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Smart and Immersive Education and Education for Sustainable Development: Possibilities for Integration based on the Sustainable Development Goals (SDGs)

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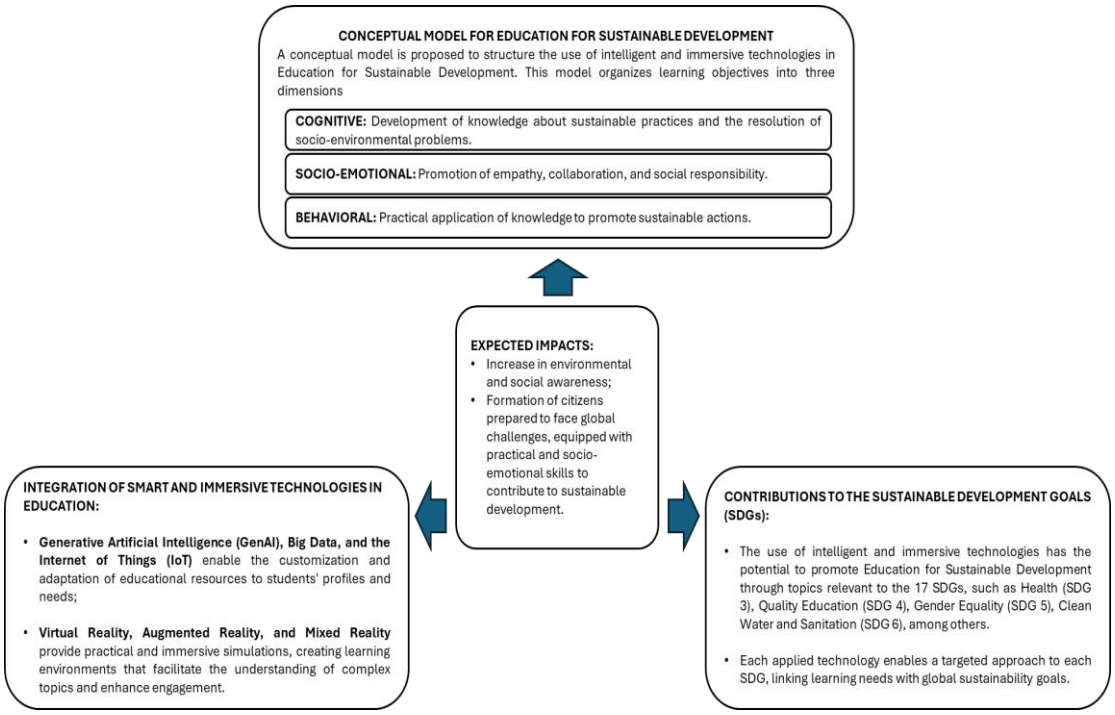
ABSTRACT

This article investigates the transformative potential of Smart and Immersive Education in promoting Education for Sustainable Development (ESD), connecting technological innovations to global sustainability demands. Through a conceptual model, it explores the contributions of emerging Technologies — such as Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) — for the transformation of education, making it adaptive, engaging, and aligned with the Sustainable Development Goals (SDGs). The argument is made that these technologies enhance learning and empower both managers and students to take on leading roles in addressing socio-environmental challenges. The study provides a basis for new empirical research and educational practices, suggesting pathways to turn environmental and social challenges into opportunities for innovation and positive impact.

KEYWORDS: Smart and Immersive Education. Education for Sustainability. Sustainable Development Goals

GRAPHIC SUMMARY



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1. INTRODUCTION

In recent decades, challenges such as climate change, environmental degradation, and the growing demand for natural resources have become central concerns due to the critical interdependence between climate, ecosystems, and human societies. Impacts on ecosystem health directly affect quality of life, exacerbating social and economic vulnerabilities and intensifying natural disasters, food insecurity, and water scarcity (ESCAP; ADB; UNDP, 2024; WMO, 2024).

The complexity of this scenario calls for a multidimensional approach that integrates environmental, social, and economic aspects. Addressing these challenges is intrinsically linked to the integration of public policies, investments in technological innovation, and the strengthening of educational structures that prepare future generations to act sustainably and resiliently (RECKIEN et al., 2017; UNESCO; MECCE, 2024).

Emerging technologies, such as generative artificial intelligence (GenAI), big data, and the Internet of Things (IoT), enable real-time data collection and processing of large datasets, improving monitoring, forecasting, and decision-making for mitigating climate change effects (HO et al., 2024; NAMMOUCHI; KASSLER; THEOCHARIS, 2024). These innovations are essential for enhancing the resilience of sectors impacted by climate challenges (ABBASS et al., 2022).

Education for Sustainable Development (ESD) is a fundamental pillar in addressing these global challenges, as it promotes awareness of environmental conservation and the reduction of social inequalities (UNESCO; MECCE, 2024). Information and communication technologies (ICTs) broaden access to and awareness of socio-environmental challenges, especially among Generation Z, who are often considered digital natives (PIKHART; KLÍMOVÁ, 2020). Additionally, these technologies help train professionals with new skills to develop innovative solutions focused on sustainable development (UNESCO; MECCE, 2024).

The use of technology in Education dates back to the early 20th century (MOORE, 2022), and recent advancements have transformed how teaching and learning are conceived and delivered (PREGOWSKA et al., 2021). In this context, Distance Education (DE) has played a crucial role in democratizing access to knowledge, overcoming physical and temporal barriers through the use of ICTs in the educational process (MOORE, 2022). Currently, DE is transitioning to a new technological generation, Smart and Immersive Education, characterized by the use of technologies such as Generative Artificial Intelligence (GenAI), Machine Learning, Big Data, Cloud Computing, IoT, Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) (FOGUEL, 2024).

Although the literature addresses the use of smart and immersive technologies in Education (ALARIO-HOYOS; KLOOS, 2019; POUPARD et al., 2024) and there exists a theoretical body on Education for Sustainability (LIM et al., 2022; VEIGA ÁVILA et al., 2018), the direct relationship between these two areas remains underexplored and underdeveloped in the literature. This article investigates the possibilities of using Smart and Immersive Education to promote Education for Sustainable Development. The central contribution of this article lies in advancing the integration between Smart and Immersive Education and Education for Sustainability, through a conceptual analysis model that structures usage possibilities based on the Sustainable Development Goals (SDGs).

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This article presents a theoretical framework on Smart and Immersive Education and Education for Sustainable Development. It describes the methodology adopted to investigate this relationship and discusses the practical implications, suggesting directions for future research and technological applications in educational contexts, aiming at sustainable development and the mitigation of climate and social impacts.

2. THEORETICAL FRAMEWORK

This section presents the theoretical concepts that guided the study.

2.1 Smart and Immersive Education

Distance Education (DE) has significantly evolved over the years, driven by Information and Communication Technologies (ICT). From correspondence-based education to online education, each new technology has transformed how teachers and students interact and learn (BETTS et al., 2021). The internet and personal computers were the technologies that enabled Online Education, fostering a significant expansion in access to professional and higher education by reducing geographical and temporal barriers. The emergence of Virtual Learning Environments (VLEs) brought dynamism and flexibility to interactions among educational actors. However, technology was still limited in terms of personalization, merely responding to user demands (AVIDOV-UNGAR; ZAMIR, 2024).

While the most intense development of smart and immersive technologies began in the 2010s, research on these topics dates back to the latter half of the 20th century. The term "Artificial Intelligence" was coined in 1956 during the Dartmouth Conference (MCCARTHY et al., 2006), and the first virtual reality devices emerged in the 1980s through Jaron Lanier's studies at VPL Research (LANIER, 2017). However, the most significant transformations have occurred recently, driven by advances in neural networks, increased computational power, advanced sensors, and graphical interfaces (PARTARAKIS, 2024). Improvements in chip capacity and connectivity enabled real-time processing of large volumes of data, essential for developing artificial intelligence and immersive technologies (GARISTO, 2024). Additionally, cloud computing and the decentralization of processing through edge computing further expanded access to these technologies (HOU; LU; DEY, 2017; SHI et al., 2016). Advances in artificial intelligence, especially generative adversarial networks (GOODFELLOW et al., 2014) and the transformer model (VASWANI et al., 2017), enabled the emergence of generative AI systems such as ChatGPT, Gemini, and others.

Smart technologies refer to systems that integrate generative artificial intelligence (GenAI), machine learning, big data, cloud computing, and the Internet of Things (IoT), creating autonomous and adaptive solutions that analyze and respond to data in real-time. These systems are designed to continuously learn, optimizing processes and enabling personalized decisions across a wide range of applications (AKHILESH, 2020; TOTLANI, 2023). In Education, these technologies create adaptive and personalized learning environments, adjusting to student behavior. Smart Education leverages cloud computing and machine learning to monitor and

analyze student performance, adapting content to their needs, thereby creating more effective and engaging learning experiences (ALARIO-HOYOS; KLOOS, 2019; PALANIVEL, 2020).

Smart Education is characterized by high levels of personalization, adjusting the pace and content to each student's profile, promoting continuity in learning across various environments and times, a phenomenon known as ubiquity (DEMIR, 2021; PALANIVEL, 2020). Learning is contextualized, applying content practically within the student's context, enriched by the integration of digital technologies that amplify the educational experience (GULNORA; FARIDA; SAYIDOLIM, 2022). Adaptive environments promote flexibility, while self-directed learning encourages students to take initiative in controlling their learning process (DEMIR, 2021).

Immersive technologies complement Smart Education by integrating the virtual and physical, fostering highly interactive and sensory learning experiences. With the use of virtual reality (VR), augmented reality (AR), and mixed reality (MR), these technologies transform the teaching process by creating interactive 3D environments that simulate both real and imaginary scenarios, offering deeper engagement and visually dynamic experiences (MOHSEN; ALANGARI, 2024). VR completely replaces the physical environment with a virtual one, allowing students immersive exploration, while AR overlays digital elements onto the real world, facilitating the visualization of complex concepts (HALABI, 2020; TORI, 2022). MR combines both worlds, enabling real-time interactions between physical and virtual objects (CHANG et al., 2022).

These technologies redefine the concept of distance, removing geographical and temporal barriers, and create more inclusive and collaborative learning environments, comparable to face-to-face experiences (TORI, 2022). In addition to facilitating the understanding of abstract concepts and practical learning through simulations of complex skill (ELDOKHNY, 2021), they offer personalization and inclusion by adapting content to individual learning styles. This enriches the educational process and allows access to scenarios that are physically inaccessible, such as historical or scientific locations (WU et al., 2021).

The integration of smart and immersive technologies significantly elevates the quality of the educational experience, providing unprecedented flexibility and personalization (DEMIR, 2021; SINGH; MIAH, 2020). This new technological paradigm establishes a dominant set of concepts, practices, and tools that guide the development and application of educational technologies. When emerging innovations reveal the limitations of the current paradigm, a shift occurs that requires a fundamental restructuring of dominant practices and concepts (CIMOLI; DOSI, 1995; DOSI, 1982). This new technological paradigm is redefining the interaction between technology and user, especially in education, replacing passive systems with interactive and adaptive ones that evolve in real-time (OUYANG; ZHENG; JIAO, 2022), positioning Smart and Immersive Education as the sixth generation of Distance Education (FOGUEL, 2024).

In addition to transforming learning by making it more dynamic and inclusive, the integration of these technologies plays a crucial role in raising awareness about global challenges. By increasing engagement and understanding, these tools prepare students to address complex issues in a constantly changing world. In this context, Smart and Immersive Education has the potential to drive Education for Sustainability, fostering citizens committed to solutions for a more sustainable and equitable future.

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Complementarily to technological innovations in education, Education for Sustainable Development plays a vital role in preparing individuals and institutions to face contemporary global challenges.

2.2 Education for Sustainable Development

Discussions on sustainable development began in the 1970s with the Limits to Growth report, which warned of the risks of unlimited economic growth in a context of finite natural resources (MEADOWS et al., 1972). In 1987, the Brundtland Report consolidated the concept, defining sustainable development as the one that balances the fulfillment of present needs with the preservation of resources for future generations (BRUNDTLAND, 1987). At the United Nations Conference on Environment and Development (RIO92), Agenda 21 was created as a guideline for sustainable policies, reinforcing global commitment (UNITED NATIONS, 1992).

In the 2000s, the Millennium Summit led to the development of the eight Millennium Development Goals (MDGs), aimed at eradicating extreme poverty by 2015. In January 2015, the 2030 Agenda was established, bringing forth 17 Sustainable Development Goals (SDGs), which encompass the economic, social, and environmental dimensions of sustainable development (UNITED NATIONS, 2015). Figure 1 presents the 17 SDGs organized according to the dimensions of sustainable development.

Figure 1 – SDGs organized by the dimensions of Sustainable Development

Source: Prepared by the author, based on United Nations (2015)

In this context, Education for Sustainable Development (ESD) emerges as a key element in promoting the knowledge and skills necessary to achieve the SDGs, especially SDG 4 – Quality Education (UNESCO, 2020). ESD is a holistic approach aimed at empowering students to make informed and responsible decisions, promoting environmental integrity, economic viability, and social justice for present and future generations (VEIDEMANE, 2022).

Education for Sustainable Development is grounded in principles that guide the building of a more just and sustainable society. The first of these is the Holistic Approach, which recognizes the interconnectedness of environmental, social, and economic aspects, promoting an integrated view of global challenges. Additionally, Equity and Diversity ensure social and economic justice by respecting the cultural and contextual differences of each community. ESD also prioritizes Action and Empowerment, enabling students to become agents of transformation, fostering individual and collective actions in favor of sustainability. The Long-Term Vision guides decisions by considering the impacts of present actions on future generations. Finally, Stakeholder Engagement reinforces active collaboration among governments, companies, NGOs, and communities in a joint effort toward sustainable development (IVASCU et al., 2017; O'FLAHERTY; LIDDY, 2018).

These principles create a solid foundation for ESD to develop citizens capable of addressing global challenges, equipped with technical knowledge, critical capacity, and engagement to drive meaningful change. Thus, ESD is not merely a form of education but a catalyst for a more aware, inclusive society committed to building a sustainable future (GROSSECK; TÎRU; BRAN, 2019).

Based on the concepts presented, this research adopts an exploratory-propositional approach to investigate how the integration between technology and sustainability can be structured into models applicable to the educational context.

3. METHODOLOGY

The methodology of this study adopts an exploratory-propositional approach, aiming to investigate the possibilities of using smart and immersive technologies in Education for Sustainable Development (ESD). Exploratory research is suitable for emerging and under-investigated topics (CRESWELL, 2014), going beyond merely describing existing practices and instead proposing their adoption within the teaching and learning process.

In this context, the study proposes a conceptual model to structure and analyze the applications of Smart and Immersive Education for the benefit of ESD, using the Sustainable Development Goals (SDGs) as a starting point (UNITED NATIONS, 2015). The model examines Smart Education through three technologies: Artificial Intelligence, Big Data, and the Internet of Things (AKHILESH, 2020). Simultaneously, it addresses Immersive Education by considering the technologies of virtual reality, augmented reality, and mixed reality (AL-ANSI et al., 2023; ALARIO-HOYOS; KLOOS, 2019).

Educational actions are organized based on the SDGs, and learning objectives are categorized into cognitive, socio-emotional, and behavioral dimensions, as suggested by UNESCO (2017). Additionally, the research discusses the expected impacts of these initiatives,

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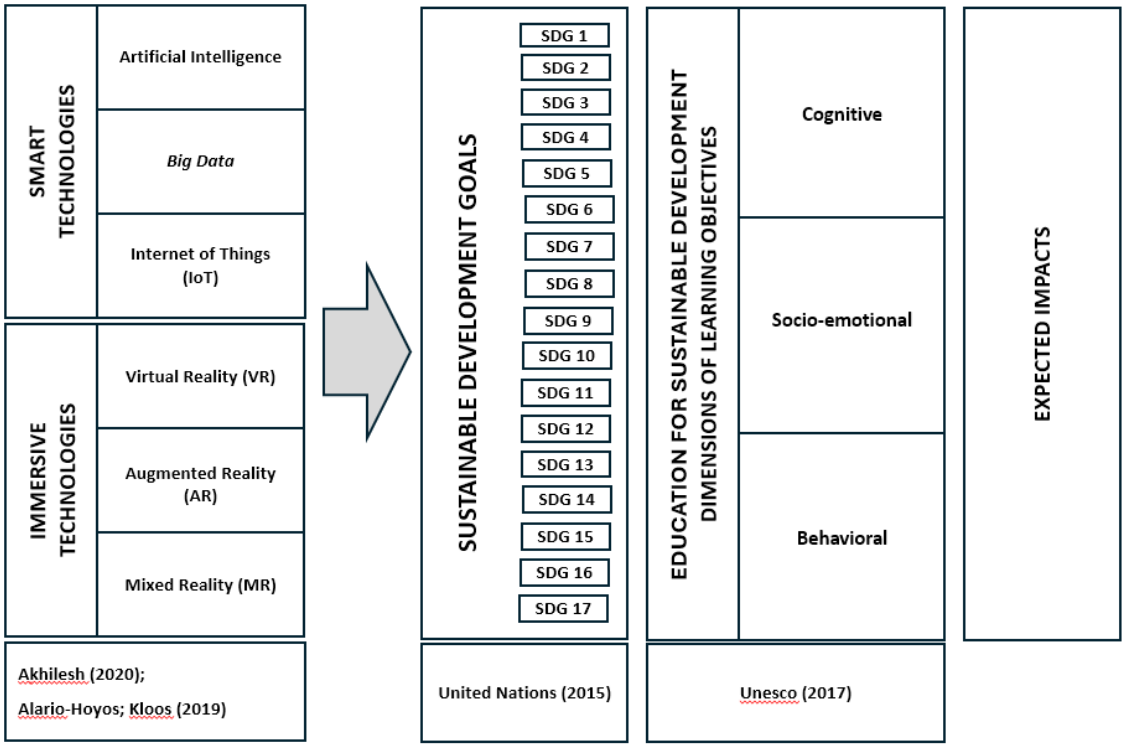
suggesting new pathways for practical application and highlighting opportunities for future empirical investigations. Figure 2 presents the conceptual model developed for the research.

Figure 2 - Conceptual Model for Analyzing the Integration Possibilities between Smart and Immersive Education and Education for Sustainable Development.



Source: Prepared by the author (2024).

4. RESULTS

Based on the proposed conceptual model, actions for Education for Sustainable Development were investigated and proposed, oriented toward each of the SDGs. These proposals are presented below, considering the sustainable development dimensions to which the SDGs relate, as shown in Figure.

4.1 SDGs Impacting the Social Dimension of Sustainable Development (SDG 2, SDG 3, and SDG 16)

The integration of technologies such as GenAI, Big Data, and the Internet of Things (IoT) in the context of **SDG 2 (Zero Hunger and Sustainable Agriculture)** enables the optimization of agricultural practices, adapting education to local climatic and environmental conditions. Vocational training projects can be personalized according to students' profiles and regional characteristics. Technical skills in sustainable agricultural Local Clusters can be disseminated to other clusters through Distance Education (FOGUEL; NORMANHA FILHO, 2007). Smart learning analytics tools allow for systematic monitoring of projects involving multiple clusters, personalizing the teaching and learning process for each one. Additionally, virtual reality (VR)

will enable students from different regions to follow the cultivation cycle of more distant and developed clusters, providing them the opportunity to experiment with different agricultural techniques in a safe environment, promoting both resource-use efficiency and environmental preservation.

In the context of **SDG 3 (Good Health and Well-being)**, smart technologies play a crucial role in monitoring public health indicators and providing Health Education programs. Through courses with preventive content for the public, teleconsultation with specialists via Digital Health, and training for healthcare professionals, smart technologies promote an integrated approach to improving the health and well-being of the population. Immersive technologies simulate health scenarios, including medical procedures and prevention campaigns, allowing students and professionals to practice in simulated environments without the risks associated with real-life situations. This facilitates practical learning in healthcare, enhancing the understanding and execution of procedures.

For **SDG 16 (Peace, Justice, and Strong Institutions)**, smart education enables the provision of personalized courses on human rights and social justice, adapting content according to the student's profile and the specific challenges of each locality. Virtual reality allows for the simulation of conflict scenarios to provide practice in mediation and conflict resolution. Students can be placed in extreme simulation scenarios to become aware of the long-term consequences caused by the weakening of human rights and social justice, making them conscious of the importance of a well-functioning, inclusive, and just democratic state.

Educational objectives involve, in the cognitive aspect, understanding sustainable practices, disease prevention, public health, and the fundamentals of social justice and democratic governance. In the socio-emotional aspect, the focus is on developing empathy, collective responsibility, and respect for human rights and the environment. In the behavioral aspect, the aim is to apply this knowledge in real contexts, promoting healthy habits, sustainable agricultural practices, and social justice within communities.

The expected impacts include the adoption of innovative and sustainable practices, increased awareness and adherence to preventive health practices, empowerment of farmers in the conscious use of natural resources, and greater civic engagement in promoting social justice and effective institutions.

4.2 SDGs Impacting the Social and Economic Dimensions of Sustainable Development (SDG 1, SDG 4, SDG 5, SDG 8, and SDG 10).

SDG 1 (No Poverty) establishes a set of targets for poverty eradication, with two approaches highlighted in the educational context: Entrepreneurship Education and Financial Education (UNESCO, 2017). Entrepreneurship Education fosters business creation, generating income and employment opportunities, especially when aligned with sustainable development, by incorporating SDGs into the educational process and encouraging socially and environmentally sustainable enterprises (REPAR; BOGUE, 2024). On the other hand, Financial Education enables individuals to make informed and responsible decisions about their resources, promoting conscious use, economic stability, and a more sustainable future (NAZ; FAROOQUI; BHATTI, 2023).

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Smart technologies, such as Generative Artificial Intelligence and Big Data, enable the personalization of financial education projects by tailoring content to the socioeconomic profile of students, using predictive analytics to support the creation of specific educational content and actions. In Entrepreneurship Education, adaptive learning platforms can adjust educational content and practices, developing entrepreneurial skills according to students' profiles and regional vocations. Immersive technologies, such as virtual reality, allow simulations of financial management in students' daily life situations, enabling them to experience real economic scenarios and face challenges similar to those they will encounter in real life.

Smart and immersive technologies are transforming Education. Within the scope of **SDG 4 (Quality Education)**, smart technologies personalize the educational process, adapting content to each student's profile. Moreover, they monitor students' progress in real time, identify learning difficulties, and provide individualized feedback in real time, promoting inclusive and personalized education. In Immersive Education, the use of virtual, augmented, or mixed reality allows students to explore interactive environments, such as laboratory simulations, historical contexts, or even virtual explorations of geographical locations. These immersive experiences increase student engagement and facilitate the understanding of complex content.

For **SDG 5 (Gender Equality)**, smart technologies enable the customization of educational content to encourage female participation in underrepresented areas, such as science and technology. In the field of Immersive Education, virtual reality (VR) can simulate scenarios addressing gender discrimination and violence, offering an immersive experience that deepens understanding of the importance of equality. VR can also help women develop leadership skills by simulating challenging situations in traditionally male-dominated environments.

Regarding **SDG 8 (Decent Work and Economic Growth)**, the integration of smart and immersive technologies into educational projects offers significant potential for impact. Smart technologies enable the creation of personalized learning pathways for skill development, career training, and financial literacy. These virtual platforms can adapt content based on each student's individual profile and the characteristics of each locality, providing access to specialized training that meets local needs and vocations. Immersive technologies allow simulations of real work environments, enabling students to develop practical skills in a controlled and safe setting. These simulations are especially useful for vocational training, allowing learners to develop competencies in fields such as healthcare, construction, and technology, which are essential for economic growth.

In **SDG 10 (Reduced Inequalities)**, smart education allows the customization of teaching to meet students' different socioeconomic and cultural needs, promoting inclusion and accessibility. Smart technologies adapt content to facilitate learning for vulnerable groups, adjusting pedagogical approaches to their specific barriers. Virtual reality can be used to simulate scenarios that demonstrate the impacts of social inequalities, fostering a practical understanding of social and economic barriers.

The synthesized educational objectives encompass, in the cognitive aspect, the development of competencies in responsible resource management, sustainable entrepreneurship, digital technology, vocational skills, gender equality, and an understanding of the causes of social inequalities. In the socio-emotional aspect, they aim to promote empathy,

social responsibility, collaboration, and respect for diversity. In the behavioral aspect, they encourage the application of skills in income generation, responsible technology use, inclusive and equitable practices, as well as entrepreneurial and collaborative attitudes in work environments and communities.

The expected impacts include greater awareness of sustainable practices, reduced financial vulnerability, strengthened entrepreneurial skills, increased inclusion and educational equity, promotion of gender equality, increased employability and reduced unemployment, as well as strengthened community capacity to address social and economic inequalities, promoting sustainable and inclusive economic development.

4.3 SDGs Impacting the Social and Environmental Dimensions of Sustainable Development (SDG 6 and SDG 11).

For **SDG 6 (Clean Water and Sanitation)**, smart and immersive technologies can be used to promote education and awareness about water sustainability and the importance of sanitation. Projects involving the use of big data and the Internet of Things (IoT) can monitor water usage and quality in real time, providing customized data for scientific research and educational materials, tailored to the characteristics of different communities. GenAI can be used to predict demand and recommend more efficient water usage practices. In Immersive Education, virtual reality (VR) can simulate water crisis scenarios, such as scarcity and pollution, deepening understanding of the impact of irresponsible consumption and conservation techniques.

Regarding **SDG 11 (Sustainable Cities and Communities)**, smart and immersive technologies can facilitate learning about urban sustainability for both the general population and city managers. The combination of GenAI and VR allows students to explore city data and experience urban realities immersively, proposing solutions whose impacts can be analyzed and presented in simulated scenarios. Immersive scenarios can also be used to enable public managers to learn from the experiences of more advanced sustainable cities, which they would not traditionally have access to, enhancing skills related to ecological urban planning, sustainable transportation, and green spaces.

The synthesized educational objectives include, in the cognitive aspect, the development of knowledge about sustainable water management and sustainable urban planning; in the socio-emotional aspect, fostering empathy for vulnerable communities and raising awareness about the importance of sustainable actions; and in the behavioral aspect, promoting responsible water use, sanitation practices, and the implementation of sustainability and urbanization projects.

The expected impacts include increased public awareness, adoption of conservation practices, improvements in sanitation education, and greater engagement in sustainable urbanization projects and actions aimed at developing more resilient and inclusive cities.

4.4 SDGs Impacting the Environmental Dimension of Sustainable Development (SDG 13, SDG 14, and SDG 15)

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In **SDG 13 (Climate Action)**, smart technologies can be used in educational platforms that personalize learning about climate change mitigation and adaptation, tailoring content to students' knowledge levels. Virtual reality (VR) can complement this process by simulating the impacts of climate change and possible solutions, such as reforestation and the use of renewable energy, providing a deeper understanding of environmental challenges.

For **SDG 14 (Life Below Water)**, smart technologies can customize teaching on topics such as sustainable fishing, pollution, and marine species preservation. VR allows students to explore underwater ecosystems and experience the impacts of pollution, offering a hands-on experience that highlights the importance of marine conservation and plastic waste reduction.

Similarly, **SDG 15 (Life on Land)** can have educational content tailored by smart technologies, covering topics such as deforestation, forest preservation, and endangered species, contextualized to the characteristics of each region. Virtual reality (VR) and augmented reality (AR) enable the creation of immersive experiences, allowing students to explore virtual forests and understand the effects of deforestation and soil degradation, facilitating learning about the importance of terrestrial ecosystem preservation.

The learning objectives for these SDGs aim, in the cognitive aspect, to foster understanding of the impacts of human activities and the threats to climate, marine, and terrestrial ecosystems, as well as to analyze solutions for mitigation and environmental preservation. In the socio-emotional aspect, the focus is on developing empathy and awareness of the urgency of sustainable actions for both vulnerable communities and biodiversity. Behavioral objectives emphasize the adoption of sustainable practices and the regular practice of environmental conservation actions.

The expected impacts include increased environmental awareness, with students attentive to the effects of human activities on ecosystems and equipped to adopt sustainable practices in their daily lives. It is anticipated that empathy and commitment to preservation will be developed, along with skills to analyze and implement mitigation solutions. In this way, the goal is to train professionals capable of making informed decisions about sustainability, promoting the conscious use of resources, waste reduction, and environmental conservation.

4.5 SDG Impacting the Economic Dimension of Sustainable Development (SDG 9)

For **SDG 9 (Industry, Innovation, and Infrastructure)**, smart and immersive technologies can customize training and educational programs focused on innovation and sustainable infrastructure, tailoring content to local needs. Additionally, they can identify efficiency patterns and promote better industrial practices. Immersive technologies provide simulations that allow students to interact with virtual infrastructures, understanding sustainable construction and innovation practices without physical risks, while visualizing environmental and economic impacts.

The learning objectives include, in the cognitive aspect, the development of knowledge about sustainable innovation; in the socio-emotional aspect, the promotion of social and environmental responsibility; and in the behavioral aspect, the application of sustainable practices in real contexts. The expected impacts are professional qualification in sustainable

innovation, greater adoption of green industrial practices, and increased awareness of responsible innovation.

4.6 SDGs Impacting the Economic and Environmental Dimensions of Sustainable Development (SDG 7 and SDG 12).

For **SDG 7 (Affordable and Clean Energy)**, teaching about energy efficiency and renewable energies can be personalized by monitoring real-time energy consumption and using this information to create sustainable content and recommendations tailored to each profile. Additionally, immersive technologies can simulate the development and operation of solar and wind power plants, providing students with practical experience without risks or costs.

For **SDG 12 (Responsible Consumption and Production)**, content on sustainable consumption can be adapted based on students' profiles and daily choices, raising awareness about areas such as food and energy. Immersive technologies can create simulations of production chains, allowing students to explore the life cycle of products, from extraction to disposal.

The learning objectives include, in the cognitive aspect, understanding the environmental impact of energy and consumption practices; in the socio-emotional aspect, developing empathy and responsibility for resource use; and in the behavioral aspect, encouraging the adoption of sustainable practices. The expected impacts are greater awareness of sustainable consumption and clean energy use, as well as behavioral changes leading to waste reduction and the adoption of sustainable solutions.

4.7 SDG 17 – Partnerships for the Goals

For **SDG 17 (Partnerships for the Goals)**, smart technologies can personalize education on international cooperation and partnership building, covering topics such as sustainable development and public-private partnerships, while immersive technologies can simulate global negotiations and conferences, allowing students to experience international partnerships.

The learning objectives include, in the cognitive aspect, understanding global collaboration; in the socio-emotional aspect, developing cooperation skills and cultural empathy; and in the behavioral aspect, encouraging the promotion of local and global partnerships. The expected impacts are students equipped to lead collaborative initiatives and facilitate effective partnerships in their projects.

5. FINAL CONSIDERATIONS

This study explored the possibilities of integrating Smart and Immersive Education with Education for Sustainability, using the Sustainable Development Goals (SDGs) as a foundation. The main contribution was the proposal of a conceptual model that structures these technologies as effective tools for promoting sustainability learning, providing an adaptive and engaging educational approach. Smart and immersive technologies have shown promise in personalizing educational content, monitoring real-time data, and simulating practical scenarios,

enabling greater immersion and understanding of global challenges related to sustainable development.

However, the lack of adequate technological infrastructure in some regions and the still high cost of these technologies may limit their large-scale implementation. Additionally, it is necessary to assess the empirical impact of these tools on the development of socio-emotional and behavioral skills, as well as in different educational contexts.

It is suggested that future studies empirically investigate the effects of applying these technologies in various scenarios and regions, in addition to exploring ways to make these solutions more accessible. Another promising area for future research involves using these technologies to train managers and public agents, enabling them to adopt sustainable practices more effectively in local policies and actions.

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