, Hosfelt, Chase, Miesnieks, & Beck, 2019; Tusher et al., 2022)
Understanding Student Demographics and Experiences	Cultural Sensitivity, Educational Equity (Carter & Egliston, 2020; Cowie & Alizadeh, 2022)
Budget and Resource Planning	Fair Resource Allocation, Sustainability and Long-term Planning (Chellappa, Mésároš, Špak, Spišáková, & Kaleja, 2022; Freina & Ott, 2015; Harris, 2016)

Identifying Educational Needs and Objectives:

The Discovery stage begins with a comprehensive approach to identifying educational needs and objectives, emphasizing fairness and inclusivity. Collaboration with educators, students, and other stakeholders is essential to understand current educational challenges and opportunities. Utilizing surveys, interviews, and focus groups, it is crucial to gather diverse perspectives, particularly from underrepresented groups. Decisions must be transparent, with documented rationales shared with stakeholders to ensure an inclusive and equitable approach, as discussed by Susser et al. (2019), Carter and Egliston (2020) and Alizadeh and Cowie (2022).

Selecting Appropriate Technologies and Environments:

Choosing the right VR technologies and environments is critical for effective integration into education. This involves evaluating various VR devices and software to determine how they can meet educational goals. The selected technologies should be unbiased and not disadvantage any demographic groups. It is essential to analyze the impact of each technology on different user groups and ensure that VR experiences are accessible to all students, including those with disabilities. Features like audio descriptions, subtitles, and easy navigation should be incorporated to enhance accessibility. Providing specialized hardware and software solutions for students with physical impairments is also necessary to increase accessibility (Bailenson, 2018; Zhao et al., 2018).

Establishing Ethical Principles:

Establishing ethical principles is a critical step to ensure the safe and ethical use of VR experiences. Robust data privacy protocols must be implemented to protect user data from unauthorized access. This includes anonymizing user data, employing secure data storage methods, and ensuring that only authorized personnel have access to the data. Additionally, it is crucial to ensure that users give informed consent before participating in VR experiences. This involves providing detailed information about the purpose, benefits, and potential risks of the VR experience and preparing informed consent forms. Content must be designed to be inclusive, ensuring that no student group is excluded and that all students benefit equally from the VR experiences (Bye et al., 2019; Tusher et al., 2022).

Understanding Student Demographics and Experiences:

Designing effective VR content requires an understanding of students' demographic characteristics and learning preferences. This involves analyzing factors such as age, familiarity with technology, and learning preferences. For students who are less familiar with technology, a user-friendly and straightforward VR interface should be provided. VR content should cater to different learning styles, using interactive 3D models for visual learners and audio descriptions for auditory learners. Collaborating with cultural advisors to ensure that VR content is culturally sensitive and respectful is also important. Designing learning experiences that are inclusive of various

cultural and demographic backgrounds creates a more effective and engaging educational environment (Carter & Egliston, 2020; Cowie & Alizadeh, 2022).

Budget and Resource Planning:

Evaluating the costs and sustainability of VR technology is a crucial aspect of the Discovery stage. Budget planning should be transparent and clearly outline how resources will be allocated. It is essential to maintain a balance between cost-effective solutions such as Google Cardboard, and high-performance VR systems, like Oculus Rift. Additionally, resources required for developing and maintaining VR content—including educational materials, technical support, and maintenance services—should be carefully planned and allocated. Regular audits should be conducted to ensure the sustainability and long-term benefits of technology investments, avoiding unnecessary expenses and promoting efficient use of resources. This approach helps ensure that VR technology remains a sustainable and valuable tool in education, while effectively utilizing the available resources (Chellappa et al., 2022; Freina & Ott, 2015; Harris, 2016).

Design Stage

The Design stage in the EVRIM Framework involves detailed planning and creation of VR content that aligns with educational objectives. This stage is crucial as it ensures that VR experiences are pedagogically effective, accessible, and ethically sound. The key components of this stage include content design, user experience (UX) and accessibility, and educational design. The importance of each component and the relevant ethical considerations are summarized in Table 2.

Table 2. Summary of Design Stage Components and Ethical Considerations

Steps	**Relevant Ethical Considerations**
Content Design	Accuracy and Reliability, Cultural Sensitivity (Alizadeh & Cowie, 2022)
User Experience (UX) and Accessibility	Accessibility, Data Privacy and Security (Heffernan & Rolfe, 2023; O Connor, Abou-Zahra, Covarrubias Rodriguez, & Aruanno, 2020)
Educational Design	Equal Learning Opportunities, Alignment with Ethical and Moral Values (Cowie & Alizadeh, 2022; Shahriari & Shahriari, 2017)

Content Design:

The content design phase involves creating VR experiences that meet educational objectives and cater to various learning styles. Interactive and immersive content should be developed to help students achieve their learning goals. Visual learners benefit from 3D models and simulations, auditory learners from narrated explanations, and kinaesthetic learners from interactive tasks. Ensuring the accuracy and reliability of the content is essential, using scientifically grounded materials to prevent the dissemination of misinformation. Additionally, content must be culturally sensitive and inclusive, addressing the diverse backgrounds of students to create an equitable learning environment, as Alizadeh and Cowie (2022) emphasize.

User Experience (UX) and Accessibility:

For VR experiences to be effective, they must be user-friendly and accessible. The user interface (UI) should be intuitive, allowing students to navigate the VR environment effortlessly. Ergonomic and functional design principles must be applied to ensure users can interact comfortably and effectively with the VR content. Accessibility is a critical ethical consideration, requiring features that accommodate all users, including those with disabilities. This can include audio descriptions, subtitles, and haptic feedback. Protecting user data privacy and security is also paramount. Transparency about data usage and obtaining informed consent from users are essential components of this process, as noted by O Connor et al. (2020) and Heffernan and Rolfe (2023).

Educational Design:

Educational design focuses on aligning VR content with the curriculum and learning objectives. Collaboration with teachers and educational designers is vital to integrate VR experiences into lesson plans effectively. The content should be student-centered and interactive, promoting active participation and critical thinking skills. Ethical considerations include ensuring that all students have equal learning opportunities and that the educational content is inclusive and fair. The materials provided to students should adhere to ethical and moral standards, ensuring that the educational experience fosters ethical awareness and understanding (Cowie & Alizadeh, 2022; Shahriari & Shahriari, 2017).

Development Stage

The Development stage in the EVRIM Framework focuses on the technical creation and integration of VR content, ensuring that the developed VR experiences are effective, accessible, and ethically sound. The key components of this stage include technical development, content creation and educational design, software and hardware integration, user interface (UI) and experience (UX) design, and the application of ethical standards. Each component's importance and relevant ethical considerations are summarized in Table 3.

Table 3. Summary of Development Stage Components and Ethical Considerations

Steps	Relevant Ethical Considerations
Technical Development	Data Privacy and Security, Accessibility (Alizadeh & Cowie, 2022; Bakhrushina, Melnik, Gegechkori, & Ramenskaya, 2023)
Content Creation and Educational Design	Accuracy and Reliability, Cultural Sensitivity (Hua & Wang, 2023)
Software and Hardware Integration	Compatibility and Scalability (Cho, 2023)
User Interface and Experience (UX) Design	Accessibility, User Experience (Xu, Lu, & Liu, 2023)
Application of Ethical Standards	Data Privacy and User Consent, User Safety (van der Kruk et al., 2023)

Technical Development:

The technical development phase involves the creation and integration of VR content using selected software and hardware tools. This includes software development, 3D modeling, and system integration. Ethical considerations in this phase include adhering to data privacy protocols and ensuring the secure storage of user data. Additionally, it is essential to develop content that complies with accessibility standards, making it available to all users. Sustainability and long-term usability of technological solutions must also be considered to ensure that VR technology remains viable and effective over time, as emphasized by Alizadeh and Cowie (2022) and Bakhrushina et al. (2023).

Content Creation and Educational Design:

In this stage, interactive and immersive VR content is created to meet educational objectives. This process involves designing materials that cater to various learning styles and help students achieve their learning goals. Ensuring the accuracy and reliability of the content is crucial, using scientifically grounded and unbiased materials. Furthermore, it is important to create culturally sensitive and inclusive content that addresses the needs of students from diverse demographic and cultural backgrounds. Avoiding harmful or traumatic elements during content development is essential to maintain a safe and supportive learning environment, as Hua and Wang (2023) have noted.

Software and Hardware Integration:

Software and hardware integration is critical to ensure the seamless and effective operation of VR applications. This process involves selecting appropriate VR platforms and devices, ensuring that these devices support the designed content and work harmoniously together. Addressing technical challenges such as latency, frame rates, and compatibility with different VR hardware is essential. Scalability is also important, ensuring that VR applications

can be used by a large number of students simultaneously without performance issues. Efficient software and hardware integration provide a smooth and immersive VR experience, as discussed by Cho (2023).

User Interface and Experience (UX) Design:

A user-friendly interface design and optimized user experience (UX) are vital for the success of VR applications. The VR interface should be simple and intuitive, allowing both students and educators to navigate easily. UX design should focus on creating immersive and interactive experiences that keep students engaged and motivated. This can include adding interactive elements, feedback mechanisms, and gamified features. Incorporating accessibility features, such as adjustable text sizes, voice commands, and alternative input methods, ensures accommodation for different learner profiles, as suggested by Xu et al. (2023).

Application of Ethical Standards:

Applying ethical standards during development ensures the safe and ethical use of VR experiences. Strong data security measures must be implemented to protect user data and prevent unauthorized access. Transparency about data usage and obtaining informed consent from users are essential components of this process. Additionally, measures should be taken to protect users' psychological and physical health during VR experiences. Content should be designed and developed with user safety and well-being as a priority, ensuring that all students benefit equally from VR experiences, as emphasized by van der Kruk et al. (2023).

Deployment Stage

The Deployment stage in the EVRIM Framework involves the integration and distribution of VR content within educational settings. This stage ensures that educators and students are adequately trained and supported, that VR content is seamlessly integrated into the curriculum, and that continuous technical support and maintenance are provided. The key components of this stage include training and support, curriculum integration, and technical support and maintenance. The importance of each component and the relevant ethical considerations are summarized in Table 4.

Table 4. Summary of Deployment Stage Components and Ethical Considerations

Steps	Relevant Ethical Considerations
Training and Support	Accessibility, Accuracy and Reliability (Alizadeh & Cowie, 2022; Tusher et al., 2022)
Curriculum Integration	Equal Learning Opportunities, Student-Centered Approach (Heffernan & Rolfe, 2023; Radianti et al., 2020)
Technical Support and Maintenance	Equality, Privacy and Security (Chellappa et al., 2022; van der Kruk et al., 2023)

Training and Support:

The Deployment stage encompasses comprehensive training programs for educators and students on the effective use of VR technology. These training sessions should cover how to use VR content, guide students, and resolve potential technical issues. Training programs must be accessible, with special accommodations for educators and students with disabilities, and should include materials catering to different learning styles. Additionally, training materials must be accurate, reliable, and unbiased. Continuous technical support is crucial to address any issues encountered during the use of VR technology, ensuring that both educators and students have quick and effective solutions at hand, as emphasized by Tusher et al. (2022) and Alizadeh and Cowie (2022).

Curriculum Integration:

Integrating VR content into lesson plans is essential for achieving educational objectives. Collaboration with teachers and educational designers is vital to ensure that VR content aligns with the curriculum. The integration process should focus on structuring VR content to support educational goals and offer equal learning opportunities

for all students. Materials used in the integration should cater to various learning styles and needs, ensuring inclusivity. For example, interactive 3D models can be used for visual learners, narrated explanations for auditory learners, and interactive tasks for kinesthetic learners. This approach ensures that all students can benefit from the educational advantages of VR, as highlighted by Radianti et al. (2020) and (Heffernan & Rolfe, 2023).

Technical Support and Maintenance:

Continuous technical support and maintenance are critical for the effective use of VR technology in education. This involves regular checks and updates of VR hardware and software to ensure they function correctly. Technical support teams should provide quick and efficient solutions to any issues faced by educators and students. Ethical considerations include offering technical support and maintenance services equally to all user groups and maintaining the confidentiality of any technical problems encountered. Ensuring user safety and security during VR experiences is also paramount. Providing fair and equal technical support services helps all users benefit equally from VR technology, promoting justice and equality in educational settings, as noted by Chellappa et al. (2022) and van der Kruk et al. (2023).

Impact Stage

The Impact stage involves evaluating the effects of VR experiences on education. This stage is critical for assessing how VR content impacts student performance, learning outcomes, and overall satisfaction. The key components of this stage include educational assessment, user satisfaction, and continuous improvement. The importance of each component and the relevant ethical considerations are summarized in Table 5.

Table 5. Summary of Impact Stage Components and Ethical Considerations

Steps	Relevant Ethical Considerations
Educational Assessment	Transparency and Fairness, Privacy (Cao, 2023; Yu & Xu, 2022)
User Satisfaction	Objectivity, Privacy (Alizadeh & Cowie, 2022; Sadek et al., 2023)
Continuous Improvement	Transparency, User-Centered (Chen, Fu, Liu, & Wang, 2024; Walker, 2022)

Educational Assessment:

The Impact stage begins with evaluating the effect of VR experiences on student performance and learning outcomes. This process involves collecting and analyzing data using various measurement tools such as tests, surveys, and observations. The data collected helps to understand how students interact with VR content and its impact on their learning. Ethically, the assessment process must be transparent and fair, ensuring the confidentiality of collected data and clearly reporting the results. It is essential to avoid any discrimination or bias during student performance evaluations, ensuring that every student is assessed under equal conditions, as emphasized by Yu and Xu (2022) and Cao (2023).

User Satisfaction:

User satisfaction is crucial in determining the success of VR experiences. This involves measuring satisfaction through surveys and feedback sessions with students and teachers. Students and teachers provide insights into the benefits, challenges, and areas for improvement of VR experiences. Ethically, it is essential to collect and evaluate user feedback honestly and impartially, maintaining the confidentiality of responses. The feedback results should be utilized to improve VR content, identifying and addressing any areas of dissatisfaction to enhance the user experience and educational success. Feedback on how students and teachers experience VR content provides valuable information for future content and application improvements, as highlighted by Alizadeh and Cowie (2022) and Sadek et al. (2023).

Continuous Improvement:

Continuous improvement involves regularly updating and enhancing VR content and applications to maintain high educational quality. This process considers collected data and user feedback to make necessary

changes to VR content and applications. Ensuring that VR content is always of the highest quality and user-friendly is a priority. Ethically, the improvement process must be transparent and fair, making adjustments based on user needs and feedback and informing all stakeholders of changes. Continuous improvement should also involve implementing new measures and updates to enhance user safety and well-being. This ensures that VR technology is used effectively and ethically in education, Walker (2022) and Chen et al. (2024) discussed.

DISCUSSION

The implementation of the EVRIM Framework underscores several critical considerations for effectively integrating VR technology into educational settings. While there are various frameworks that guide the integration of Virtual Reality (VR) in educational settings, such as the Personalized Fully Immersive Framework (Marougkas, Troussas, Krouska, & Sgouropoulou, 2021), the ScienceVR Framework (Qorbani, Arya, Nowlan, & Abdinejad, 2021), and Studio Thinking Framework (Steele, Burleigh, Bailey, & Kroposki, 2020), the EVRIM Framework offers a distinct approach by systematically addressing ethical considerations alongside pedagogical effectiveness. For instance, the Personalized Fully Immersive Framework primarily focuses on optimizing user engagement through personalized and gamified VR experiences, yet it lacks a structured emphasis on ethical concerns like data privacy and user consent. The ScienceVR Framework, on the other hand, is tailored for STEM education and emphasizes simulation and performance assessment, but it does not address inclusivity or accessibility comprehensively. Similarly, the Studio Thinking Framework is designed to enhance creativity and cognitive skills in higher education but does not provide detailed guidance for inclusive practices or the broader ethical implications of VR use.

In contrast, the EVRIM Framework stands out by incorporating data privacy, inclusivity, cultural sensitivity, and long-term ethical considerations across all its stages, ensuring that VR technology is integrated in a way that is both pedagogically sound and ethically responsible. Furthermore, unlike the VR Curriculum Development Framework (Lawlor, Smith, Steele, Johnston, & Lamppa, 2021), which provides a structured approach for curriculum alignment, the EVRIM Framework addresses the ethical dimensions of VR deployment, ensuring transparency, user autonomy, and equitable access. As such, the EVRIM Framework provides a comprehensive structure that aligns educational objectives with ethical standards, thus promoting a balanced approach to VR integration in education.

One of the primary challenges in integrating VR is ensuring alignment with educational goals and ethical standards. Issues such as data privacy, user consent, accessibility, and the potential for addiction or negative psychological effects necessitate careful consideration, as noted by Carter and Egliston (2020). While existing frameworks often focus on pedagogical strategies or technical aspects, they lack a cohesive approach that addresses these ethical challenges comprehensively. The EVRIM Framework systematically bridges this gap by incorporating a multi-dimensional structure that integrates ethical principles at every stage of the VR implementation process. Through its focus on transparency, inclusivity, and long-term psychological well-being, the EVRIM Framework not only ensures effective learning outcomes but also upholds the broader ethical responsibilities of educational institutions.

The Discovery stage establishes the groundwork by identifying educational needs and objectives through comprehensive needs analysis and stakeholder engagement, ensuring that VR integration aligns with both educational goals and ethical standards (Radianti et al., 2020). Selecting appropriate technologies and environments is crucial for creating effective and inclusive VR experiences, considering accessibility and technological sustainability (Cho, 2023; Yu & Xu, 2022). This stage addresses the initial challenge of aligning VR technology with educational objectives and ethical considerations, ensuring that decisions are transparent and inclusive.

In the Design stage, creating pedagogically sound and ethically robust VR content is essential. This involves designing immersive experiences that cater to diverse learning styles and ensuring content is culturally sensitive and inclusive. The importance of user experience (UX) and accessibility cannot be overstated; intuitive interfaces and features accommodating all users, including those with disabilities, are necessary for effective VR integration (Heffernan & Rolfe, 2023; Madary & Metzinger, 2016). The design process must also consider data privacy and ensure

that user data is protected, highlighting the need for robust data security measures (Carter & Egliston, 2020). This stage effectively addresses the challenge of creating inclusive and secure VR content that meets diverse educational needs.

The Development stage focuses on the technical creation and rigorous testing of VR content and applications, ensuring that VR experiences are effective, accessible, and ethically sound. Ethical considerations include adhering to data privacy protocols, ensuring content accuracy and reliability, and providing continuous technical support and maintenance (Alizadeh & Cowie, 2022; Makransky et al., 2019). Developing user-friendly interfaces and optimizing the user experience (UX) is vital for the success of VR applications, emphasizing the need for interactive and immersive experiences that engage students (Cowie & Alizadeh, 2022). This stage tackles the technical and usability issues that can hinder the effective deployment of VR technology.

The Deployment stage involves the practical implementation of VR technologies in educational settings, including training educators and students, integrating VR content into the curriculum, and providing continuous technical support. Ensuring that training programs are accessible, and that technical support is available to all users is critical for the successful deployment of VR technology (Bailenson, 2018). This stage underscores the importance of equal learning opportunities and inclusive educational practices, aligning with ethical standards to promote justice and equity in educational settings (Radianti et al., 2020). This stage addresses the practical challenges of integrating VR into existing educational frameworks and ensuring continuous support.

Finally, the Impact stage evaluates the effects of VR experiences on education, including student performance, learning outcomes, and overall satisfaction. Collecting and analyzing data through various measurement tools helps understand how students interact with VR content and its impact on learning (Madary & Metzinger, 2016). Continuous improvement based on user feedback ensures that VR content remains effective and user-friendly, reinforcing the importance of a user-centered approach and ethical considerations in the iterative development process (Cowie & Alizadeh, 2022). This stage ensures that the effectiveness of VR integration is continuously monitored and improved.

By addressing these critical aspects, the EVRIM Framework ensures that VR technology is integrated into education in a manner that is not only effective but also ethically sound, inclusive, and supportive of diverse learning needs. This comprehensive approach provides a valuable tool for educators, designers, and policymakers aiming to leverage VR technology responsibly and effectively in educational contexts (Carter & Egliston, 2020; Cho, 2023; Radianti et al., 2020; Yu & Xu, 2022).

CONCLUSION

This study aimed to develop and present the EVRIM Framework (Ethical Virtual Reality Integration Model) to guide the ethical and effective integration of Virtual Reality (VR) technology in educational settings. The framework is organized into five distinct stages: Discovery, Design, Development, Deployment, and Impact. Each stage addresses key aspects of VR integration, such as identifying educational needs, designing and developing immersive content, implementing VR in the classroom, and evaluating its impact on student learning and performance. By addressing these phases comprehensively, the EVRIM Framework ensures that VR technology not only enhances learning experiences but also adheres to ethical standards while promoting inclusivity and accessibility.

The significance of the EVRIM Framework lies in its potential to revolutionize education by providing immersive and interactive learning environments. VR technology offers unique opportunities to bridge the gap between theoretical knowledge and practical application, making learning more engaging and effective. By addressing ethical considerations such as data privacy, inclusivity, and cultural sensitivity, the framework ensures that VR experiences are not only educationally valuable but also ethically sound. The structured approach of the EVRIM Framework equips educators, designers, and policymakers with the tools needed to leverage VR technology responsibly, ultimately contributing to the overall improvement of educational practices.

For future research, several avenues can be explored to further enhance the integration of VR technology in education. Longitudinal studies are needed to assess the long-term impact of VR on various educational outcomes, providing deeper insights into its effectiveness. Additionally, further development of accessibility features and assistive technologies is essential to ensure that all students, including those with disabilities, can fully benefit from VR experiences. To support the ethical integration of VR in education, the EVRIM Framework can serve as a foundational guide for developing comprehensive guidelines and standards, ensuring that data privacy, content quality, and user safety are prioritized in VR-based learning environments. To refine and expand the EVRIM Framework, future research can explore its application in various educational settings, including primary, secondary, and higher education, to understand its effectiveness across diverse contexts. For instance, the framework can guide teachers and instructional designers in creating VR-based activities for subjects like science and technology, where students can conduct virtual experiments in a simulated laboratory environment. By implementing the EVRIM Framework across different educational levels and subjects, researchers can better evaluate its potential to enhance student engagement, improve learning outcomes, and address ethical challenges specific to each context.

Despite the comprehensive nature of the EVRIM Framework, there are certain limitations that must be acknowledged. Firstly, the framework is primarily developed through theoretical modeling and a systematic literature review, lacking empirical validation through large-scale applications in diverse educational settings. This may limit its generalizability to varying educational contexts, especially across different educational levels and cultural environments. Additionally, the framework's development was informed by a limited set of expert opinions, which, though valuable, may not encompass the full spectrum of stakeholder perspectives. Lastly, given the rapid pace of technological advancements in VR, the proposed framework may need some periodic updates to remain relevant and effective in addressing emerging ethical and pedagogical challenges. Future studies should aim to empirically validate the EVRIM Framework and expand its applicability across broader educational scenarios.

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