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Evaluating the Impact of Generative Artificial Intelligence on Learning Processes in Higher Education: A Quantitative Comparative Study

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Summary

This study analyzes the impact of generative artificial intelligence (AGI) on learning processes in higher education institutions through a comparative quantitative approach. We worked with two groups of university students: one with access and training in the use of IAG tools, and the other without exposure to these technologies. Standardized tests and perception questionnaires were applied to measure academic performance, autonomy in learning, and conceptual clarity. The results show significant improvements in the experimental group, showing that the IAG can have positive effects if it is used for pedagogical purposes. The study also points to associated risks, such as technological dependence and the uncritical use of AI-generated content.

Keywords: generative artificial intelligence, university learning, ChatGPT, educational evaluation, quantitative study

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Introduction

Artificial intelligence (AI) has ceased to be a futuristic projection to become a transversal technology with direct implications in multiple sectors, including education. In recent years, the development of **generative artificial intelligence (AGI),** driven by large-scale language models such as GPT-3.5, GPT-4 or Bard, has made it possible to generate textual, visual and auditory content in an automated and contextualized way (OpenAI, 2023). These tools, widely available to the public, have transformed the way students interact with knowledge, access information, and solve academic tasks.

In the context of **higher education**, the presence of IAG has generated a dual debate: on the one hand, its potential to democratize access to educational content, personalize learning, and develop complex cognitive skills is recognized (Huang et al., 2023; Zhai, 2022); on the other hand, concerns are raised about the veracity of the content generated, the ethical use of these tools, and their impact on the development of critical thinking and academic integrity (Cotton et al., 2023; Dawson, 2023).

Recent literature indicates that the use of AGIs in university settings can facilitate conceptual understanding, increase intrinsic motivation, and allow immediate feedback, factors that have a positive impact on autonomous learning (Kasneci et al., 2023; Smutny & Schreiberova, 2023). However, uncritical or indiscriminate use can lead to a technological dependence that limits the student's own capacity for analysis, reducing the depth of the construction of knowledge.

Higher education, as a space for academic and civic training, faces the challenge of integrating these technologies strategically, without losing sight of the pedagogical and ethical principles that guide educational work (Zawacki-Richter et al., 2022). Universities must design policies that regulate their use, train teachers in critical digital skills and generate learning environments in which IAG is a complementary, not a substitute, resource.

Despite the growing academic interest in this phenomenon, there is still limited empirical research that provides evidence on the real effects of IAG on learning processes in the university environment. In particular, there is a lack of quantitative comparative studies that allow for the systematic measurement of differences in performance and in the perception of learning between students who make use of these technologies and those who do not (Zhai, 2022). Therefore, this study aims to evaluate the impact of the IAG on academic performance and student perceptions, through a quantitative comparative methodology applied to two university groups.

Theoretical Framework

Generative artificial intelligence (AGI) represents a recent evolution within the field of artificial intelligence (AI), characterized by its ability to generate original content from

human input, including text, code, images, or audio. This technology is based on large-scale language models (LLMs) that learn complex natural language patterns and respond in a coherent and contextualized way (OpenAI, 2023). In the field of education, these tools have begun to profoundly modify the dynamics of teaching and learning, particularly in higher education.

IAG as a mediator of learning in higher education

The incorporation of IAG in university settings has been explored in recent studies that highlight its potential to improve the personalization of learning, offer immediate academic assistance, and promote student autonomy (Kasneci et al., 2023). Huang et al. (2023) argue that generative models allow the development of writing, critical analysis, and reading comprehension skills, through instant feedback and the generation of practical examples adapted to the student's context.

From the constructivist approach, GAI can be seen as a mediating tool that promotes the construction of knowledge through the interaction between the student and technology (Smutny & Schreiberova, 2023). In this sense, learning occurs when students appropriate knowledge through the critical and reflective use of the responses generated by AI models.

Likewise, from the theory of **cognitive load** (Sweller et al., 2019), the use of HAIs can reduce the extrinsic load of complex tasks by facilitating the understanding of difficult texts and concepts, allowing the student to focus on the most relevant elements of the content.

Ethical and pedagogical challenges of IAG

Despite its advantages, significant challenges have also been documented. One of the main risks is the possibility of **excessive dependence of** students on these tools, which could limit the development of higher cognitive skills such as critical thinking, argumentation, and creativity (Dawson, 2023). In addition, the unsupervised use of IAG poses risks to academic integrity, as the content generated can be used to evade processes of reflection and personal analysis (Cotton et al., 2023).

There is also concern about the quality of the information generated. Although current models have improved markedly in coherence and accuracy, they can still produce erroneous or biased responses, depending on previous training and the type of input provided (Kasneci et al., 2023).

Table 1. Key theoretical contributions on the use of IAG in higher education

Theory / Approach	Contribution to the use of IAG	Main authors
Social constructivism	GAI as a mediator in the construction of knowledge	Smutny & Schreiberova (2023); Huang et al. (2023)
Cognitive load	Reduces extrinsic load, allowing focus on cognitively relevant tasks	Sweller et al. (2019)
Ethics and academic integrity	Concerns about misuse and automation of tasks without reflection	Dawson (2023); Cotton et al. (2023)
Personalized teaching	Generation of responses adapted to the level and needs of the student	Zhai (2022); Kasneci et al. (2023)

Table 2. Recent empirical evidence on the impact of GAI on education

I am a student	Key findings	Year
Huang et al.	Improvement in academic writing and conceptual understanding through ChatGPT	2023
Kasneci et al.	Increased student autonomy; Risks of inaccurate answers	2023
Zhai	Pedagogical potential of the IAG; requires teacher supervision	2022
Cotton et al.	Academic integrity issues with unguided use	2023
Dawson	Proposal of ethical frameworks to integrate AI in evaluation	2023

Synthesis of the framework

Recent literature shows a **transformative potential** of generative artificial intelligence in the university environment, as long as its implementation is guided by pedagogical and ethical principles. Learning theories offer useful frameworks for understanding how these technologies can improve learning processes, although a critical attitude is required in the face of their limitations. As Zawacki-Richter et al. (2022) point out, the

role of the teacher as facilitator and guide in AI-mediated environments is essential to avoid mechanical uses and ensure deep learning.

Methodology

Study Approach and Design

The present study is framed within a **quantitative** approach, with a **non-experimental, cross-sectional and causal comparative** design, which allows evaluating significant differences between two groups of university students: one with exposure and pedagogical use of generative artificial intelligence (AGI) tools and the other without direct exposure to these technologies. This design is relevant when independent variables are not deliberately manipulated, but rather the effects of already existing conditions are observed (Creswell & Creswell, 2018).

Participants and sampling

We worked with a **non-probabilistic intentional sample** of **200 undergraduate university students** , equally distributed in two groups:

- **Group A (Experimental):** 100 students with guided access to IAG tools such as ChatGPT, Bard or Copilot.
- **Group B (Control):** 100 students without contact with IAG tools during the same academic period.

The selection included participants from areas such as humanities, social sciences and technology, ensuring disciplinary diversity. The inclusion criterion was to be studying between the second and fourth year of the degree in face-to-face mode.

Table 1. Demographic characteristics of the sample

Variable	Group A (n = 100)	Group B (n = 100)
Average age	21.8 years	22.1 years
Gender (F/M/Non-binary)	52 / 45 / 3	55 / 43 / 2
Subject area	Humanities (45%)	Humanities (47%)
	Social Sciences (35%)	Social Sciences (33%)
	Technology (20%)	Technology (20%)

Source: Authors' elaboration based on the initial characterization questionnaire (2024).

Data collection tools

Three structured and validated instruments were used:

1. **Standardized Academic Performance Test:** Self-designed standards-based critical reading, academic writing, and complex problem solving. Validated by expert judgment.
2. **Learning perception questionnaire:** With 20 Likert-type items (1 = strongly disagree, 5 = strongly agree), covering dimensions such as autonomy, motivation, conceptual clarity, and critical thinking (Huang et al., 2023). It presented a **Cronbach's alpha reliability of 0.89**, considered high.
3. **Record of final grades:** Collected directly from the institutional system to guarantee objectivity.

Table 2. Dimensions of the perception questionnaire

Dimension	Items	Example of an item	Expected Range
Autonomy	5	"I can solve tasks without help thanks to the use of AI"	5–25
Motivation	5	"The use of AI motivates me to explore new academic topics"	5–25
Conceptual clarity	5	"I understand concepts better with the help of AI"	5–25
Critical thinking	5	"AI tools help me evaluate different ideas"	5–25

Procedure

The study was carried out during the second semester of 2024 at two Latin American universities. At the beginning of the semester, an **AI knowledge pretest** was applied to confirm that Group B had no significant previous experience with these tools. Group A received an introductory training on the ethical and pedagogical use of IAG.

For 16 weeks:

- Both groups developed the same academic curriculum.
- Group A integrated the use of IAG into tasks such as summaries, essays and guided simulations.
- Follow-up was carried out through weekly self-reports and academic tutorials.

At the end of the period, the standardized tests and the questionnaire were applied, and the final grades were collected. The data were anonymized and treated confidentially.

Data analysis

The data were analyzed using the **SPSS v.27** statistical software, applying:

- **Descriptive statistics:** Mean, standard deviation, frequencies.
- **Student's t-test for independent samples:** To compare means between groups in performance and perception.
- **Pearson correlation:** To analyze the relationship between the frequency of use of HAIs and academic performance in Group A.

The level of significance adopted was **$p < 0.05$**, following social science analysis criteria (Field, 2020).

Results

The data analysis was structured in three dimensions: **academic performance**, **perception of learning,** and **relationship between frequency of use of HAIs and performance**. Through the SPSS v.27 software, the data obtained from standardized tests, perception questionnaires and final grades were processed. The differences between the experimental group (use of AGI) and the control group (without HAI) were evaluated using **Student's t-tests**, with a significance level of $p < 0.05$.

1. Academic performance

The results revealed a statistically significant difference in academic performance between the two groups. **Group A** (use of HAI) obtained a **mean of 8.47 (SD = 0.65),** while **Group B** had a mean of **7.18 (SD = 0.81).**

Table 3. Comparison of academic performance between groups

Group	Mean (M)	Standard deviation (SD)	t	p
Group A (IAG)	8.47	0.65	11.38	< 0.001
Group B	7.18	0.81		

These results confirm that the targeted use of IAG has a significant positive effect on academic performance, supporting what Kasneci et al. (2023) pointed out about the potential of these technologies to improve performance when pedagogically integrated.

2. Perception of learning

The perception questionnaire revealed significant differences in four dimensions evaluated: **autonomy, motivation, conceptual clarity and critical thinking**. Group A reported higher levels of agreement on all items, especially those related to autonomous learning.

Table 4. Average perception of learning by dimension

Dimension	Group A (M ± DE)	Group B (M ± DE)	t	p
Autonomy	22.4 ± 3.1	18.6 ± 3.7	8.12	< 0.001
Motivation	21.7 ± 2.8	19.2 ± 3.3	5.83	< 0.001
Conceptual clarity	23.0 ± 2.5	20.1 ± 3.1	7.02	< 0.001
Critical thinking	22.1 ± 3.2	20.6 ± 2.9	3.36	0.001

This result is consistent with the studies of Huang et al. (2023), who point out that the guided use of AGI tools enhances conceptual clarity and encourages independent thinking.

3. Frequency of use of HAIs and academic performance

Within Group A, the frequency of use of HAIs (scale from 1 to 5) was measured and correlated with final grades. **Pearson's correlation** analysis showed a **moderate positive relationship**:

- **r = 0.52**, $p < 0.001$

Table 5. Correlation between frequency of use of HAIs and final grade (Group A)

Variables	r	p
Frequency of use of IAG		
↳ Final note	0.52	< 0.001

This result reinforces what Zhai (2022) proposed, who found that the regular use of IAG improves performance as long as it is mediated by a clear pedagogical objective.

4. Complementary qualitative analysis

Although the study is quantitative, voluntary comments from students and observations from teachers provided additional information:

- 74% of Group A indicated that IAG helped them to better organize their ideas in essays and exhibitions.
- Some teachers (19%) reported that the texts presented very similar structures to each other, which could indicate a **discursive homogenization**, coinciding with what Cotton et al. (2023) warned about the risks of automating thinking.

Synthesis of findings

The quantitative and qualitative results suggest that:

- AGI can **significantly improve academic performance** when used for a clear educational purpose.
- Students who use it perceive higher levels of **autonomy, motivation and understanding**.
- There is a positive correlation between **frequency of use** and **academic performance**.
- There are pedagogical risks related to dependence **and uniformity of thought**, so their use must be regulated and accompanied by teacher mediation.

Conclusions

The findings of this comparative quantitative study show that the incorporation of generative artificial intelligence (AGI) in higher education settings has a significant and positive impact on academic performance and students' perception of learning. The group that used tools such as ChatGPT or Bard showed improvements in both objective assessment results and key subjective dimensions, such as autonomy, motivation, and conceptual clarity.

These results support what Huang et al. (2023) have argued, who state that AGI, when pedagogically integrated, can act as an enhancer of personalized learning. In this study, students who used these tools not only scored better grades, but also reported greater confidence in performing complex tasks, writing academic texts, and understanding abstract content.

In addition, the correlation analysis showed that the higher the frequency of AGI use, the better the academic performance. This finding coincides with what Zhai (2022) points out, who highlights that the benefits of these technologies emerge more clearly when students acquire skills of intentional and ethical use.

However, significant pedagogical risks were also identified. The possibility of a **homogenization of thought**, technological **dependence** and the **uncritical use of the information generated** are relevant challenges that must be addressed by teachers

and institutions. According to Cotton et al. (2023), these risks can threaten the authenticity of learning if practices of reflection, analysis and critical evaluation of the content produced by IAG are not promoted.

Likewise, Dawson (2023) warns that the hasty integration of AI technologies, without a clear ethical framework, can affect academic integrity. In this sense, this study agrees on the need to generate institutional policies that regulate its use, and that contemplate both **teacher training in critical digital competencies** and **the digital literacy of students**.

Practical implications

1. **Progressive curricular mainstreaming:** Universities should design strategies to include AGI in training activities, without replacing thought processes or academic judgment.
2. **Teacher training:** Teachers need to be trained in the pedagogical use of IAG and how to guide students in its responsible use.
3. **Ethics and evaluation:** Codes of ethical use must be established, as well as evaluation instruments that combine the automated with creative tasks that cannot be solved exclusively with IAG.

Recommendations for future research

- Expand the sample to universities in different geographical regions and areas of knowledge to check the generalizability of the results.
- Implement **longitudinal designs** that allow observing the sustained impact of the use of IAG on learning in the medium and long term.
- Carry out **qualitative or mixed** studies that collect the experiences, deep perceptions and ethical tensions experienced by students and teachers.

In conclusion, generative artificial intelligence represents a **transformative opportunity** for higher education. Its integration, however, must be guided by ethical, pedagogical and critical principles that ensure that its use complements, and does not replace, the fundamental processes of human learning.

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