OmniaScience

Journal of Technology and Science Education
JOTSE, 2024 – 14(1): 244-269 – Online ISSN: 2013-6374 – Print ISSN: 2014-5349
https://doi.org/10.3926/jotse.2512

HORIZONS ARCHITECTURE WITH VIRTUAL REALITY FOR COMPLEXITY ENVIRONMENTS: MIXED METHODS

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Received October 2023
Accepted December 2023

Abstract

In the field of complexity, new methodologies emerge, such as horizon architecture, which help to focus solutions that can be integrated to foster innovation in university education. Technologies are also opening up opportunities for training, such as virtual and augmented reality. This article aims to answer the question: What innovations do postgraduate students perceive in environments using horizons architecture to integrate virtual reality? In this project's training experience for students, the horizons architecture strategy was implemented with virtual reality resources and emerging technologies. The present research was conducted with a mixed methodology, using a concurrent triangulation design. The participants were chosen from a sample for non-probability convenience. Three instruments were administered to 99 graduate students in Humanities and Education: i) a semi-structured questionnaire with demographic data and interests in contributing to the Sustainable Development Goals (SDGs), ii) a semi-structured questionnaire on students' perceptions of learning and innovative projects, and iii) a validated Likert-scale questionnaire on elements and types of educational innovation. Virtual and augmented reality supported the distance education modalities and project presentations. The results show that: (a) open and systemic innovation, (b) creation of new products and services, (c) the potential of horizons architecture strategy, (d) motivation boosted by virtual and augmented reality, and (e) critical aspects of integrating virtual and augmented reality (technical and academic). It is concluded that horizons architecture with virtual reality in university education encourages complex reasoning and invites the search for new solutions. The challenge is to train citizens with critical, scientific, systemic, innovative and entrepreneurial thinking, who are also empathetic, cooperative and committed to sustainable development. This study may be valuable to teachers, entrepreneurs, and decision-makers interested in innovative educational environments and technologies, especially those in graduate education.

Keywords – Educational innovation, Virtual reality, Postgraduate, Higher education, Learning environments, Complexity.

To cite this article:

Ramirez-Montoya, M.S., Martinez-Perez, S., & Zepeda-Orantes, L.P. (2024). Horizons architecture with virtual reality for complexity environments: Mixed methods. *Journal of Technology and Science Education,* 14(1), 244-269. https://doi.org/10.3926/jotse.2512

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1. Introduction

In a versatile and complex society, with rapid transformations in all areas, innovation and technologies are seen as driving forces for change. In complex environments, high skills training is required to cope with uncertainty and constant changes in society (Morín, 2001, 2020). In the context of education, these changes are gradually taking place in order to keep pace with current needs. Focusing on higher education, both innovation and technologies play an important role in promoting new ways of teaching and other learning processes in which students interact, generate creative ideas and acquire competences adapted to the socio-labor demands of the moment. The university assumes its role as an educator, where teachers reflect on how, for whom and for what they are teaching. In this sense, educational innovation covers a spectrum of possibilities, from macro-areas (curricula, plans, programs) to specifics (learning processes, motivation, technologies). The integration of a new element and emerging methodologies by themselves do not have a direct impact on educational innovation (Biasi, Deming, Moser & Dillon, 2022). Educational research is required to know the results of these implementations. For example, virtual and augmented reality (VR/AR) companies provide fundamentally new forms of communication, treatment, education, and specialist training within the medical industry. However, they still pay little attention to academic research (Kulkov, Berggren, Hellström & Wikström, 2021). The same is true for training programs integrating VR/AR and new methodologies such as "horizon architecture" that incentivize innovative, far-reaching projects based on relevant empirical evidence.

Creating alternative solutions using VR/AR is possible and intriguing in entrepreneurial learning environments, because these technologies open new doors to visualization and interactive techniques. Educational innovation embraces integrating such technologies with a view to process improvements technology-mediated (Guillén-Yparrea, Hernández-Rodríguez & Ramírez-Montoya, 2023; Pacheco-Velazquez, Salinas-Navarro & Ramírez-Montoya, 2023; Riofrío-Calderón & Ramírez-Montoya, 2023). Suppose AR and VR, representing new possibilities in a learning environment, are integrated for process improvements (Rocha-Estrada, Ruiz Ramirez, George-Reyes & Glasserman-Morales, 2022). Can it be stated that there is a direct relation between these and educational innovation? The opportunity to generate empirical evidence is what motivated this article and research. The starting point was the question: What innovations do postgraduate students perceive in environments using horizons architecture to integrate virtual reality? We sought the theoretical foundations of educational innovation, augmented reality, virtual reality, and horizon architecture to support the study. While there has been an increase in the production of studies related to VR/AR since 2015 the studies have been conducted mainly with Asian, European or American students (Rojas-Sánchez, Palos-Sánchez & Folgado-Fernández, 2023). Studies from Latin American institutions and students are considerably few, this is a gap that this study can help to reduce, by providing a Latin American perspective to the existing literature. It is also notable that many studies on VR/AR focus in STEM and medical fields (Hamilton, McKechnie, Edgerton & Wilson, 2021; Radianti, Majchrzak, Fromm & Wohlgenannt, 2020).

The present study expands the knowledge about the use of digital technologies for learning in the social sciences with an emphasis on innovation and entrepreneurial education. From this logic, the application of Horizons Architecture, in the field of humanities and education, encourages, on the one hand, multidisciplinary collaboration and the generation of impact in different disciplines, and the design of projects which glimpse the complexities of diverse realities; and, on the other hand, seeks the achievement of the Sustainable Development Goals (SDGs) of the 2030 Agenda. The implementation of the Horizon Architecture model can have an impact on increasing the scope of educational innovation. Finally, unlike most studies that have analyzed the impact of digital technologies in Higher Education focusing on undergraduate students (Altınpulluk, Demirbağ, Ertan, Yıldırım, Koçak, Yıldız et al., 2021), this study explores the perceptions and experiences of postgraduate students, which allows identifying the specific expectations of this group and provides valuable insights to improve the learning experience at this educational level.

The following sections of this paper present the method and results, the findings, the conclusions that answer the guiding question, the study limitations, and recommendations for future work.

1.1. Educational Innovation Applied to University Education

Educational innovation and improvement are terms that are intercepted in the action of change. In education policy, innovation is often a weak point, as most countries have programmes oriented towards professional development rather than systemic improvement (Vincent-Lancrin, 2023). To this end, innovation has four fundamental aspects: an innovation-friendly culture (empowering staff for new ideas and new approaches in their work), knowledge and skills (knowledge as a crucial element for innovation and decision-making), innovation management (working in teams, taking risks, managing obstacles), and resources and drivers of innovation (OECD, 2017; Andersen & Jakobsen, 2018; Torfing, 2019). In this sense, educational innovation aims to generate a product, service, or solution that introduces novelty to existing production and modifies its being and operation to improve it (Valencia & Valenzuela-González, 2017). Various educational innovation types (continuous, formative, disruptive and open) facilitate new products, services, processes, and knowledge (Ramírez-Montoya & Lugo-Ocando, 2020). It is necessary to value innovation as a process that leads to incremental or radical transformation to overcome, complement, or improve an object, process, or phenomenon; these may be social, cultural, technical, productive, economic or environmental (Aguiar, Velázquez & Aguiar, 2019). Thus, educational innovation entails changes in spaces, times and forms (Rubua-Avi, 2022), and involves creatively drawing on new theories, concepts, practices and cutting-edge educational technologies of the digital era. For example, Marzal & Cruz-Palacios (2018) analyzed the competency-based educational model of 21st century higher education. They looked at competencies acquired in the multi-literacy environment, providing a modular and progressive instructional design of a teaching methodology for greater educational effectiveness. In this example, we see how changes are integrated through new processes to improve the educational environment.

In recent studies, the types of changes in learning environments have been researched. Martínez de Miguel, Salmerón and Moreno (2020) analyzed the profile of didactic innovations incorporated in a university, determining that changes in methodologies, resources, and teaching-assessment instruments were taking place, mainly in the technological resources used by the teaching staff. These significant changes contributed to autonomous, participative, and dialogical student learning. They coincide with the methodological innovations found by Larrondo, Canavilhas, Fernandes-Teixeira, Martins, Meso, Pérez-Dasilva et al. (2020) in university cyberjournalism subjects that employ strategies such as virtual cooperative work, project-based learning (PBL), and "internationalization at home". Internationalism is a crucial factor that has been studied by Bykova, Ermolaeva and Scraybin (2018), saying there must be a systemic approach by the state and universities to solve the problems that prevent the internationalization of education. An innovative educational framework can be applied, particularly in educational innovation classes, contributing to higher education internationalization. Technological frameworks are also essential to support innovation. Ferrero and Gewerc (2019) Kholikova (2021) and Temirov (2022) point out that the development of innovative thinking skills, the use of interactive methods and the incorporation of new technologies requires specific rules of use, independent of traditional learning practices and, moreover, emphasize how such technologies and the development of innovative activities contribute to the improvement of the educational system.

Another perspective is from the space where educational processes are developed. Curricular transformation, strategic policies, the dynamization of learning environments and the improvement of digital competence and learning autonomy are necessary in innovative environments. In their study, Chuquimarca, Rodriguez and Bedón (2018) determined a significant increase in the competencies analyzed, reflecting the students' interest in new educational scenarios. Soto-Guerrero, Quezada-Sarmiento, Condolo-Herrera, Mengual-Andrés, Moreno-León and Rey-Mendoza (2018) proposed a new model that allows better tutorial interactions between the student and the teacher, supported by technologies, through a mobile application that promotes tutoring. This app better organizes the time that the participants have for learning and records the students' questions. In the same vein, Díaz and Suárez (2019) encourages higher education institutions to analyze virtual courses by competencies, relevance, and educational and technological innovation. They invite universities to enter new technological scenarios that will enrich and strengthen educational processes and achieve educational relevance by offering programs that meet the labor market's needs and demands. Likewise, Cifuentes and Velásquez (2019) provide a scale that measures dimensions necessary to understand these institutional conditions: technological leadership, management of innovation with technologies, and appropriation of technology policies at the institutional and individual levels. Technologies and spaces are seen as strategic points for educational innovation. Also Griffin and Venaruzzo (2019) point out the importance of strategic policies for transforming curricula. The study points out that changing the curriculum promotes whole-of-institution curriculum innovation.

1.2. Virtual and Augmented Reality In Education

The emerging changes in society have led to a redesign of the role of university education: what, how, for whom and what is being taught are blurred. The incorporation of methodologies and technologies in the classroom seems to shed light on the teaching-learning processes. The new ways of doing and the use of new resources and digital tools are considered as strategies to meet the diversity in the classroom, and as educational answers for a quality and inclusive education. They also have great potential to transform the way we relate, interact and communicate with others. Thus, several university degrees have begun to redesign their curricula in order to respond to the current demands of the labor market (Verma, Purohit, Thornton & Lamsal, 2023). Augmented reality (AR) and virtual reality (VR) are two of the technological trends in the educational context. AR is considered a technology that allows digital information (text, image, audio, video, 3D) to be added to reality through mobile devices, encouraging interaction. It can therefore be defined as a technology that blends the real world and the virtual world (Umborg & Uukkivi, 2020; Bozan, Akcay & Karahan, 2021; Fernández-Robles & Martínez-Pérez, 2023) by superimposing digital elements over the real-world environment, thus allowing the users to understand reality in a better way (Hamzah, Ambiyar, Rizal, Simatupang, Irfan & Refdinal, 2021). AR offers a wide range of possibilities in teaching and learning processes. It offers teachers the opportunity to enrich content, and students the opportunity to produce resources and technologies. VR, on the other hand, consists of three-dimensional virtual environments where users immerse themselves by typically using Head Mounted Displays (HMD) devices to navigate through these environments (Albus, Vogt & Seufert, 2021; Bower, DeWitt & Lai, 2022). The use of the HMD represents an accessibility and portability difference between VR and AR because in the case of AR, the devices commonly used are mobile devices and tablets. Beyond the technical devices, VR and AR differ from each other in terms of degree of immersion, interaction and integration with the physical world, realism, and visualization (Shaukat, 2023). A fundamental difference is the degree to which people interact with the real world or with a simulated world, AR allows the visualization of 3D elements directly on the real world so the real world never ceases to be visible to the user, on the contrary, with VR the user only visualizes a simulated virtual environment, even when this environment pretends to simulate the real world it is an artificially generated scenario. The use of head mount displays and the complete loss of sight of the real world to immerse oneself in a virtual environment produces a higher degree of immersion in VR when compared to AR, resulting in different sensory experiences (Kim, Kim, Park & Yoo, 2023). Therefore, although both technologies converge in providing an enriched experience through 3D elements, they present differentiating characteristics between them.

The use of Augmented Reality (AR) / Virtual Reality (VR) in teaching and learning processes has had a significant impact on students, offering them attractive and meaningful learning experiences (Aekanth, 2023; Creed, Al-Kalbani, Theil, Sarcar & Williams, 2023). These technologies in learning environments allow the creation of simulations using immersive technologies. For example, such simulations support second-language learning that encourages learners to reflect on their creative process and include ideas about culture and language (Caspar, 2021). They also help prepare English teachers to speak other languages through mixed-reality classroom simulations (Lew, Gul & Pecore, 2021). Mixed reality simulation experiences have also been used in teacher training, with feedback sessions enhancing self-efficacy through active learning, vicarious learning, receiving feedback, and managing one's emotions (Gundel & Piro, 2021). Innovating AR/VR learning environments with immersive technologies helps to bring simulations into the classroom (Zhang, Liu, Kang & Al-Husdsein, 2020).

The uses to which virtual and augmented reality have been put span a range of disciplines. Smutny (2022), in his study, identified how VR applications were most popular in areas related to nature, space, medicine, art, and history. In medicine, for example, it has been shown that the ability to learn, synthesize and incorporate the materials and ideas learned through virtual, augmented, and mixed reality tools offers an excellent opportunity to put medicine at the forefront of surgical education (Lee, Moshrefi, Fuertes, Veeravagu, Nazerali & Lin, 2021). Even using VR technology with a live communication tool can be an alternative teaching method. During the mandatory social distancing of the COVID-19 pandemic, the technology allowed the 3D understanding of surgery and related anatomy (Iwanaga, Kamura, Nishimura, Terada, Kishimoto, Tanaka et al., 2021). Virtual reality has also been useful in operator training in the chemical industry. Features that enhance virtual reality training effectiveness were integrated, such as game-based learning elements, learning analytics, and assessment methods (Garcia, Chan, Gallagher, Tehreem, Toyoda, Bernaerts et al., 2021). In Biology, Nasharuddin, Khalid and Hussin (2021) mention that one of the problems students face is the difficulty in visualizing complex cellular processes such as cell division through mitosis and meiosis. They developed an interactive mobile learning application with virtual reality technology to help students see the process of human cell division, improving their understanding and interest and having a significant positive impact on their knowledge development. With respect to foreign language learning, Nicolaidou, Pissas and Boglou (2021) found empirical data on how VR applications are engaging and effective for language learning.

These immersive technologies have also identified areas that need to be addressed in learning environments. Albus et al. (2021) warn that virtual reality learning environments, being highly visual, require pedagogical aids for the learner. Too much visual information can impair the selection and organization processes by overloading the learner's cognitive capacity. Another warning was raised by Morélot, Garrigou, Dedieu and N'Kaoua (2021), who showed that immersion promotes procedural learning but not conceptual learning. Neither the sensation of presence nor the interactions of immersion affected the two types of learning in the training task being performed. In a study with teachers who worked with immersive virtual field trips (VFT) in primary classrooms, usability problems occurred in the lack of interaction, language affordances, and hardware and network issues (Cheng, 2021). The teachers suggested five instructional approaches for implementing immersive VFTs in classrooms: anticipatory organization, learning extension, learning assessment, collaboration, and role-play. Similarly, Solmaz and Van Gerven (2021) found a lack of inclusive system development for computational fluid dynamics (CFD) simulations with AR/VR. They proposed a component-oriented system architecture to generate dedicated workflows for any AR/VR environment supported by CFD simulations.

1.3. Horizons Architecture Methodology in Complex Environments

How can we contribute to a more just and equitable society? Sustainable development is the shared, holistic, and long-term vision that invites us to build the best ways to improve people's lives. We have an excellent opportunity to contribute to sustainable development objectives. In particular, encouraging social engagement through high-level training such as complex thinking skills, encouraging critical, systemic, scientific and innovative thinking (López-Caudana, Vázquez-Parra, Cruz-Sandoval & Baena-Rojas, 2024). High-level competencies need to be encouraged because the challenges facing contemporary organizations are interconnected, uncertain and dynamic (Vázquez-Parra, Cruz-Sandoval & Suárez-Brito, 2023), in the complexity of what is implied by Society 5.0 where digital technologies and human-centered approaches are integrated, merging with cyber-physical spaces to create a smart and sustainable society (González-Pérez, Ramírez-Montoya & Enciso-Gonzalez, 2023). In this contribution, educational innovation, entrepreneurship, multidisciplinary collaboration, and emerging technologies can support innovative projects for social impact, aimed to resolve the significant challenges described by the sustainable development objectives promulgated by the United Nations.

Thus, the creation of a teaching-learning environment will be essential. One methodology for creating innovative ventures is found in "Horizons Architecture." Barroso, Molina and Poiré (2019) conceived it as an adaptive model to generate qualitative and quantitative strategies and ventures for future scenarios in complex and highly probable systems within a specific period. Transferring these ideas to education and the humanities, we can create impactful, far-reaching solutions for sustainable objectives challenges through entrepreneurship and innovation (Ramírez-Montoya, Rodríguez-Abitia, Martínez-Pérez & Lopez-Caudana, 2021). In 2022, Deloitte (2023) identified eight key characteristics of architectural maturity: lean (shedding the unnecessary), scalable (appropriate growth at reduced cost), nimble (adapting to changes and priorities), stable and resilient (performance and security), governed (supporting integrity, security, and performance), flexible coupling (avoiding lock-in), innovative and interoperable.

Horizons architecture in educational innovation implies starting from the beginning to find new ways to create that fulfill the sustainable development objectives of the 2030 agenda established by UNESCO and linking the academic, governmental, business, social, and environmental sectors.

Based on these ideas, we invite developing a long-range projection (10 years, for example) with seven elements (Figure 1):

- *Legacy*. What? To focus on the long-range view where one wants to contribute, mainly for the advancement of that field.
- *Community*. With whom? Locate the networks and people who can contribute to the legacy. Find the networks and primary subjects to support the actions to be executed.
- *Learning*. How? Identify the knowledge that addresses and sustains the legacy based on scientific evidence and innovation.
- *Technologies*. With what? Search for the latest technologies that support the project. The search is both in references and in specialized companies.
- *Context*. Where? Stage the place where the innovative project will be carried out. Describe the place and the subjects of the intervention.
- *Projects*. How? Plan what can be done to achieve the enunciated legacy with staged actions that are timely and well-managed.
- *Management*. When? Visualize the human and financial resources required to achieve the legacy and the possible risks. Delineate the social organizations needed to help, the sources of funding, strategic development, and the time and strategic resources.

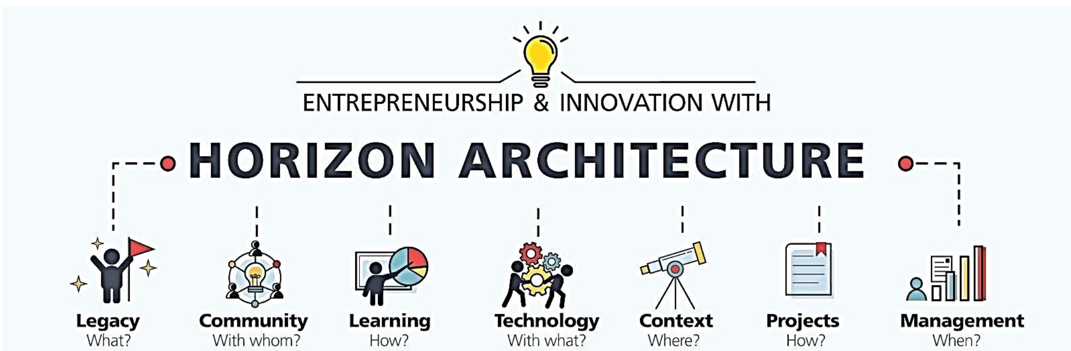

Figure 1. Adapted from Ramirez-Montoya and González-Padrón (2022)

Horizons architecture invites us to dream about sustainable development by undertaking new products, services, methods, and techniques that benefit social welfare. This article aims to analyze the training characteristics that support the development of entrepreneurship for social impact. The student training experience was an Entrepreneurship and Innovation course where graduate students in Education and Humanities conceived innovative projects. This course aligned with the new institutional educational model called Tec21. Its mission is to form innovative and entrepreneurial leaders who seek human flourishing, balance economic and social factors, and care for the planet and environment through time in all activities.

The basic-level course, "Entrepreneurship and Innovation," is taught in the postgraduate programs of Educational Entrepreneurship (MTO), Digital Humanities (MHD), and Management for Educational Leadership and Innovation (EHE) at Tecnologico de Monterrey. It seeks that the students know and apply the elementary concepts of entrepreneurship and innovation. Also, it integrates relevance, viability, feasibility, usability, and educational impact with the process of needs diagnosis, ideation, prototyping, production and entrepreneurship. The course requires basic knowledge of socio-cultural intervention, project management, and finance.

The learning goal is to develop innovative, entrepreneurial competency in the students through an integrative project applied in an impact sector (government, industry, academia, society, or the environment). The course aims to contribute to the Sustainable Development Goals (SDG) enunciated in the 2030 Agenda for Sustainable Development.

2. Methodology

The present research was conducted with a mixed methodology, using a concurrent triangulation design. The use of this type of methodology allows us to analyze, understand and explain in greater depth the results obtained from the instruments applied (Onwuegbuzie & Leech, 2006; Creswel & Plano Clark, 2011). To this end, mixed analyses were conducted to identify the types of innovation perceived by graduate students in learning environments employing horizon architecture and virtual reality. The participants were chosen from a sample for non-probability convenience. The students had a wide range of profiles, enrolled in Humanities and Education.

2.1. Instrumentation

Three instruments were applied: a) a semi-structured questionnaire with 20 indicators collected the demographic and interests' data to contribute to the sustainable development objectives; b) a validated Likert scale questionnaire from 1 to 4 (4: Strongly, and 1: Disagree), a 5th option was also offered (Can't answer / Don't want to answer), which is scored according to the mode (García-González & Ramírez-Montoya, 2019). The scale consisted of 28 indicators, structured in two parts: elements of innovation (change/novelty and added value) and types of educational innovation (incremental, systematic, disruptive, and open). For this purpose, qualitative content validity was carried out, considering the aspects of sufficiency, clarity, coherence, and relevance. The instrument was validated by the judgment of eight experts with a Kendall concordance coefficient $W = .198$, p-value $= .000$. And Cronbach's alpha coefficient was calculated to estimate the internal consistency or reliability of the instrument. The Cronbach's alpha result is 0.83; this indicates that the reliability is high. Finally, c) a semi-structured questionnaire with 11 questions that investigated the students' perceptions about the learning acquired (the content and format and their experience in the course) and the innovative projects they generated. The students classified these by the types of innovation, sectors of linkage, and the sustainable development objectives to which their projects contributed.

2.2. Form of Application

The basic-level course, "Entrepreneurship and Innovation," is taught in the postgraduate programs of Educational Entrepreneurship (MTO), Digital Humanities (MHD), and Management for Educational Leadership and Innovation (EHE) at Tecnologico de Monterrey. It seeks that the students know and apply the elementary concepts of entrepreneurship and innovation. Also, it integrates relevance, viability, feasibility, usability, and educational impact with the process of needs diagnosis, ideation, prototyping, production and entrepreneurship. The course requires basic knowledge of socio-cultural intervention, project management, and finance.

As a result of the learning process, the student is expected to develop the competency of innovative entrepreneurship through an integrative project applied in an impact sector (government, industry, academia, society, or the environment) aimed at contributing to the SDG set out in the 2030 Agenda for Sustainable Development.

The course lasted 12 weeks. The instruments were applied in three moments: At the beginning of the course, the semi-structured questionnaire instrument was applied to gather the demographic data and present the SDG to the students to decide which would guide their project development. With this information, the students strategized with Horizons architecture to form the teams to build their projects. In the middle of the training experience (week 7), the students received the innovation instrument to identify the type of innovation they perceived in the course. At the end of the course, the semi-structured questionnaire instrument was applied to collect their perceptions of the learning and the types of projects they developed.

2.3. Data Analysis

After collecting data from the tree instruments, the analysis was carried out with a two-folded approach: qualitative and quantitative. For the qualitative analysis the responses obtained in the open-ended questions were analyzed using Voyant Tools to automatically extract topics derived from the text, a list of 512 common words were excluded from this analysis. From the topic clusters identified we defined topic categories, and then frequency of ideas on each category was measured. The responses obtained related to the VR environment were also categorized in two categories: positive comments and negative comments, and a triangulation was carried out between the categorized responses and the sociodemographic data of the participants. Quantitative data were analyzed with the Excel program, using data analysis tools such as pivot tables, filters, statistical functions and graphs. Frequencies and percentages were calculated. The results were expressed in tables and figures, and compared with the existing literature.

2.4. Course Structure and Methodology

As mentioned above, the course lasted 12 weeks. The students had to dedicate 12 hours per week to review content, carry out activities and work collaboratively with their teams on the innovation project.

In the course methodology, we decided to divide the entire group into three large segments, according to the project's focus or objective that the students wanted. We used a space mission analogy for this purpose. Students could select from three spaceships, each with a particular mission that they would embark on during the course. The missions of each spaceship correlated with the students' collaborative projects. The defined spaceships were the following:

- APOLLO: directed towards value proposals in the educational field (e.g., new educational models, plans or programs, new communities of practice, EdTech, and others).
- SATURN: directed towards generating cultural projects (e.g., the proposal of creative resources such as video, applications, storytelling, and virtual reality projects).
- ATLAS: directed towards projects to design solutions to educational challenges (e.g., a proposal from an educational center to solve a problem or an inter-institutional undertaking).

This LMS course was designed with visual elements for space missions. One example is the logotype generated for each spaceship (Figure 2).

The students formed teams under the spaceship. Each represented a project development; thus, the students formed teams with members who selected the same general purpose for their project. Besides the spaceships and their particular missions, there was a space center called NISA (a clear allegory to NASA). The space center was a virtual interaction space (Figure 3) developed within Mozilla Hubs (https://hubs.mozilla.com/), a platform that enables immersive virtual reality environments. In this space, the different teams interacted to learn about their projects and give and receive feedback.

Figure 2. Visual representation of the course spaceships

Figure 3. NISA Space Center, virtual reality environment

The course structure had three learning units. Each included content and activities on specific topics about entrepreneurship and innovation to achieve specific learning objectives. Table 1 presents the relationship between the units, contents, and corresponding specific objectives.

Unit	Content topics	Specific learning objectives
Unit 1. Innovation	What is innovation? What are the Sustainable Development Goals (SDGs)? What are the issues related to the SDGs?	Analyze components of innovation and different proposals for entrepreneurship and intra-entrepreneurship identified in educational institutions, non-profit organizations, cultural organizations, social enterprises, and others for their social contributions, impact, and value generation. Select an SDG where you can have an impact to carry out your entrepreneurial and innovative project.
Unit 2. Entrepreneurship	What is entrepreneurship? What is an entrepreneurial opportunity in the social sphere? How are entrepreneurship and innovation linked? What elements are critical for designing educational-cultural entrepreneurship and intrapreneurship? What aspects should be considered to design prototypes characterized by innovation, entrepreneurship, and educational-cultural intrapreneurship?	Analyze components of entrepreneurship and different types of entrepreneurships. Define a project linked to the identified SDG that generates value to society. Experience design techniques that lead you through phases from empathy to prototyping. These are conceptualized within entrepreneurship and intrapreneurship in educational institutions, non-profit organizations, cultural organizations, and social enterprises.
Unit 3. Innovative Entrepreneurship Validation	What needs validation? How are entrepreneurship and intra-entrepreneurship proposals evaluated in the specific educational-cultural context? How are validation instruments designed? How is data analyzed and processed? How are problem iteration and validation presented for educational-cultural entrepreneurship and intrapreneurship proposals?	Validate a social problem through understanding and empathizing with its various actors and beneficiaries. Apply methodological tools to search for information and pose objective, pertinent, and relevant questions. Validate a need to resolve a social problem identified under SDGs where the entrepreneurial and innovative solution project makes an impact.

Table 1 Relationship between learning units, content topics and specific objectives of the course

In the different units, students carried out the following types of activities:

– Individual Activities:

- Readings. These materials provided the theoretical foundation for the course.
- Videos. Audiovisual resources complemented the course content, presenting some review topics, examples of entrepreneurial proposals, concept explanations, interviews, and lectures and reports by experts in the field.
- Quizzes. Based on the assigned readings, two evaluation instruments on innovation and entrepreneurship were applied during the course.
- Zoom Meetings. Live web conferences where interaction between the course faculty team and the students took place. Introductions to the didactic units were made, and general feedback was given regarding the subject's progress. Some of the sessions included the participation of external guest experts on specific topics related to the course.

– Collaborative Activities:

- Discussion forums. Spaces for team collaboration on vitally important issues for the realization of the project.
- Project "Mission: Emprende.edu." This was the project carried out during the course in three phases. The project design followed the Horizons architecture methodology. This activity produced the primary evidence of developing innovative entrepreneurial competency. The project is divided into three main phases:
  - Phase 1: Identification of a problem or need to be solved. Definition of the project to be carried out. Definition of the SDGs of impact on the project. Development of the Horizons Architecture, specifically, the aspects Legacy, Community, and Learning.

    During this stage, each team generated an infographic that synthesized the project information.
  - Phase 2: Development of the Horizons Architecture, specifically Technology, Context, Projects, and Learning: Technology, Context, Projects and Management.

    During this stage, each team generated a video that presented the innovative project's context and objective.
  - Phase 3: Validation of the proposed innovation. This involved creating a digital prototype to show others what the project was, delimiting the validation methodology (survey, interviews, focus groups, etc.), designing the validation instrument, applying the instrument to collect information, analyzing, and forming conclusions.

The student's learning path is illustrated below in Figure 4.

2.5. Course Group Composition

The group included 99 students with a wide variety of profiles. The group's specific composition is described below, considering four dimensions: age, study program, geographic location, and working situation.

2.5.1. Age

The postgraduate students' age was relevant to the study, considering that older students tend to have had less contact with technological tools, such as virtual reality, in their previous academic training. Therefore, there has been concern among academicians that such learning experiences should be included. The group was classified into age ranges, each including five years. It is to be noted that the students' classification in these age ranges considered their ages at the time of the course in Fall 2020. In Figure 5, we can see that the group had students ranging from 20 to 55 years old. Students aged 35 to 39 predominated, followed by students 25 to 29 and 30 to 34. Older students (50 to 55 years) represented the smallest group.

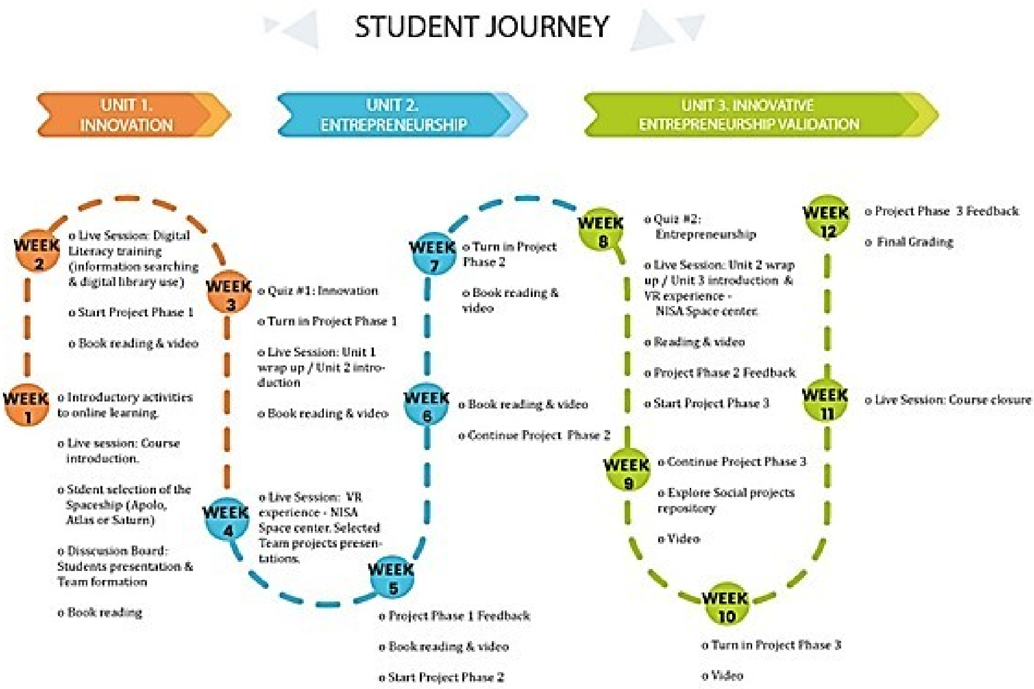

Figure 4. Student's Learning Path for the EMIN course. Source: Own creation, designed with vector image from Freepik.com

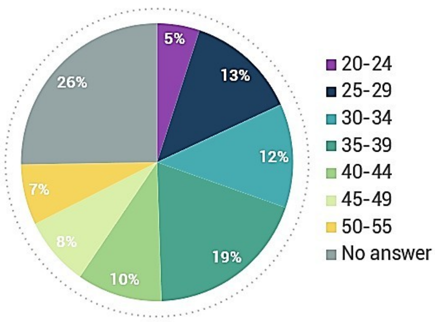

Figure 5. Group distribution by Age

2.5.2. Post Graduate Program

The course was open for students from five postgraduate programs:

- MEE - Master in Education: The Master's degree in Education responds to society's current knowledge needs to enrich the education professionals in the most advanced theories, methodologies, and pedagogical techniques to form different scholarly levels that assure the students' integral development.
- MHD - Master in Digital Humanities: A trimestral program of professional orientation linked to the cultural and creative industries, proposing a broad, interdisciplinary, creative, enterprising and global approach to Digital Humanities. It is aimed at graduates and professionals from

humanities, communication and social sciences, and information technologies. It includes cultural managers, community managers, editors, journalists, publicists, creators, information analysts, librarians, graphic designers, visual artists, educators and academicians.

- MTE - Masters in Educational Technology: This Masters responds to the current needs of the knowledge society to prepare professionals in education and human talent development in the most current and advanced technologies for teaching-learning processes and training. This degree program is aimed at the various school levels and public and private organizations, allowing a comprehensive development of students and collaborators.
- MTO - Master in Education Entrepreneurship: This program aims to train professionals with the necessary skills to undertake innovative educational projects that transform their communities socially and economically.
- EGE - Specialization in Management for Educational Leadership and Innovation: This program is a specialization for professional managers and is aimed to bring leadership and innovation competencies to education.

The variety of study programs represented in our course provided an exciting mix that enabled a multidisciplinary approach to the projects. Students from the MHD Program were the largest group in this course (Figure 6), followed by students from the MTO Program. Students from the MTE program were the smallest group.

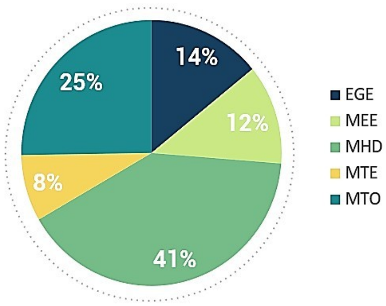

Figure 6. Group distribution by Post Graduate Program

2.5.3. Geographic Distribution

There were students from 11 countries. Students from Mexico predominated, although there were a significant number of Colombian students (Table 2).

Country	Total
USA	3
Mexico	72
Honduras	1
Costa Rica	1
Chile	1
Colombia	13
Ecuador	1
Paraguay	1
Peru	4
Spain	1
China	1

Table 2 Group distribution by Country

2.5.4. Working Backgrounds

As for the students' working backgrounds (Figure 6), most of the students worked in the Education field. They were members of the faculty or in administrative positions in an educational institution.

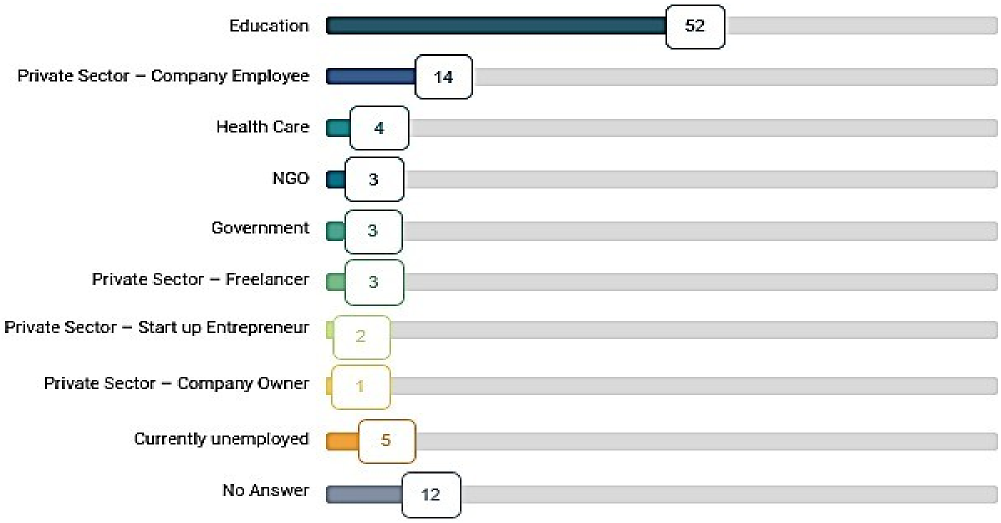

Figure 7. Group distribution by Current Working Sector

3. Results

3.1. Course Projects Created by the Students

The student work teams developed 21 projects. Each project was classified by the element of innovation and the corresponding type of innovation, determined by the scope, objective, context, and expected innovation results.

Based on the projects' information, 95% focused on three of the four innovation forms: service, product, and process (Figure 8). Forty-three percent of the teams identified their project as generating a new product, followed by 33% offering new services, while only 19% generated projects oriented to process innovation. However, it is not clear from the information obtained why the teams opted for one or the other innovation type.

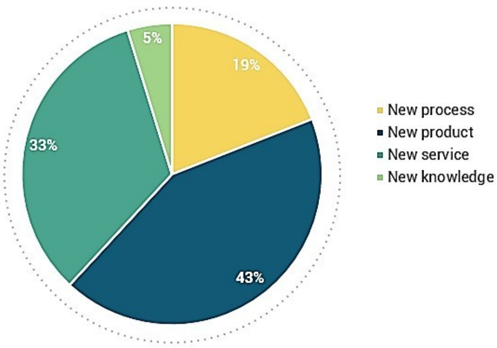

Figure 8. Projects' distribution based on the element of innovation

Regarding the type of innovation, most of the projects were classified as systematic innovation (Figure 9) because the changes they produced were planned, orderly, and methodical. Most of these only improved already existing other products, services or processes. On the other hand, 9% of the projects were identified as disruptive, considering that nothing in the current market was similar to the team's solution.

Projects identified as incremental represented 29% of the total. The students identified them this way because the innovation changes were minor, continuous, and incremental. There were similar products, services or processes that were improved by the proposals presented.

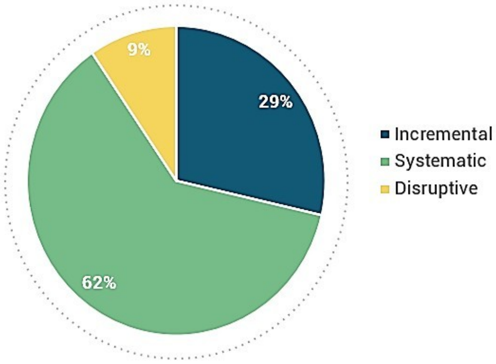

Figure 9. Projects distribution based on the type of innovation

3.2. Student Perceptions of the Horizons Architecture Methodology

Regarding the perception of students about the Horizons Architecture Methodology, 21 comments from 17 students collected. Among these comments, six categories were identified:

1. *Learning Impact:* Comments referring to Horizons Architecture Methodology as one of the main learning aspects from the course.
2. *Future usage:* Comments referring to the use of the Horizons Architecture Methodology in the future for other projects.
3. *Project structure impact:* Comments highlighting how Horizons Architecture Methodology helps to provide structure to an entrepreneurship project.
4. *Project success:* Comments referring to Horizons Architecture Methodology as a form to ensure the success of the project and its sustainability over time.
5. *Future scenarios:* Comments referring to Horizons Architecture Methodology as a form to visualize future scenarios for an entrepreneurship project.
6. *Technology understanding:* Comments highlighting how Horizons Architecture Methodology helps to broaden the understanding of technology in the entrepreneurship project.

The correlation between the identified categories and the student's characteristics based on the four dimensions collected (age, study program, geographic location and working situation) is presented in Table 3. It is highlighted that the largest group of comments (8 comments) were related to project structure impact category, followed by the learning impact category (5 comments), as for the rest of the categories all of them were given 2 comments each.

Some of the salient comments students shared about the Horizons Architecture Methodology were:

- "Learning Horizons Architecture was very useful to be able to imagine and propose projects in an environment with many uncertainties." (S10, 30-34 years old, MHD study program, Mexico, working in Education).
- "The horizons architecture turns out to be a process that allows designing, projecting and building an initiative with various innovation components that allow the entrepreneurship project to guarantee its sustainability over time." (S46, 35-39 years old, MHD study program, Colombia, working in NGO).

- "I'd like to reuse this format of making projects to use in my own businesses, as I feel that it gives you an easier way to understand the technologies you use, who it is aimed at, what similar projects or skills you have and how to manage the project." (S16, 20-24 years old, MHD study program, Mexico, working in private sector - company employee).
- "Horizons Architecture showed me a new panorama for approaching entrepreneurial projects, especially the management perspective that makes you delve into elements that you would not consider when first thinking about entrepreneurship." (S65, 30-34 years old, MEE study program, Mexico, working in NGO).

Student ID	Students' perception categories	Age	Study Program	Geographic Location	Working background
S1	Project structure impact	45-49	MHD	México	Education
S10	Project structure impact	30-34	MHD	México	Education
S16	Project structure impact	20-24	MHD	México	Private Sector - Company Employee
S47	Project structure impact	35-39	MHD	Colombia	Education
S62	Project structure impact	35-39	MHD	México	Education
S63	Project structure impact	25-29	MEE	México	Education
S65	Project structure impact	30-34	MEE	México	NGO
S78	Project structure impact	No Answer	MHD	México	Private Sector - Company Employee
S20	Learning Impact	20-24	MHD	México	Education
S22	Learning Impact	20-24	EGE	México	Education
S23	Learning Impact	25-29	MHD	México	Private Sector - Company Employee
S44	Learning Impact	35-39	MTO	México	Currently Unemployed
S61	Learning Impact	30-34	MEE	México	Education
S1	Technology understanding	45-49	MHD	México	Education
S77	Technology understanding	No Answer	MHD	México	Private Sector - Company Employee
S16	Future usage	20-24	MHD	México	Private Sector - Company Employee
S62	Future usage	35-39	MHD	México	Education
S75	Future scenarios	No Answer	MTO	México	No Answer
S76	Future scenarios	No Answer	MEE	México	Currently Unemployed
S46	Project success	35-39	MHD	Colombia	NGO
S77	Project success	No Answer	MHD	México	Private Sector - Company Employee

Table 3. Perception's category related to student's age, study program, geographic location and working background

3.3. Student Perception about the Virtual Reality Environment

The students' perception about the VR environment was analyzed through 11 comments received. The comments were first classified in two categories: positive comments and negative comments. The comments were analyzed in greater depth identifying three subcategories for the positive comments and two subcategories for the negative ones, which are described below:

Positive comment subcategory:

1. *Enthusiasm/Excitement:* Comments that showed enthusiasm or excitement from the student of the VR environment through words such as: great, amazing, surprised or similar.

2. *High value:* Comments that showed that the student finds value in the use of the VR environment, whether for their learning, their activities or the overall course experience.

3. *Innovative element:* Comments highlighting the VR environment as an innovative element in the course.

Negative comment subcategory:

1. *Low value:* Comments noting perceived low value in the use of the VR environment in the course experience.

2. *Technical difficulties:* Comments related to any kind of technical difficulty in the use of the VR environment, such as: access, connection speed, lags, or similar.

A total of 11 comments were given to the VR environment, Table 4 below presents the student's comments full categorization. In the positive comments, comments related to enthusiasm/excitement predominated (8 comments), as for the negative comments there were only 3 of them, two of them identifying low learning value from the use of the VR environment. It is worth noting that students who made negative comments about the VR environment were from 30 to 39 years old, while students who commented positively were from 20 to 29 years old and from 35 to 49.

Student comment	Category	Subcategory	Student's Age
"I loved getting to know this virtual reality section that was introduced to us in the class."	Positive comment	Enthusiasm/ Excitement	20-24
"Sessions at NISA: Great! [...] engaging sessions [...]"	Positive comment	Enthusiasm/ Excitement	20-24
"I think the Nisa platform was great. We could have exploited it better. It would have been great to have more sessions in that space."	Positive comment	Enthusiasm/ Excitement	25-29
"The course methodology surprised me, the concept of spaceships, the interaction in virtual environments. [...]"	Positive comment	Enthusiasm/ Excitement	35-39
"Sessions with virtual reality: I had not had the opportunity to get to know these tools. I was fascinated [...]"	Positive comment	Enthusiasm/ Excitement	35-39
"It was very enriching to learn about new platforms for collaborative work."	Positive comment	High value	40-44
"We made the visit to the NISA Space Station, and the experience of navigating in another environment that allows us to visualize all the Saturn equipment deliveries was very valuable."	Positive comment	High value	40-44
"I learned to use innovative tools like Nisa to collaborate and learn with my colleagues."	Positive comment	Innovative element	45-49
"I think the VR elements of NISA are sometimes overdone. I don't think it's necessary to spend so much time on it."	Negative comment	Low value	30-34
"I was not able to visualize the real learning outcome in the context of virtual reality (the same LO is achieved by zoom)"	Negative comment	Low value	35-39
"I think that using the Nisa tool instead of contributing hinders because it doesn't load well, there are problems getting in, you need a certain level of computer to make it work [...]"	Negative comment	Technical difficulties	40-44

Table 4. Students' comments categorization

3.4. Student's Perceptions about the Learning Environment Using Horizon Architecture Methodology and Virtual Reality

Student perceptions of the learning environment were obtained from the Likert scale and were divided into four categories: attitudes it promotes, effectiveness for their learning needs, perceived scalability, and perceived degree of novelty.

The best-rated dimension was *Attitudes it promotes* with 3.50, while the one with the lowest evaluation was *Effectiveness for their learning needs*, obtaining a score of 2.97. The ratings of all four categories are shown in Figure 10.

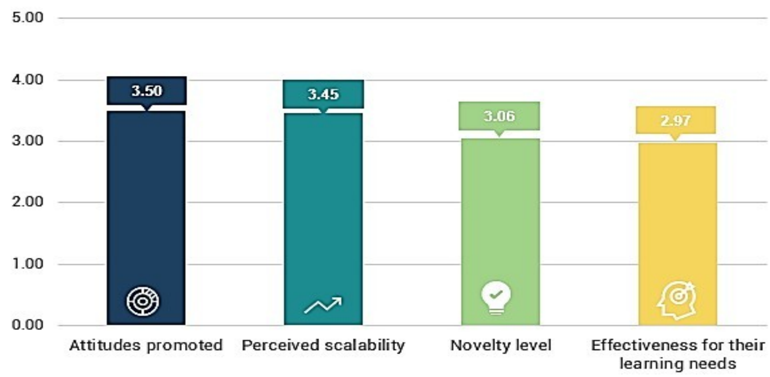

Figure 10. Evaluation of the learning environment in the four dimensions

3.4.1. Attitudes it Promotes

For the dimension *Attitudes that it promotes*, two aspects were evaluated. First, the learning environment using Horizons Architecture and the Virtual Reality environment would promote a critical stance on the learning topics. Second, such an environment could motivate participation in the different activities to improve learning. In Figure 11, we observe that students valued both aspects positively; *critical stance* scored higher with a minimum difference of .11pts over motivates participation.

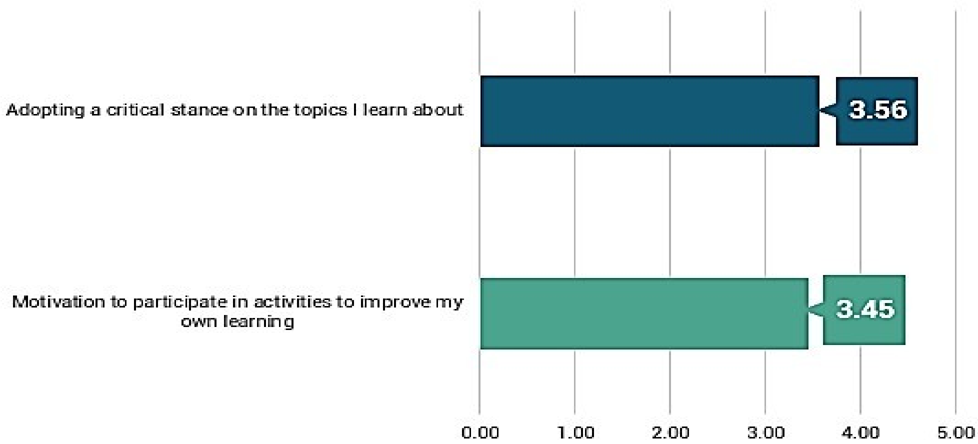

Figure 11. Students' perception of the attitudes promoted by the learning environment

3.4.2. Effectiveness for their Learning Needs

Several aspects were evaluated concerning the effectiveness for learning needs, which can be observed in Figure 12. Students mostly agreed that it is valuable for improving their quality of learning. Likewise, many agreed that it allows them to have a clear idea of exploiting the learning acquired and that the learning environment contributes to meeting learning needs.

Within this dimension, we decided to identify if there were perceptions that the learning environment, although innovative, did not satisfy the students' particular learning pace. We also wanted to assess whether the environment did not cover the quality learning needs. These two aspects were rated low, with 1.84 and 1.76, respectively.

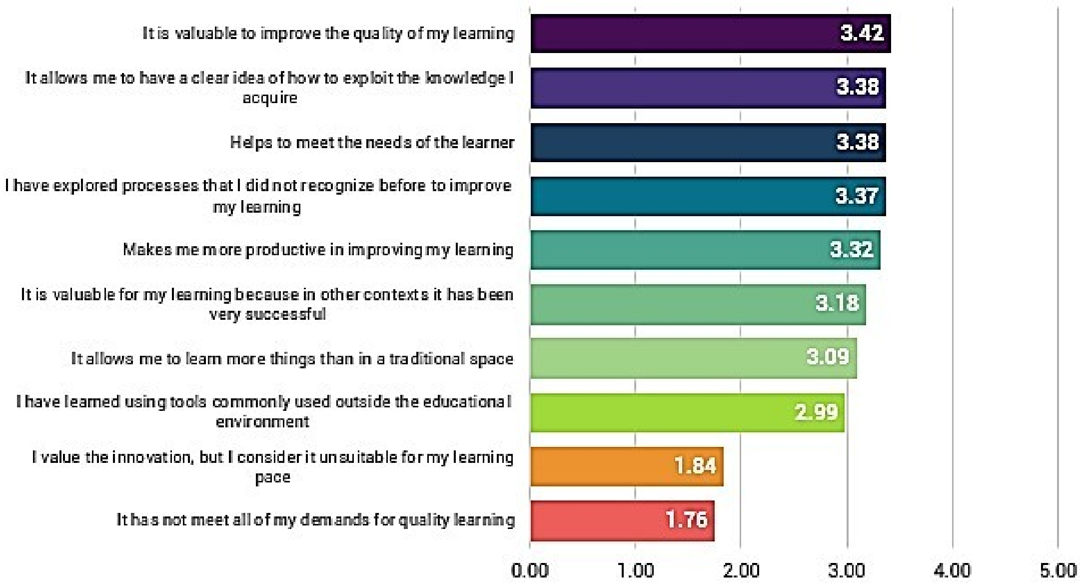

Figure 12. Students' perception of the effectiveness of the learning environment to meet their needs

3.4.3. Perceived Scalability

Concerning the perceived scalability of the learning environment, we measured whether the students considered it feasible to scale this type of environment to other educational contexts and whether the environment facilitates the accessibility of learning for many people. Both aspects scored similarly (Figure 13): a mean of 3.59 for scalability and 3.32 for making mass learning accessible.

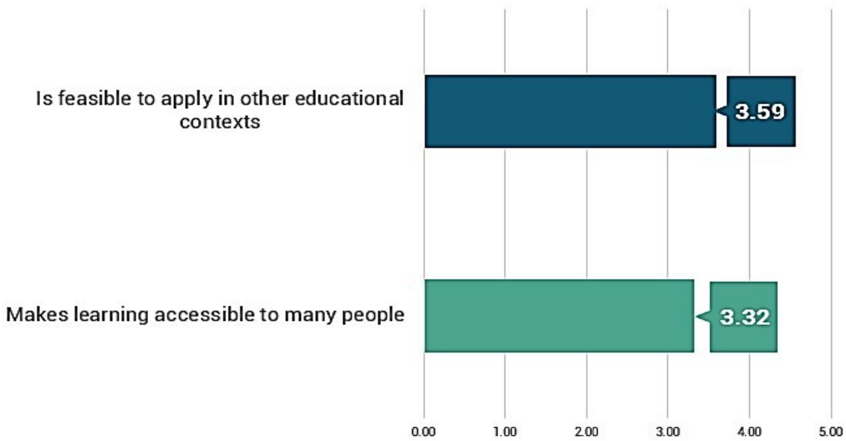

Figure 13. Students' perception of the scalability of the learning environment

3.4.4. Perceived Degree of Novelty

In terms of the degree of novelty, we assessed five aspects. As shown in Figure 14, most students perceived that the learning environment differed from others they had experienced (mean, 3.39). As to how different it was from other learning experiences, the mean was 3.35 that it maintains traditional elements adapted to enhance learning. As for being revolutionary, the students valued it conservatively (mean, 2.76). The lowest mean was for the item that this type of experience was already applied in almost all contexts (mean, 2.54).

Based on the Likert scale questions, as shown in Figure 15, it can be determined that the students perceived the learning environment as a novel and global innovation in a more significant proportion. A smaller proportion considered that the change in the learning environment added value to the experience.

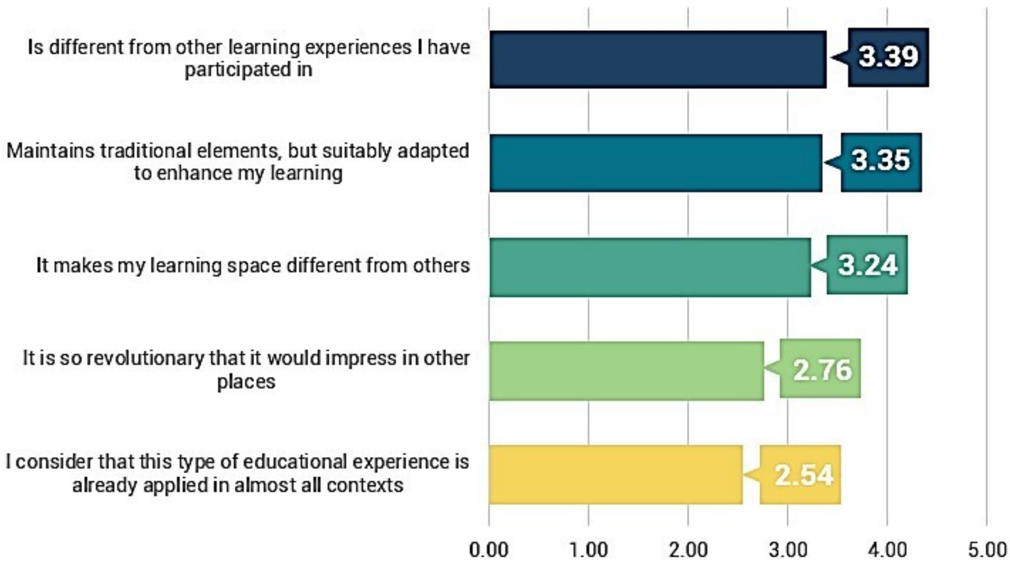

Figure 14. Students' perception on the novelty level of the learning environment

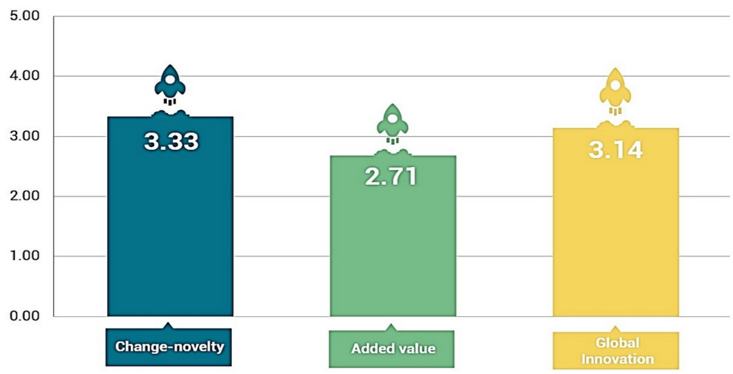

Figure 15. Students' perception of the novelty created by the learning environment

Finally, the type of innovation that students perceived about the learning environment is illustrated in Figure 16. A high proportion perceived it as open and systemic innovation. A small proportion perceived it as a disruptive innovation.

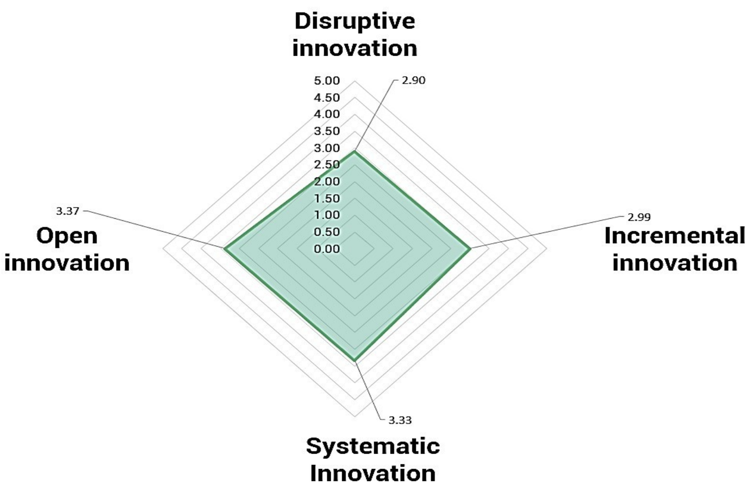

Figure 16. Type of innovation of the learning environment perceived by the students

4. Discussion

Virtual and augmented reality integrated into learning environments provide opportunities to generate creative scenarios that promote educational innovation for improvement. Virtual and augmented reality integrated into learning environments provide opportunities for creative scenarios that promote educational innovation for improvement. Aekanth (2023), in his literature review, highlighted the importance of both AR and VR as technologies with significant impact in providing learners with both an immersive and engaging experience. In the present study, students identified novelty in the learning environment, different from what they had in other experiences (Figures 14 and 15). Similar to the studies conducted by Valencia & Valenzuela-González (2017) and Biasi et al. (2022), in the present research it is observed that educational innovation aims to generate a product, service or solution that integrates novelty into existing reality, modifying it and improving its operations. Emerging technologies, particularly virtual and augmented reality, help change elements to improve instructional designs.

According to the data obtained, it should be noted that proposing to students the creation of complex scenarios under the architecture of the horizon with virtual reality is a challenge that they are willing to take on, as they feel more satisfied when they become producers of their own projects, which is reflected in their motivation, allowing them to develop and acquire technopedagogical competences related to the application of AR and VR in education. Students highly value new learning environments that motivate them to participate in the activities and learn to take a critical stance on the topics; they can perceive that this learning environment could be easily replicable in other contexts. The students ventured into new spatial environments, assisted by virtual and augmented reality (Figure 3). They were motivated in four environmental dimensions and developed an acute sense of their effectiveness for learning. The dimensions were attitudes promoted by the learning environment, the learning environment's effectiveness to meet their needs, scalability of the learning environment, and the novelty level of the learning environment (Figures 10, 11, 12, 13, 14 and 15). In the same vein is the study by Çetin and Türkan (2022), whose results show how the application of AR in various courses significantly increased students' own performance and attitudes. Chuquimarca et al. (2018) identified a significant increase in the analyzed competencies that reflected students' interest in new educational scenarios. And, in addition, it is observed, as happened in Temirov's (2022) study, the promotion of skills such as innovative thinking for the development of the units. Knowing the benefits and critical factors when using virtual and augmented reality facilitates integrating various elements in instructional designs for training.

Integrating emerging technologies like virtual and augmented reality necessitates resolving critical aspects in the academic environment, and the importance of policies, strategies for transforming the curriculum. The integration of emerging technologies such as virtual and augmented reality requires solving critical aspects in the academic environment, as well as the importance of policies, strategies for curriculum transformation. It is therefore advisable to design new learning scenarios and environments through the use of technologies, in order to promote innovation and generate transversal competences. Along the same vein, the studies by Kholikova (2021) and Ramírez-Montoya et al. (2021) point out the following. In the study conducted, positive factors predominated. However, it is essential to delve into the unfavorable reflections, such as those by students in this study who do not find the added value (Table 4). Authors agree on these difficulties (Albus et al., 2021; Morélot et al., 2021) and invite identifying pedagogical supports for virtual and augmented reality in high-level learning spaces. The effectiveness of learning in virtual reality environments seems questioned, so it is crucial to enhance teaching - learning processes with VR/AR, as pointed out by Soto-Guerrero et al. (2018), Solmaz and Van Gerven (2021) and Smutny (2022), and to identify difficulties, transcend them and guide improvements for their potential use.

Integrating virtual and augmented reality also presents critical factors from a technological perspective, from infrastructure to connection networks. In the training experience analyzed, the students questioned the technical requirements, which they considered could limit beneficial experiences. Also, they felt that the time dedicated to its use detracted from a tangible learning result and its potential added value to the learning experience (Table 4). In a study with teachers who worked with immersive virtual field trips in primary classrooms, usability problems were identified as lack of interactions, language affordances, and hardware and network issues (Cheng, 2021). Virtual and augmented reality environments require visualizing such limitations that can be encountered when designing and implementing training experiences (Zheng, Mountstephens & Teo, 2020).

Innovations in learning environments require a creative vision of strategies and resources that accompany improvement processes. In this study's formative experience, the horizon architecture strategy (Figure 1) that accompanied the perspective for future creation was perceived as a helpful methodology by providing project structure to entrepreneurship projects (Table 3). For the most part, the student projects proposed new products and services in systemic innovation. Most students stated that the environment had been supportive for their learning (Figure 12) and the development of open and systemic innovation (Figure 16). The studies by Andersen and Jakobsen (2018) and Ramírez-Montoya and Lugo-Ocando (2020) with the results obtained agree on the importance of generating new products, services, processes, and knowledge, saying it is required to value innovation as a process that incrementally or radically transforms, overcomes, complements, or improves an object, process or phenomenon. The object can be social, cultural, technical, productive, economic or environmental (Aguiar et al., 2019). Educational innovation for improvement comes in different types: continuous, formative, disruptive or open, generating scenarios that improve learning experiences.

5. Conclusions

The future horizon of education invites the formation of reasoning that enables a closer approach to complexity, as a priority for a society in search of new solutions. Challenges lie in the formation of citizens with critical, scientific, systemic, innovative and entrepreneurial thinking, who are also empathetic, cooperative and committed to sustainable development. This article's objective was to analyze the types of innovation perceived in postgraduate environments that integrated virtual and augmented reality. We provided data for designing innovative environments, using technologies that can be leveraged by teachers, entrepreneurs, and decision-makers interested in educational innovation environments and technologies, especially graduate-level audiences.

The starting point was the question: What innovations do postgraduate students perceive in environments using horizons architecture to integrate virtual reality? The data show that (a) the most perceived types were open and systemic innovation; (b) the projects developed by students were primarily new products and services, with systemic types of innovation; (c) horizons architecture allowed visualizing new educational ventures; (d) virtual and augmented reality supported distance education scenarios that were motivational and provided knowledge of new tools; (e) the technical requirements of integrating virtual reality environments are critical for a good experience that supports learning and, (f) the learning objective, when using virtual and augmented reality, must be explicit and clear to students and motivate them to learn and identify the benefits it has brought them.

The implications for educational practice lie in fostering the development of high abilities, creating innovative environments with virtual and augmented reality. Linking education with technology, both in training experiences for learning and in transferring them to other training situations. The implications for Educational Research lie in integrating methods and experiments that shed light on benefits and critical factors of using virtual and augmented reality and facilitate planning, designing, implementing, assessing, and overcoming obstacles in integrating technology-mediated environments. One seeks new options for generating learning. In this sense, the students visualized that the use of emerging technologies can provide different types of innovation in complex learning environments, and can be an enabler of changes and solutions in learning processes. Therefore, the applicability of the horizon architecture is seen as an innovation and a strength in the learning process.

The limitations of this study are found on one side in the profile of the participants. It was directed to postgraduate, adult professionals studying humanities and education. Future studies should broaden the profile of the participants and target other educational levels. Another limitation of the study corresponds to the role given to the VR environment within the analyzed course and its learning outcomes, as this environment was used in a very specific moment of the course to present the final projects from the students. For future studies it is suggested to analyze the use of VR environments in a more predominant way throughout the learning experience. In terms of methodological limitations this study did not include a control group, therefore there can not be established a causal relationship between the use of the VR environment and the outcomes. Future studies could benefit from an experimental design considering a control group. Finally, the sample size, specifically for the students' perception regarding the VR environment and their perceptions of the Horizons Architecture Methodology from sections 3.2 and 3.3, was a limitation of this study, considering that the open-ended questions to collect comments from these aspects were not required questions, the results are based only in the perceptions from the students who did respond. For future studies, it is recommended to use a larger sample. This paper is an invitation to continue exploring the potential of virtual and augmented reality, emerging technologies, and innovative strategies that increase the potential of distance learning.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors acknowledge the financial support through the "Challenge-Based Research Funding Program 2022". Project ID # I003 - IFE001 - C2-T3 – T. Also, academic support from Writing Lab, Institute for the Future of Education, Tecnologico de Monterrey, México.

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Journal of Technology and Science Education, 2024 (www.jotse.org)