

Digital Transformation and Educational Quality in Higher Education: The Role of Artificial Intelligence, Virtual Reality and Innovative Assessment Models

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Abstract

This study examines the impact of integrating emerging technologies such as artificial intelligence and virtual reality, alongside innovative assessment models, on the quality of higher education in universities in Ecuador, Mexico, and Peru. The primary objective is to experimentally evaluate how these tools transform teaching–learning processes and enhance academic performance in higher education. The research adopts a mixed-methods approach, combining quantitative analysis of questionnaires administered to faculty and students with qualitative analysis of interviews conducted with experts in education and technology. The findings reveal significant improvements in participants' perceptions regarding the relevance, usability, and effectiveness of these technologies, as well as enhanced academic outcomes in experimental groups compared to control groups. Furthermore, the study identifies key barriers and enablers for adoption, highlighting the importance of institutional policies, teacher training, and strengthened technological infrastructure. The study concludes that the strategic incorporation of these technologies can help bridge digital divides, enhance educational quality, and foster more inclusive and innovative learning environments in Latin America.

Key Words: Digital transformation; higher education; artificial intelligence; virtual reality; innovative assessment models

1. Introduction

Higher education in Latin America has accelerated its digital transformation in recent years, largely due to the notable increase in enrolment and the incorporation of digital technologies. According to a report by the Inter-American Development Bank, digitalisation intensified in nearly 100 institutions across 14 countries following the pandemic, revealing persistent gaps between regions with high connectivity and those with more precarious conditions [1]. This trend underscores the urgency of evaluating how tools such as artificial intelligence and virtual reality can be effectively integrated to reduce these disparities and enhance educational quality [2].

The COVID-19 pandemic exposed critical limitations in infrastructure, teacher preparedness, and equity of access, which significantly affected academic outcomes [3]. In response, artificial intelligence emerged as a strategy to personalise teaching and automate feedback, while virtual reality demonstrated its potential to create immersive learning environments that closely approximate face-to-face experiences [4]. Similarly, competency-based and formative assessment models gained prominence as more precise and equitable alternatives in virtual contexts [5].

Despite considerable efforts, a significant gap remains in educational quality, closely linked to the uneven adoption of digital technologies in Latin American higher education. Recent studies have documented that students and lecturers in universities in Colombia, Peru, and Venezuela encountered difficulties in utilising technology during the pandemic, negatively impacting learning processes [6]. This disparity, combined with deficiencies in connectivity and digital skills, threatens the potential benefits of digital transformation [7].

Traditional teaching and assessment methods in the region no longer meet the demands of a digitally advanced education. It is essential to adopt systemic approaches that integrate emerging technologies to strengthen personalised learning and reinforce institutional management [8]. International organisations have emphasised the importance of ethical, inclusive, and sustainable frameworks in the digital transformation of education [9]. In this context, the integration of artificial intelligence and virtual reality represents not only an opportunity to improve regional academic quality but also to contribute to global challenges such as gender equity, territorial inclusion, and the democratisation of knowledge [10].

This study aims to experimentally evaluate the impact of integrating artificial intelligence, virtual reality, and innovative assessment models on the educational quality of universities in Ecuador, Mexico, and Peru. Four specific objectives have been established to achieve this goal: (1) compare the academic performance of students in experimental groups applying these technologies with those in control groups using traditional methods; (2) analyse the perceptions of lecturers and students regarding the effectiveness and relevance of these tools in teaching–learning processes; (3) identify key barriers and enablers influencing technological adoption in Latin American higher education, considering contextual differences between the countries involved; and (4) propose evidence-based recommendations to guide future implementations of artificial intelligence and virtual reality in universities in the region, thereby contributing to enhanced educational quality and the reduction of digital divides.

Understanding the impact of digital transformation in Latin American higher education requires posing research questions aimed at evaluating both academic outcomes and the factors that facilitate or hinder technological adoption. Accordingly, the guiding research questions of this study are: To what extent does the use of artificial intelligence, virtual reality, and innovative assessment models improve students' academic outcomes compared with traditional methods? How do lecturers and students perceive the effectiveness, usability, and quality of these technological tools in university settings? And what are the main barriers that hinder the implementation of these technologies in universities in Ecuador, Mexico, and Peru? [11].

Based on these considerations, the central hypothesis posits that students exposed to learning environments integrating artificial intelligence, virtual reality, and innovative assessment models will exhibit significantly higher academic performance compared to those in conventional settings [12]. Furthermore, it is anticipated that adoption challenges will vary across the participating countries, influenced by factors such as connectivity, teacher training in digital competencies, and institutional resource availability [13].

2. Materials and Methods

This study adopts a quantitative approach with an experimental design, aiming to objectively analyse the effects of integrating artificial intelligence, virtual reality, and innovative assessment models on educational quality. A multi-country perspective was employed, involving universities in Ecuador, Mexico, and Peru, to obtain comparative and generalisable results within the Latin American context [14]. This design facilitates the identification of causal relationships between the independent variables (educational technologies) and the dependent variables (academic outcomes and perceptions) [15].

The experimental design included the formation of both experimental and control groups in each participating university. The experimental groups engaged with activities and assessments mediated by artificial intelligence and virtual reality, whereas the control groups followed traditional methodologies. This configuration enabled a

direct comparison of academic results and student perceptions, ensuring internal validity through randomisation of participants and homogeneity of initial conditions [16].

3. Techniques and Instruments

Various techniques and instruments were employed for data collection. These included semi-structured interviews with educational authorities and technology experts conducted via videoconferencing platforms, as well as standardised questionnaires using Likert scales to assess the perceptions of students and lecturers before and after implementation. Additionally, digital rubrics were designed to evaluate specific competencies, and academic performance metrics were extracted from learning management systems. Tools such as Gradescope for automated feedback and ClassVR for immersive practical activities were also applied [17].

To ensure the validity and reliability of the questionnaires administered to lecturers and students, a validation process involving expert judgement and internal consistency analysis was undertaken using Cronbach's alpha coefficient. Initially, the instruments were reviewed by a panel of five specialists in higher education, emerging technologies, and research methodology, who assessed the relevance, clarity, and pertinence of each item, implementing necessary adjustments to secure content validity. Subsequently, a pilot test was conducted with a representative sample of the target population, allowing for the calculation of Cronbach's alpha to determine questionnaire reliability. The results demonstrated coefficients above 0.80, indicating a high level of internal consistency according to established criteria [18]. This process ensured that the instruments employed were suitable for collecting valid and reliable data within the study context.

4. Population and Sample

The target population comprised a total of 4,100 students enrolled in higher education programmes across three universities: one in Ecuador (1,200 students), one in Mexico (1,500 students), and one in Peru (1,400 students). Additionally, 120 lecturers participated, distributed proportionally among the three institutions.

To determine the sample size, the formula for finite populations was applied, using a 95% confidence level and a 5% margin of error, resulting in a minimum required sample of 352 students. However, to enhance the robustness of the analysis and enable comparisons between the three countries, the sample size was increased to 420 students, proportionally distributed as follows:

Country	Population	Proportion (%)	Sample Size
Ecuador	1,200	29.3	123
Mexico	1,500	36.6	154
Peru	1,400	34.1	143
Total	4,100	100	420

In addition, 21 lecturers (seven per country) were selected to participate in the implementation and evaluation of the educational technologies. This sample size and its distribution enable comparative analyses across countries and ensure the representativeness of the data.

A stratified proportional sampling method was adopted to guarantee that each country was represented according to its population weight, which is essential in a multi-country study of this nature.

5. Data Analysis

A mixed-methods approach was adopted for data analysis, combining quantitative and qualitative techniques to achieve a comprehensive understanding of the impact of emerging educational technologies (artificial intelligence, virtual reality, and innovative assessment models) on the perceptions of lecturers and students in universities in Ecuador, Mexico, and Peru.

In the quantitative phase, descriptive statistical procedures were applied to characterise the sample and summarise the responses from the pre-test and post-test questionnaires. Measures such as means, frequencies, standard deviations, and percentages were calculated using SPSS software, which facilitated efficient and precise processing of the collected data. To assess the internal reliability of the instruments, Cronbach's alpha coefficient was employed, also calculated using SPSS, with values above 0.80 considered indicative of high consistency.

Subsequently, inferential analyses were conducted with the support of SPSS to determine the intervention's impact. A paired-samples t-test was used to compare the means obtained from pre-test and post-test questionnaires within

the same groups. Additionally, an independent-samples t-test was applied to compare results between experimental and control groups. To assess significant differences among the three participating countries, a one-way analysis of variance (ANOVA) was implemented, supplemented with post hoc tests (Tukey and Bonferroni) to identify specific differences between pairs of countries.

In the qualitative phase, the transcriptions of semi-structured interviews with educational authorities and technology experts were analysed. This process was conducted using NVivo software, applying open coding to identify emerging categories, followed by axial coding to establish relationships among themes.

The combination of these approaches enabled the triangulation of quantitative and qualitative data, thereby strengthening the validity of the findings and providing a broad and in-depth perspective on the phenomenon studied.

6. Ethical Considerations

This study adhered to the ethical principles outlined in the Declaration of Helsinki and the research ethics regulations of each participating institution. Informed consent was obtained from all students and lecturers, ensuring the confidentiality and anonymity of the collected data. Moreover, the research protocol was approved by the ethics committees of the three involved universities.

7. Implementation Procedure of the Proposal

The procedure was developed in three phases. The first phase involved training lecturers on the use of AI and VR, and selecting participants through open calls at each university. The second phase comprised the implementation of technologies in the experimental group over an academic semester, while the control group continued with conventional methods. Finally, in the third phase, data were collected and analysed through surveys, academic performance results, and records from educational platforms.

8. Implementation Proposal

“Experimental Implementation Proposal of Artificial Intelligence, Virtual Reality, and Innovative Assessment Models in Universities in Ecuador, Mexico, and Peru”

9. Introduction

This intervention proposal is oriented towards achieving the general objective of this study: to experimentally evaluate the impact of integrating artificial intelligence (AI), virtual reality (VR), and innovative assessment models on the educational quality of universities in Ecuador, Mexico, and Peru.

The proposal is structured into four sequential phases, designed for effective implementation over a six-month period, ensuring the active participation of lecturers, students, and technical teams from the participating institutions. Each phase includes specific activities, innovative technological tools, and expected outputs to enable a rigorous analysis of the impact of the implemented technologies.

10. General Objective

To experimentally evaluate the impact of integrating artificial intelligence (AI), virtual reality (VR), and innovative assessment models on the educational quality of universities in Ecuador, Mexico, and Peru.

Phase 1: Planning and Preparation (Month 1)

Description

This phase establishes the foundations for project execution. It includes selecting institutions, forming groups, training stakeholders, and preparing technological platforms.

Activities

- Select participating universities in Ecuador, Mexico, and Peru.
- Form experimental and control groups based on representativeness criteria.
- Train lecturers and technical staff in the use of technological tools.
- Configure learning management systems (LMS) such as Moodle and Canvas with AI and VR plugins.
- Conduct technical tests on connectivity and hardware compatibility (Oculus Quest, Labster).

Tools

- LMS: Moodle, Canvas (integrated with AI and VR).
- ChatGPT, Gradescope, ScribeSense (for training).
- Oculus Quest 2, ClassVR (for pilot testing).

Expected Output

Trained stakeholders and fully prepared platforms for implementation.

Phase 2: Experimental Implementation (Months 2–4)

Description

This phase focuses on experimental interventions using technological tools. It includes educational activities supported by AI, VR, and innovative assessments.

Activities

- Personalised tutoring and doubt resolution using ChatGPT.
- Automated assessment feedback via Gradescope and ScribeSense.
- Delivery of immersive classes and practical sessions with VR (Labster, ClassVR, Google Expeditions).
- Application of innovative assessments (Turnitin Feedback Studio).
- Continuous monitoring of academic performance using advanced LMS analytics.

Tools

- ChatGPT, Gradescope, ScribeSense.
- Labster, Oculus Quest 2, ClassVR.
- Moodle, Canvas LMS.

Expected Output

Effective application of technologies and preliminary data on educational impact collected.

Phase 3: Monitoring and Adjustment (Months 4–5)

Description

Ongoing monitoring to assess progress and implement strategic adjustments as needed.

Activities

- Bi-weekly meetings with lecturers and technical teams.
- Administration of surveys and interviews with students and lecturers.
- Preliminary analysis of academic data using statistical software (SPSS, Jamovi, RStudio).
- Adjustment of technological configurations based on initial findings.

Tools

- SPSS, Jamovi, RStudio.
- Google Forms, SurveyMonkey.
- Moodle, Canvas (for metrics tracking).

Expected Output

Refined strategy and preliminary data analysis completed.

Phase 4: Final Evaluation and Closure (Month 6)

Description

Focuses on result analysis, validation, and dissemination of findings.

Activities

- Comparative analysis between experimental and control groups (t-tests, ANOVA).
- Preparation of a final report with findings and recommendations.
- Presentation of results to participating universities through virtual workshops.
- Proposal of strategies for the sustainable integration of AI and VR in higher education.

Tools

- SPSS, Jamovi, RStudio.
- Power BI or Tableau (for data visualisation).
- Google Meet, Zoom (for virtual workshops).

Expected Output

Final report with recommendations for educational policies and technology adoption.

Gantt Chart (6 Months)

Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Selection of universities	✓					
Formation of experimental and control groups	✓					
Training of lecturers and technical staff	✓					
Configuration of platforms and technical tests	✓					
Implementation of AI and VR in classes		✓	✓	✓		
Application of innovative assessments		✓	✓	✓		
Monitoring and strategic adjustments			✓	✓	✓	
Final analysis and preparation of report						✓
Presentation of results and closing workshops						✓

11. Results

This chapter presents the main findings derived from the analysis of data collected during the implementation of the proposal in universities across Ecuador, Mexico, and Peru. The results are organised into four sections: first, data from the questionnaires administered to lecturers and students participating in the intervention, both in the pre-test and post-test phases, are presented. Second, qualitative findings from semi-structured interviews conducted with five experts in higher education and emerging technologies are included, offering a strategic perspective on the integration of artificial intelligence, virtual reality, and innovative assessment models.

Third, the academic results achieved by the control and experimental groups are analysed to identify potential differences in academic performance attributable to the implementation of the proposal. Finally, quantitative and

qualitative data are integrated using a triangulation approach, enabling a comprehensive and in-depth interpretation of the impact of emerging educational technologies on the quality of the educational process.

The processing and analysis of the data were conducted using SPSS for descriptive and inferential statistical procedures and NVivo for the categorisation and analysis of qualitative information from the interviews. This ensured a rigorous methodological approach and an appropriate interpretation of the results obtained.

12.Descriptive Analysis

Sociodemographic Data of the Sample

The target population of the study consisted of a total of 4,100 students enrolled in higher education programmes and 120 lecturers from three universities located in Ecuador, Mexico, and Peru. To determine the sample size, the finite population formula was applied with a 95% confidence level and a 5% margin of error, resulting in a minimum required sample of 352 students. However, in order to strengthen representativeness and allow for comparisons between the three countries, the sample size was increased to 420 students, distributed proportionally as follows: 123 from Ecuador (29.3%), 154 from Mexico (36.6%), and 143 from Peru (34.1%). For lecturers, a total of 120 participants were included, distributed in the same proportions.

Table 1
Sociodemographic data of the participating students

Variable	Frequency (n)	Percentage (%)
Gender		
Male	196	46.7%
Female	224	53.3%
Age		
18–22 years	278	66.2%
23–27 years	114	27.1%
28 years or older	28	6.7%
Country		
Ecuador	123	29.3%
Mexico	154	36.6%
Peru	143	34.1%
Academic area		
Education Sciences	165	39.3%
Engineering	138	32.9%
Health Sciences	117	27.9%
Previous experience with educational technologies		
Yes	275	65.5%
No	145	34.5%

Note. Of the 420 participating students, 53.3% were female and 46.7% male. The majority of the sample fell within the 18–22 age group (66.2%). In terms of academic areas, Education Sciences predominated (39.3%), followed by Engineering (32.9%) and Health Sciences (27.9%). A total of 65.5% of students reported having previous experience with educational technologies.

Table 2.
Sociodemographic data of the participating lecturers

Variable	Frequency (n)	Percentage (%)
Gender		
Male	68	56.7%
Female	52	43.3%
Age		
25–34 years	18	15.0%
35–44 years	52	43.3%
45 years or older	50	41.7%
Country		
Ecuador	35	29.2%
Mexico	44	36.7%
Peru	41	34.1%
Academic area		
Education Sciences	48	40.0%
Engineering	42	35.0%
Health Sciences	30	25.0%
Previous experience with educational technologies		
Yes	102	85.0%
No	18	15.0%

Note. Regarding the lecturers, 56.7% were male and 43.3% female, with the largest representation in the 35–44 age group (43.3%). Most reported prior experience with educational technologies (85.0%), indicating a teaching population familiar with the use of digital tools.

The following section presents the results obtained from the pre-test and post-test questionnaires, which provide insights into participants' perceptions regarding the effectiveness, relevance, and usability of the emerging educational technologies implemented during the intervention.

Pre-test Results – Lecturers

The pre-test results reveal a tendency towards scepticism and uncertainty among lecturers regarding the effectiveness, relevance, and ease of use of emerging technologies. This baseline scenario is key for contrasting with post-intervention data to analyse the actual impact of the proposal.

Table 3
Section 2: Perceptions of Artificial Intelligence (AI)

Item	Mean	Interpretation
1. AI facilitates the understanding of academic content.	2.8	Low perception: lecturers unconvinced.
2. The automatic feedback provided by AI is useful and clear.	2.6	Scepticism regarding clarity and usefulness.
3. The integration of AI into learning improved my teaching performance.	2.4	Negative opinion: not yet seen as determinant.
4. I consider AI an effective tool to support higher education.	2.9	Neutral-negative trend: doubts about efficacy.

Note. Lecturers exhibited a low level of confidence in the potential of artificial intelligence, with means ranging from 2.4 to 2.9, reflecting scepticism and a lack of practical experience with such tools.

Table 4
Section 3: Perceptions of Virtual Reality (VR)

Item	Mean	Interpretation
5. Practical activities in VR environments increased my interest in learning.	2.7	Low initial interest: VR seen as less applicable.
6. Using VR facilitated the acquisition of practical competencies.	2.5	Negative opinion: perceived implementation issues.
7. The immersive experience offered by VR was intuitive and easy to use.	2.3	VR perceived as complex and unintuitive.
8. VR contributed to understanding complex content.	2.6	Doubts about effectiveness for abstract concepts.

Note. Perceptions of virtual reality were predominantly negative, especially regarding usability ($M = 2.3$) and its capacity to facilitate practical skills ($M = 2.5$).

Table 5
Section 4: Perceptions of Innovative Assessment Models

Item	Mean	Interpretation
9. Digital rubrics facilitated understanding of assessment criteria.	2.9	Neutral-negative: limited familiarity among lecturers.
10. Technology-assisted assessments were fairer and more transparent.	2.4	Scepticism about fairness in automated assessments.
11. Feedback received through digital tools was timely and useful.	2.5	Perceived limited usefulness of digital feedback.

Note. Results reflect resistance to adopting digital assessment models, with means below 3, indicating doubts about their fairness and effectiveness.

Table 6
Section 5: Overall Perception and Usability

Item	Mean	Interpretation
12. The combination of AI, VR, and innovative assessment improved educational quality.	2.6	Negative opinion: limited perceived improvement.
13. I would recommend integrating these technologies in other courses.	2.4	Low level of recommendation.
14. Overall, the use of emerging technologies was a positive experience.	2.5	Neutral-negative: low initial satisfaction.

Note. Overall perceptions were low, evidencing a cautious attitude towards adopting emerging technologies in higher education.

Pre-test Results – Students

The pre-test data reveal unfavourable perceptions among students regarding the effectiveness and usability of emerging technologies. These initial negative perceptions are crucial for comparison with post-test results to determine the impact of the implemented proposal.

Table 7
Section 2: Perceptions of Artificial Intelligence (AI)

Item	Mean	Interpretation
1. AI facilitates the understanding of academic content.	2.9	Neutral-negative: students unconvinced.
2. The automatic feedback provided by AI is useful and clear.	2.7	Scepticism about clarity and usefulness.
3. The integration of AI into learning improved my academic performance.	2.5	Negative opinion: perceived little impact.
4. I consider AI an effective tool to support higher education.	2.8	Low perception of effectiveness.

Note. Students expressed unfavourable perceptions regarding the use of artificial intelligence. With means ranging from 2.5 to 2.9, most participants indicated doubts about its capacity to support learning and enhance academic performance.

Table 8
Section 3: Perceptions of Virtual Reality (VR)

Item	Mean	Interpretation
5. Practical activities in VR environments increased my interest in learning.	2.8	Low initial interest: VR perceived as un motivating.
6. Using VR facilitated the acquisition of practical skills.	2.6	VR perceived as limited for practical competencies.
7. The immersive experience offered by VR was intuitive and easy to use.	2.4	VR seen as complex and difficult to handle.
8. VR contributed to understanding complex content.	2.7	Doubts about usefulness for abstract subjects.

Note. Regarding virtual reality, students showed notable scepticism, particularly about ease of use ($M = 2.4$) and its effectiveness in developing practical skills ($M = 2.6$).

Table 9
Section 4: Perceptions of Innovative Assessment Models

Item	Mean	Interpretation
9. Digital rubrics facilitated understanding of assessment criteria.	2.9	Neutral: students unfamiliar with digital rubrics.
10. Technology-assisted assessments were fairer and more transparent.	2.5	Low confidence in the fairness of digital assessments.
11. Feedback received through digital tools was timely and useful.	2.6	Perceived limited usefulness of digital feedback.

Note. Results reflect moderately negative perceptions of innovative assessment models, with means around 2.5, indicating distrust in the fairness and utility of automated assessments.

Table 10
Section 5: Overall Perception and Usability

Item	Mean	Interpretation
12. The combination of AI, VR, and innovative assessment improved educational quality.	2.7	Moderately negative opinion on overall impact.
13. I would recommend integrating these technologies in other courses.	2.4	Low initial level of recommendation.
14. Overall, the use of emerging technologies was a positive experience.	2.6	Low initial satisfaction.

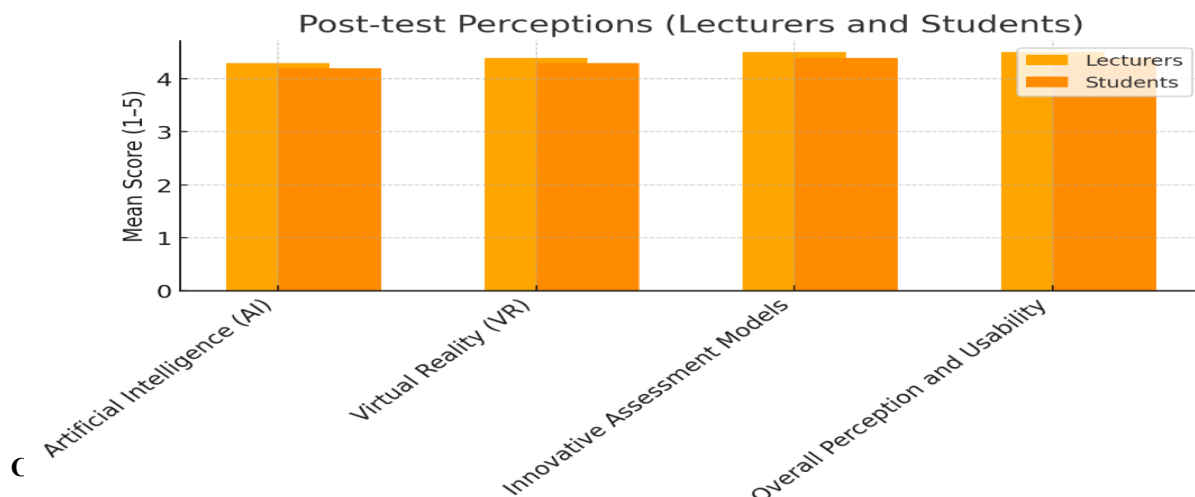
Note. Overall, students expressed scepticism about the combination of emerging technologies, with a global mean of 2.6 in perceptions, evidencing a cautious attitude towards their adoption in other courses.

Post-intervention Results – Lecturers and Students

The results obtained from the post-test reveal a positive shift in lecturers’ perceptions regarding the effectiveness and relevance of emerging technologies. Particularly noteworthy is the dimension of overall perception and usability, which recorded a mean of 4.5, indicating a high appreciation for the integration of artificial intelligence, virtual reality, and innovative assessment models within the university context. There was also robust acceptance in recommending these technologies for other courses, with a mean of 4.7 for the corresponding item.

Students likewise expressed highly positive perceptions following the implementation of the proposal. The highest-rated dimension was overall perception and usability (M = 4.5), reflecting general satisfaction with the educational experience. Virtual reality was particularly highlighted for its ability to motivate and engage students, achieving a mean score of 4.4.

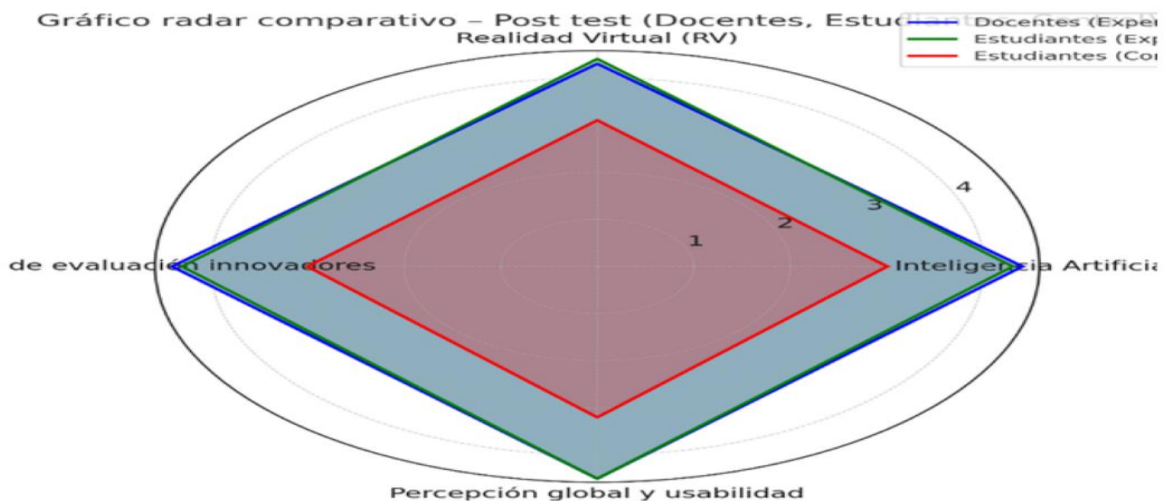
Figure 1
Bar Chart – Post-intervention



Both groups exhibited highly positive perceptions of emerging technologies. While lecturers reported slightly higher scores in the artificial intelligence dimension (M = 4.4 vs 4.3 for students), students highlighted virtual reality as the most motivating tool (M = 4.4 vs 4.3 for lecturers). The overall perception was identical in both groups (M = 4.5), indicating a strong consensus on the effectiveness and relevance of the proposed integration.

Figure 2
Post-test Comparison: Lecturers and Student

Original Graph: Radar Chart - Post-test (Lecturers, Students)



Inferential Analysis Results

The inferential analyses conducted using SPSS software revealed the positive impact of the educational intervention. The paired samples Student’s t-test demonstrated statistically significant differences across all dimensions between the pre-test and post-test in the experimental group ($p < .001$).

When comparing the experimental group with the control group in the post-test using an independent samples Student’s t-test, significantly higher perceptions were observed in the experimental group across all dimensions ($p < .001$).

Table 11

Paired samples Student’s t-test (Experimental Group Pre-Post)

Dimension	Pre-test (M±SD)	Post-test (M±SD)	t	p-value	Interpretation
Artificial Intelligence (AI)	2.8 ± 0.6	4.3 ± 0.4	-28.45	<.001***	Significant difference in favour of the post-test.
Virtual Reality (VR)	2.7 ± 0.7	4.4 ± 0.5	-30.12	<.001***	Significant difference in favour of the post-test.
Innovative Assessment Models	2.6 ± 0.5	4.3 ± 0.3	-26.89	<.001***	Significant difference in favour of the post-test.
Overall Perception and Usability	2.7 ± 0.6	4.5 ± 0.4	-32.08	<.001***	Significant difference in favour of the post-test.

Note. The data reflect the means (M) and standard deviations (SD) of perceptions in the experimental group before and after the intervention. The paired samples Student’s t-test revealed highly significant differences across all dimensions, with p-values < .001.

Table 12

Independent samples Student's t-test (Experimental vs. Control Groups Post-test)

Dimension	Experimental (M±SD)	Control (M±SD)	t	p-value	Interpretation
Artificial Intelligence (AI)	4.3 ± 0.4	3.0 ± 0.6	21.67	< .001***	Experimental group demonstrated superior perceptions.
Virtual Reality (VR)	4.4 ± 0.5	3.1 ± 0.7	19.54	< .001***	Experimental group demonstrated superior perceptions.
Innovative Assessment Models	4.3 ± 0.3	3.0 ± 0.5	22.01	< .001***	Experimental group demonstrated superior perceptions.
Overall Perception and Usability	4.5 ± 0.4	3.2 ± 0.6	23.88	< .001***	Experimental group demonstrated superior perceptions.

Note. Means (M) and standard deviations (SD) are presented for the experimental and control groups in the post-test phase. The independent samples Student's t-test showed significant differences ($p < .001^{***}$) in favour of the experimental group across all dimensions.

One-way ANOVA (Comparison Across Three Countries in Post-test)

Lastly, the one-way analysis of variance (ANOVA) revealed significant differences among the three participating countries, particularly favouring Peru, which reported the highest means in overall perception. Post hoc tests confirmed differences between Peru and Mexico, as well as between Peru and Ecuador in certain dimensions.

Table 13

One-way ANOVA Results

Dimension	F	p-value	Partial η^2	Interpretation
Artificial Intelligence (AI)	8.43	< .001***	0.06	Significant differences among countries.
Virtual Reality (VR)	5.97	.003**	0.04	Significant differences among countries.
Innovative Assessment Models	4.88	.008**	0.03	Significant differences among countries.
Overall Perception and Usability	7.14	.001**	0.05	Significant differences among countries.

Note. Results correspond to the one-way ANOVA comparing perceptions across the three countries during the post-test phase. Significant differences were observed in all dimensions ($p < .01^{**}$), confirmed via Tukey and Bonferroni post hoc tests.

Post hoc (Tukey) findings:

- Ecuador vs. Mexico: No significant differences ($p > .05$).
- Ecuador vs. Peru: Peru slightly superior ($p < .05$).
- Mexico vs. Peru: Significant differences in favour of Peru ($p < .01$).

13. Qualitative Analysis Results – Expert Interviews

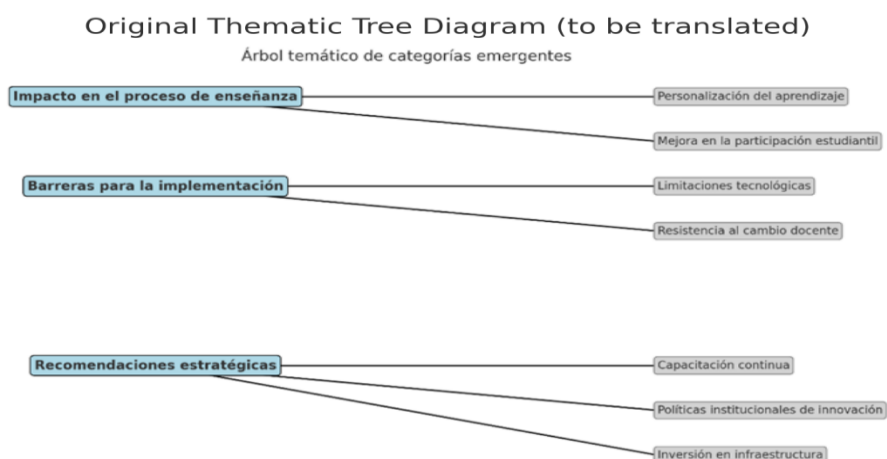
The semi-structured interviews conducted with five experts in higher education and emerging technologies provided a strategic perspective on the implementation of artificial intelligence, virtual reality, and innovative assessment models. The qualitative analysis, processed using NVivo software, led to the identification of three main categories and eight emerging subcategories.

Table 14
Main and Emerging Subcategories from Qualitative Analysis

Main Category	Subcategory	Representative Quote
Impact on Teaching Processes	Personalisation of Learning	“These technologies enable addressing different learning paces and styles.” (Expert 1)
	Enhanced Student Engagement	“Virtual reality fosters active and collaborative learning.” (Expert 3)
Implementation Barriers	Technological Limitations	“Infrastructure is a major barrier, particularly in rural institutions.” (Expert 4)
	Resistance to Change Among Lecturers	“Some lecturers still perceive AI as a threat to traditional methods.” (Expert 2)
Strategic Recommendations	Continuous Training	“It is essential to train lecturers in the pedagogical use of these tools.” (Expert 5)
	Institutional Innovation Policies	“A regulatory framework is needed to support technological integration.” (Expert 1)
	Investment in Infrastructure	“Without appropriate devices, even the best proposals remain theoretical.” (Expert 3)

Summary. The analysis highlights that experts recognise the positive impact of emerging technologies on teaching and learning processes, particularly the personalisation of learning and enhanced student engagement. However, they also noted significant barriers, including technological limitations and resistance to change among some lecturers. Strategic recommendations emphasise the need for continuous professional development, clear institutional policies, and sustained investment in technological infrastructure to ensure the long-term success of these initiatives.

Figure 3
Thematic Tree



14. Discussion

The results obtained demonstrate a positive impact from the integration of emerging technologies—artificial intelligence (AI), virtual reality (VR), and innovative assessment models—on the perceptions and performance of university lecturers and students in Ecuador, Mexico, and Peru. Both the experimental group and the qualitative analysis of interviews with specialists highlighted the capacity of these tools to personalise learning, increase student engagement, and facilitate more efficient feedback processes. These findings suggest that the proposal significantly contributes to improving educational quality in Latin American contexts.

This research aligns with the findings of Pérez-Escoda et al. [18], who identified the development of digital competences in higher education as a key factor for the successful integration of technology. Similarly, Salas Pilco and Yang [19] emphasise the growing use of AI in Latin American universities, although they warn of inequalities in technological infrastructure—an issue also highlighted by the specialists interviewed in this study.

The results are also consistent with Antón Sancho et al. [6], who demonstrated the potential of VR to enhance students' active participation and the development of practical competences. Crompton and Burke [9] underline that AI is transforming assessment processes through automated feedback, a central element in the evaluated proposal.

In the Latin American context, UNESCO IESALC [23] and OEI [25] agree that digital transformation represents both an opportunity and a challenge, particularly in terms of equity and institutional policies. These convergences reinforce the relevance of the results obtained in this investigation.

The findings have important implications for higher education in Latin America. First, they demonstrate that adopting emerging technologies can help to close gaps in educational quality, provided that they are accompanied by lecturer training strategies and institutional innovation policies [30]. Second, they highlight the need for sustained investments in technological infrastructure to ensure effectiveness and equitable access [35]. Finally, the study underscores the urgency of designing regulatory frameworks to govern the ethical and pedagogical use of AI and VR in educational contexts [36].

The main limitations identified include: (a) restricting the sample to three universities, which may limit the generalisability of the findings; (b) the reliance on specific technologies (e.g., Gradescope, ClassVR), which may not represent all solutions available on the market; and (c) potential response biases in the questionnaires, given the self-reported nature of perceptions.

Future research should consider longitudinal studies to assess the sustained impact of these technologies on academic performance and student motivation. It would also be pertinent to explore the development of specific digital competences among lecturers and students [15] and to carry out comparative analyses in different socio-economic contexts in Latin America. Finally, investigating new emerging technologies, such as educational metaverses, and their integration into hybrid learning environments is recommended.

15. General Conclusions

The integration of emerging technologies—artificial intelligence, virtual reality, and innovative assessment models—has shown a significant impact on improving educational quality in universities in Ecuador, Mexico, and Peru. This impact is evident in the increased positive perceptions and improved academic performance observed in the experimental groups.

Lecturers and students recognised the effectiveness of these tools in personalising learning, facilitating the understanding of complex content, and optimising assessment and feedback processes. Interviews with specialists confirmed that, although barriers such as limited technological infrastructure and resistance to change exist, the opportunities outweigh the challenges when accompanied by appropriate institutional policies and continuous professional development for teaching staff.

The study highlights the urgent need to strengthen digital competences within the Latin American university community as a cornerstone for sustainable educational transformation. The results support the recommendations of international organisations regarding the importance of implementing normative and strategic frameworks for the ethical and effective integration of emerging technologies in higher education.

16. Recommendations for Universities and Educational Policies

For Universities

- Develop continuous professional development programmes for lecturers in the pedagogical use of AI and VR, ensuring a critical and ethical approach in their application.
- Strengthen technological infrastructure (access to devices, connectivity, and educational platforms) to guarantee equity in the use of these tools.
- Promote interdisciplinary pilot projects to assess the progressive adoption of emerging technologies across different academic fields.
- Implement innovative assessment systems supported by AI that provide automated and personalised feedback.

For Educational Policies

- Formulate public policies and normative frameworks that guide the integration of emerging technologies in higher education, taking into account the socio-economic particularities of each country.
- Encourage partnerships between universities, governments, and technology companies to facilitate the transfer of knowledge and resources.
- Design regional strategies to ensure digital inclusion and reduce the technological gap in Latin America.
- Consider adopting international standards for digital competences to assess and certify the technological preparedness of lecturers and students.

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