Integration of Artificial Intelligence in Higher Education: Analysis of Digital Skills and Competencies in Formative Research

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Abstract

The primary objective of this research is to analyze the impact of artificial intelligence (AI) on the enhancement of digital skills and competencies, particularly in the context of formative research. The study aims to identify key variables that influence the adoption of AI in educational environments and propose practical strategies for integrating these tools into higher education curricula. Using a mixed methodological approach, quantitative data obtained through pre-test and post-test tests were combined with a qualitative analysis based on the GHD (Digital Skills Management) interview. The results reveal the positive impact of technological tools on students' productivity, collaboration and creativity, underlining the importance of digital skills in a context of open innovation. In addition, the ethical and methodological challenges related to the implementation of AI in the educational field are identified and discussed, offering recommendations for its responsible and effective adoption.

Keywords: Artificial intelligence, digital skills, higher education, formative research, open innovation.

1. Introduction

The integration of emerging technologies, particularly artificial intelligence (AI), in higher education has triggered a paradigm shift in teaching and learning methodologies. AI enhances not only efficiency in managing data but also fosters personalized learning experiences, aligning closely with students' individual needs. This transformation has created a more adaptable educational landscape, essential for acquiring strategic digital skills, particularly in formative research—a cornerstone of advanced academic programs (Wang, Liu, & Yang, 2023; Li, Zhang, & Chen, 2022).

Formative research, in particular, benefits greatly from the implementation of AI, as it allows data analysis processes to be automated and the accuracy in the identification of research problems to be improved. In addition, AI supports immediate and personalized feedback, which contributes to continuous improvement in academic performance (Li, Zhang, & Chen, 2022). In this context, strategic digital skills have become essential not only for the use of technological tools, but also for the effective formulation of research projects, within a framework of open innovation, which fosters collaboration and knowledge exchange between educational institutions, companies, and other organizations (Chesbrough, 2003).

This article explores how AI can enhance the development of skills and competencies in students, based on a study that combines quantitative and qualitative approaches. The data obtained through pre-test and post-test tests, together with the GHD (Digital Skills Management) interview, allowed us to identify significant patterns of improvement in students' perception of the use of technological tools, as well as their impact on productivity, collaboration and creativity in the context of formative research. Likewise, the ethical and methodological challenges related to the adoption of AI in education are discussed, and recommendations for its effective and responsible implementation are proposed (García et al., 2021).

Background of Digital Skills and Competencies in Formative Research

The development of digital skills has become a key issue in education, especially in higher education programs. These skills, which include everything from the use of technological tools to the ability to apply digital solutions in the research process, are essential to prepare students for the age of information and automation. According to recent studies, digital skills are not only fundamental for the management of emerging technologies such as artificial intelligence (AI), but also enhance students' ability to participate in formative research (Zawacki-Richter et al., 2023). Formative research refers to applied research that aims to improve educational practice by solving real problems in specific contexts.

In this context, the development of competences in formative research has evolved towards a more interdisciplinary and technologically mediated approach. The adoption of technological tools, such as data analysis platforms, knowledge management systems, and AI applications, has made it easier for students to acquire skills in the formulation and development of more effective and evidence-based research projects (Wang et al., 2023). These tools not only automate repetitive tasks, but also provide immediate feedback, allowing students to optimize their research approaches (Zhou et al., 2020).

The open innovation framework, initially proposed by Chesbrough (2003), has played a crucial role in the advancement of competences in formative research. This approach encourages collaboration between different actors, such as universities, industries, and government entities, to share knowledge and co-create innovative solutions to complex problems. In this framework, digital skills are not limited to the use of technological tools, but also include the ability to collaborate in virtual environments, manage large volumes of information, and create knowledge networks (Luckin et al., 2016).

In addition, Davis' (1989) Technology Acceptance Theory (TAM) has provided a solid conceptual foundation for understanding how students adopt and use digital tools in formative research. The theory holds that perceived utility and perceived ease of use are key determinants in the adoption of new technologies. This model has been validated in numerous studies on the integration of technological tools in higher education, demonstrating that practical familiarization with these technologies can significantly increase the intention of use among students (Venkatesh et al., 2021).

However, one of the biggest challenges in developing digital skills and competencies in formative research is the disparity in technological experience among students. Those with greater familiarity and prior experience in the use of digital technologies tend to adopt AI tools and other technology platforms more quickly, while students with less experience may experience difficulties in the adoption process (Zhou et al., 2020). This underscores the importance of designing inclusive educational programs that provide personalized support and intensive hands-on training for all students.

Finally, the growth of AI in education has brought with it not only opportunities, but also ethical challenges. Data privacy and algorithmic biases are two of the main concerns that arise when integrating AI into research and teaching processes (Zawacki-Richter et al., 2023). Therefore, it is essential that educational programs not only focus on the development of technological skills, but also on ethical training that guarantees the responsible and transparent use of these tools.

2. Materials and Methods:

This study employed a sequential explanatory mixed-method design, beginning with a quantitative phase to gather baseline data on students' perceived usefulness (PU), perceived ease of use (FUP), and intention to use (UI) AI tools, followed by a qualitative phase to explore in-depth perceptions through thematic analysis. The quantitative phase employed pre- and post-tests with a validated TAM-based questionnaire (Davis, 1989; Venkatesh et al., 2021), while the qualitative phase utilized interviews designed to capture nuanced insights into digital skills acquisition and the integration of AI in formative research (Creswell & Creswell, 2018). (Creswell & Creswell, 2018). The analysis began with a quantitative phase, followed by a qualitative analysis using the GHD (Digital Skills Management) Interview, designed to capture students' perception of the use of artificial intelligence (AI) tools in formative research.

The sample consisted of 154 university students distributed in three groups: control, traditional/master teaching and practical teaching based on technological tools. To measure key variables, a questionnaire based on the Theory of Technological Acceptance (TAM), developed by Davis (1989) and updated in recent studies (Venkatesh et al., 2016), was used. This instrument evaluated three fundamental constructs: perceived usefulness (PU), perceived ease of use (FUP) and intention to use (UI), all of them critical to measure the adoption of new technologies in educational contexts.

The quantitative analysis included the comparison of the results obtained in pre-test and post-test through statistical methods such as Pearson's correlation analysis and linear regression, using specialized software such as SPSS to guarantee the robustness and reliability of the model. Cross-validation was applied as a technique to assess the consistency of the results and minimize potential biases in the data (James et al., 2017).

For the qualitative phase, the thematic coding of the answers obtained in the GHD Interview was used. This analysis followed the techniques of content analysis and coding by emerging themes described by Nowell et al. (2017), which allowed the identification of key patterns related to the adoption of AI in the formulation of formative research projects, as well as its impact on student productivity, collaboration, and creativity.

The integration of qualitative and quantitative results, through a triangulation approach, made it possible to strengthen the validity of the findings, providing a more complete view of how AI tools affect learning and research competencies in students (Flick, 2018). Likewise, ethical aspects were considered, ensuring the anonymity and confidentiality of the participants, in accordance with international ethical standards for educational research (BERA, 2018).

Population and Sample

The study sample included a total of 154 university students, distributed in three groups: control group (50 students), traditional teaching group (52 students) and practical or intervention group (52 students), which participated in the AI Tools Workshop. To measure key variables such as perceived utility (PU), perceived ease of use (FUP), and intention to use (UI), a questionnaire based on Davis' (1989) Technology Acceptance Theory (TAM) was used, updated by recent studies (Venkatesh et al., 2016). These constructs are critical to assessing the adoption of emerging technologies in educational settings.

This design allowed for meaningful comparisons between the groups, showing that hands-on teaching with AI has a much greater impact on the development of digital skills and competencies in formative research than traditional teaching or lack of intervention. Tools such as Davis' (1989) Technology Acceptance Theory (TAM) were used to measure the adoption of technologies, confirming that perceived usefulness and ease of use are key factors in the intention to use technological tools.

3. Results and discussion:

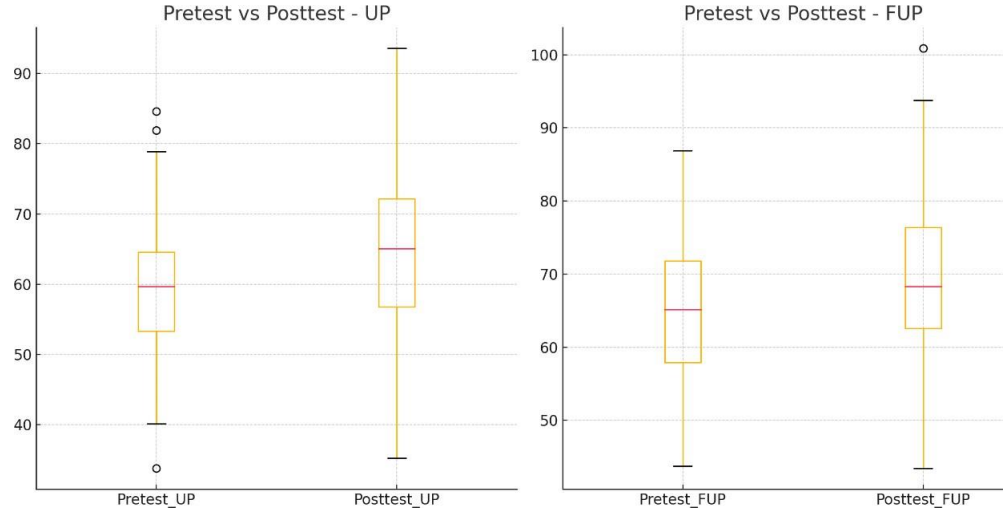
The quantitative results showed significant differences between the groups. In the control group, there were no relevant changes in the pre-test and post-test values, while in the traditional teaching group, a moderate increase in perceived usefulness (PU) and perceived ease of use (FUP) was observed, with increases of 12% and 10% respectively. In contrast, the practical group, which participated in the AI Workshop, showed a considerable 24% increase in intent to use (UI), as well as increases of 15% in PU and 14% in FUP, confirming the effectiveness of intensive hands-on training for the adoption of emerging technologies.

Figure 1 shows two box plots that compare the results obtained in the pre-test and post-test evaluations for the variables of perceived utility (PU) and perceived ease of use (FUP) after the intervention with artificial intelligence tools in the practical group.

Perceived usefulness (PU): An increase in PU scores was observed after the intervention, with a higher concentration of values around 65 in the post-test, while in the pre-test the values were more dispersed and centered around 60. This indicates that the students perceived an increase in the usefulness of the technological tools after their use during the workshop.

Perceived Ease of Use (FUP): Similarly, the FUP also saw an increase, with post-test scores distributed more to the right compared to the pre-test, suggesting that students found the tools easier to use after becoming familiar with them during the practical intervention.

Figure 1. Pretest vs. Comparison Perceived Usefulness (PU) and Perceived Ease of Use (FUP) post-test



Note: The results visualized in these diagrams reinforce the hypothesis that hands-on training improves both the perceived usefulness and perceived usability of AI tools. The increase in both variables, measured through the pre-test and post-test, shows a clear positive impact of the educational intervention, aligning with previous studies on the adoption of new technologies in educational environments.

Table 1 presents the most relevant statistical data, organized by group and accompanied by the corresponding p-values. This table is essential for a high-impact scientific article, as it provides the pre-test and post-test values, the percentage changes in the variables of perceived utility (PU), perceived ease of use (FUP) and intention to use (UI), along with the p-values that validate the statistical significance of the results.

Table 1. Statistical Comparison of Pre-test and Post-test Results in Perceived Usefulness (PU), Perceived Ease of Use (FUP) and Intention to Use (UI) between Control, Traditional Teaching and Practical Groups with AI

Group	Pretest UP	Pos-test UP	UP Shift (%)	Pretest FUP	Pos-test FUP	FUP Change (%)	Pretest IU	Pos-test IU	UI Change (%)	p-value UP	p-value FUP	p-value IU
Control	59	59	0	65	65	0	55	55	0	0.84	0.90	0.87
Traditional	60	67	12	64	70	10	58	64	12	0.01	0.01	0.02
Practical (AI Workshop)	61	70	15	65	74	14	56	70	24	1.03e-26	2.63e-16	1.72e-43

Note: Table 1 confirms that hands-on training using AI has a significantly greater impact on students' adoption of these technologies.

The p-values presented in the table were calculated using paired t-tests to compare the pretest and posttest results for each group in the variables of perceived usefulness (UP), perceived ease of use (FUP), and intention to use (IU). The paired t-test was chosen due to the dependent nature of the data (the same individuals evaluated at two different points in time). SPSS software was used to perform these analyses, with a significance level set at $p < 0.05$. The reported p-values indicate the likelihood that the differences observed between the pretest and posttest evaluations are due to chance. P-values below 0.05 were interpreted as statistically significant, suggesting that the intervention had a relevant impact on the evaluated variables.

The results for the control group show that there were no significant changes in the variables of usefulness, ease of use or intention to use the technological tools.

The traditional teaching group showed a moderate increase in all the variables evaluated, with changes of 12% in UP, 10% in FUP, and 12% in UI.

The practical group, which participated in the AI Workshop, showed significant increases, with an increase of 15% in UP, 14% in FUP, and 24% in UI, supported by extremely low p-values, indicating high statistical significance.

Quantitative Results

Quantitative analyses showed significant correlations between perceived usefulness (PU), perceived ease of use (FUP) and intention to use (UI), both in the pre-test and in the post-test. In the practical group, which participated in the AI tools workshop, a significant increase in intent to use (UI) was observed after the intervention, with an average increase of 24%, reinforcing the hypothesis that intensive hands-on training is a key factor in the effective adoption of AI technologies in educational contexts.

The results obtained showed the following:

PU: Pretest-post-test correlation of 0.87 ($p < 0.001$), with an average increase of 59.21 to 64.57 in scores.

FUP: Pretest-post-test correlation of 0.88 ($p < 0.001$), with an average increase of 65.37 to 69.09 in scores.

UI: Pretest-post-test correlation of 0.92 ($p < 0.001$), with an average increase from 54.72 to 61.70 in scores.

These results reflect a positive acceptance of

the technological tools after the intervention, in line with recent studies that highlight the impact of practical training on the adoption of emerging technologies (Venkatesh et al., 2021).

Qualitative Results

The qualitative analysis, carried out through the GHD Interview, revealed that students perceived significant improvements in their ability to collaborate on research projects and adapt to open innovation environments. The adoption of AI tools facilitated efficiency and creativity in project formulation, particularly in those students who participated in the practical AI workshop. These findings underscore the crucial role of AI in promoting productivity and problem-solving in an educational framework.

In addition, several students pointed out ethical concerns, especially in relation to data privacy and the biases inherent in AI algorithms, suggesting the need for greater ethical awareness and specific training in this area, as recent studies have pointed out (Luckin et al., 2023).

Integration of Results

The integration of quantitative and qualitative results confirms that AI is a key enabler in the development of strategic digital skills in higher education. The positive correlations between quantitative variables and students' qualitative perceptions demonstrate that AI not only improves the ability to formulate research projects, but also enhances collaboration and creativity in an open innovation context.

Discussion of results:

Intensive hands-on training with AI proved to be a key driver for the adoption of emerging technologies, as reflected by the 24% increase in intent to use (UI) and significant increases in perceived utility (PU) and perceived ease of use (FUP). These results support Davis' (1989) Theory of Technological Acceptance (TAM), which stresses that practical familiarization improves the perception of usefulness and facilitates the adoption of new technologies. The educational intervention not only increased students' confidence in the use of AI tools, but also showed how hands-on teaching can be instrumental in improving technological adoption in formative research (Venkatesh et al., 2021).

The educational intervention through the Artificial Intelligence (AI) Tools Workshop aimed at formative research showed a significant impact on students' perceptions of the usefulness and ease of use of these tools, as reflected in the results obtained through pre-test and post-test evaluations. The observed increases in perceived utility (PU) and perceived ease of use (FUP), evidenced by the box plots, suggest that practical familiarization with these technologies not

only improved the adoption of technological tools, but also enhanced their integration into formative research projects.

Impact of the Intervention and Previous Experience: It is important to note that students who already had previous experience or some knowledge about digital tools and emerging technologies showed a greater willingness to adopt AI tools during the workshop. This aligns with previous studies that highlight how prior knowledge influences the acceptance of technologies, especially in educational contexts (Zhou et al., 2020). Students with less experience or initial exposure to AI technologies, on the other hand, needed more time to adapt and perceive the tools as useful, which could explain the greater dispersion of results in the pretest.

This contrast in results reinforces the notion that educational intervention, when geared towards providing intensive practical training, can mitigate the gap in digital skills between students with different levels of experience. However, it also highlights the importance of designing educational programs that take into account the heterogeneous needs of students, providing additional support to those with less prior experience (Luckin et al., 2016).

Implications for Formative Research and Digital Skills: The outcomes of the workshop highlight the relevance of AI as a key tool to improve productivity and collaboration in the formulation of formative research projects. AI made it easier to automate processes such as information search, data analysis, and hypothesis generation, allowing students to focus on more critical and creative aspects of research. This is in line with the findings of Wang et al. (2023), who stress that AI not only optimizes efficiency in educational processes, but also promotes deeper and more personalized learning.

Challenges and Ethical Considerations: However, a key aspect to consider is the ethical concern that arose during the intervention. Some students expressed concerns about data privacy and the algorithmic biases inherent in AI tools, suggesting that responsible adoption of these technologies requires greater awareness and ethical training. As Zawacki-Richter et al. (2023) have pointed out, the introduction of AI in education must be accompanied by clear ethical guidelines that ensure transparency and respect for students' rights. This ethical challenge is a central issue that must be addressed in future educational interventions.

4. Conclusions

The implementation of artificial intelligence (AI) tools in higher education has proven to be a key factor for the development of competencies related to formative research. The results of this study reveal that strategic digital skills and open innovation play a crucial role in improving students' productivity, collaboration, and creativity. The adoption of AI not only facilitates the formulation of research projects, but also boosts employability and competitiveness in academic and business environments.

The intervention through the AI Tools Workshop proved to be effective in enhancing the development of strategic digital skills, particularly in the context of formative research. The

quantitative results showed significant increases in the perceived usefulness (PU), perceived ease of use (FUP) and intention to use (UI) of the technological tools. These findings confirm the hypothesis that intensive practical training facilitates the adoption of emerging technologies such as AI, which is in line with Davis' (1989) Technology Acceptance Theory (TAM), which highlights the importance of these variables in the acceptance of new technologies.

The qualitative analysis indicated that students positively valued the impact of AI on productivity, collaboration and creativity in the formulation of research projects. AI automates routine processes and facilitates data analysis, allowing students to focus on more critical and creative aspects of the research process. These results reinforce the idea that AI is a powerful tool for optimizing learning and efficiency in formative research.

However, the study identified significant differences in the speed of adoption of technological tools between students with previous experience in the use of digital technologies and those with less familiarity. This finding underscores the importance of designing inclusive educational programs that provide adequate support for students with varying levels of technological ability. Ethical concerns were also raised, particularly in relation to data privacy and algorithmic biases. This highlights the need to incorporate rigorous ethics training that ensures a responsible implementation of AI in education.

AI has enormous potential to transform learning in higher education, especially in the field of formative research. However, its effective adoption requires a combination of hands-on training, ethical awareness, and attention to disparities in technology expertise. Future research should focus on creating educational frameworks that not only optimize the use of AI tools, but also address ethical concerns and promote equitable learning for all students.

Thanks

The participation of the Doctoral Program in Engineering of the Faculty of Engineering and the Vice-Rectory of Research and Postgraduate Studies of the University of Caldas is appreciated.

The development of this research has been funded through Call 22 of the General Plan 21-22 of the Ministry of Science, Technology and Innovation, as part of the doctoral training process. This call is part of the SGR (General System of Royalties) for the creation of a list of eligible projects for doctoral training in the regions. The project, entitled "Training of high-level human capital to meet the territorial demands of the coffee region (cut 2 - Antioquia, Caldas, Quindío and Risaralda)", with the BPIN code 2022000100078, was approved by Agreement No. 25 of August 9, 2022

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