Exploring the Impact of Artificial Intelligence Generative Tools on Research in Higher Education Institutions: A Perspective from Portugal

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Abstract: Artificial Intelligence (AI) generative tools have emerged as transformative instruments in various domains, including research and academia. It is important to see what is positive and what is not. This study focuses on the integration of GAI in Portuguese higher education institutions and explores its multifaceted implications and potential. Our research, conducted through a comprehensive survey between April and June 2023, garnering 77 responses. To this purpose, the analysis will have several insights into the research process, namely, to assess the frequency of use and objectives of using generative AI for higher education research and to explore possible trends and future directions in the adoption and application of generative AI in this field.

Keywords: Generative AI (GAI), Higher education, Personalized learning, Ethical implications, Educational outcomes

1. Introduction

Artificial Intelligence generative (GAI) tools have emerged as transformative instruments in various domains, including research and academia. Technological evolution, and more specifically the launch of ChatGPT on November 30, 2022 (Alier, García-Peñalvo & Camba, 2024), has exponentially increased the use of GAI in higher education. But it's not just ChatGPT, there are a multitude of models competing to provide the best results, which are used through chat applications, web browsers, integrated with different applications or tools embedded in mobile devices (García-Peñalvo. JF, 2024).

Artificial intelligence in academia has been used for different purposes. In a study on Artificial intelligence in higher education until the end of 2022, Crompton and Burke (Crompton, H. & Burkused:2023), found that five usage codes were used: Assessment/Evaluation, Predicting, AI Assistant, Intelligent Tutoring System (ITS) and Managing Student Learning. In a study of the 50 most cited publications on AI in higher education in the WoS database to find researchers' focus of attention (Chu et al., 2022), it was found that AI technology has been used to analyze and provide predictions about learning effectiveness, as well such as student dropout rates, but also to aid learning by giving students appropriate learning recommendations and giving teachers useful information to help improve their teaching strategies and designs.

The potential of these tools is enormous, but many questions arise: positive and negative implications of employing AI generative tools in research within higher education institutions. While these tools offer unprecedented opportunities for innovation, efficiency, and creativity, they pose significant challenges and ethical considerations that necessitate careful examination. The emergence of GAI is having an enormous implication for science educators, and it is important that they question themselves: GAI fit into our research and teaching pedagogy (Cooper, G., 2023), knowing that in the minds of educators there is always a shadow related to potential misuse, as well as the risk of erosion of students' critical thinking skills (Hao, Y., 2024). However, alongside these promising developments, it is imperative to acknowledge the potential pitfalls and ethical dilemmas associated with the widespread adoption of AI generative tools in research. Issues such as bias in algorithms, data privacy concerns, and the displacement of human expertise raise essential questions about the ethical use of AI in academic settings. Furthermore, there is a risk of overreliance on AI generative tools, leading to the erosion of critical thinking skills and the devaluation of traditional research methods.

Although it is a recent topic, as mentioned, there are studies in the literature that show the use of GAI tools in different areas of higher education, namely language learning (Vu et al., 2024), programming teaching (Haindl & Weinberger, 2024) or just to written assignments (Črček & Patekar, 2023). Studies of GAI in higher education

have been carried out all over the world: one study (Polat et al., 2024) found that the United States and the United Kingdom have leading status in production and citation impact; Belgium, Korea, and Canada rank high in citations; The USA, Australia, and China provide most corresponding authors. What can be seen is that Gai's tools are and will change the way we learn and teach in higher education. It's time to see the problem from different perspectives and in several universities worldwide.

Through strategic implementation and ethical governance, AI generative tools can alter high-education research in Portugal, foster a dynamic research environment, empower researchers, and advance knowledge creation and dissemination in the digital age. In this context, the research question arises: "Are Portuguese researchers, in the context of higher education, using generative AI tools as 'collaborators' in their research?". To answer the question and also to find out at what stage the implementation of Artificial Intelligence tools in research in Portuguese higher education is, an online survey was carried out between April 1, 2023 and June 30, 2023, to which 77 responses were obtained. The collected data were processed through descriptive and inferential statistical procedures using the IBM SPSS 29.0 statistical software.

To this purpose, the analysis will have several insights into the research process, namely, to assess the frequency of use and objectives of using generative AI for higher education research and to explore possible trends and future directions in the adoption and application of generative AI in this field.

2. Background and Related Work

In academic, scientific, and business circles, Artificial Intelligence (AI) is acknowledged as a pivotal force driving technological change in the fourth industrial revolution (Mannuru et al., 2023). Notably, substantial strides have been made in this field, with a significant focus on Generative Artificial Intelligence (GAI). GAI, a revolutionary concept, refers to artificial intelligence tools or technologies that generate content, such as text, audio, or video, to produce new, unique, and creative content using the data on which it has been trained (Aydın & Karaarslan, 2023).

Although the concept of generative AI has been used for several years, it was only in the mid to late 2010s that it gained widespread recognition. This growth in popularity was in line with the increase and acceptance of generative models, such as Generative Adversarial Networks (GANs), in the AI research community. GANs, a class of machine learning frameworks introduced by Ian Goodfellow and his team in 2014 (Goodfellow et al., 2014), were crucial in bringing the term generative AI into the limelight. However, the term gained wider recognition, i.e. beyond the research community, around November and December 2022, which aligns with the launch of ChatGPT and other commercial tools (García-Peñalvo & Vázquez-Ingelmo, 2023).

As mentioned earlier, generative AI has the unique ability to create content from existing patterns, a feature that has had a transformative impact on fields as diverse as medicine, social sciences, biology, and particularly research. This transformative potential cannot be underestimated. The tools and applications developed are revolutionizing and enhancing productivity. Moreover, by simplifying various aspects of research, GIA can assist scientists in navigating the increasingly complex landscape of their respective fields, ultimately leading to innovative discoveries and improved research results (Chem, 2023). GAI is at the forefront of today's technological innovation, offering fresh perspectives on how machines can process data and create original and creative content. For Gangwal et al. (2024), one of the most exciting aspects of generative AI in research is its ability to ignite creativity and innovation. Studies have shown that GAI can identify intricate patterns in large data sets and, from these patterns, generate new ideas, concepts, and designs that can inspire new lines of research.

GAI, a new and rapidly evolving field, is transforming research in higher education, presenting opportunities and challenges in several dimensions. The literature review below aims to bring together the results of recent research and learn about central themes and collective undertakings to comprehensively analyze the impact of Generalized Artificial Intelligence (GAI) in the context of research carried out in higher education. In this scenario, a search sequence was built and used in the Scopus database "Generative Artificial Intelligence" AND "Higher education" AND ("research" OR "Research"), without date limitations; the result presented was 45 publications. A search was also carried out on Scopus in which Portugal was added to the search sequence, with one publication result. The second search aimed to find out whether there were any studies in Portugal.

The abstracts of the 45 articles from the search were analyzed to identify which dealt with the topic under analysis, i.e., research carried out by researchers in academic contexts using GAI. From the study carried out it turns out that only two of them present topics in the field. The first (Carabantes, 2023) explores whether chat GPT can replace a reviewer, concluding that AI models have limitations in peer review. Human reviewers are

essential due to ethical and accuracy concerns. GAI tools can help but require improvement and responsible use. The second article (Drug, T. et al., 2023) discusses the use of AI tools in higher education and tourism and hospitality research, highlighting the potential for data collection, analysis and writing in academic research; in parallel, it points out that legal complexities require transparent attribution, clear usage policies and an understanding of the implications. The study in Portugal (Gouveia et al., 2023) on Master's students analyses how they perceive and apply AI in their academic research, concluding that using AI tools in research activities is scarce or non-existent.

3. Methodology

This study is based on the responses to an online questionnaire with the title "Characterizing the use of generative artificial intelligence applications in higher education in Portugal". The information was collected from April to June 2023 and aims to find out which IAG applications are most used in research, how often they are used to support research and what they can do, as well as the strengths and weaknesses of using these applications. Were obtained 77 responses, and the data collected was processed and treated using the IBM SPSS Statistics 29.0 software. The statistical analyses used was reliability analysis (Cronbach's alpha), descriptive measures and graphical representations (for example, boxplot), Spearman correlation and Nonparametric Kruskall-Wallis and Mann-Whitney test.

4. Results and Discussion

The sample is composed by 77 individuals, with a slightly higher percentage of males (59.7%). The participants' ages ranged from 25 to 89 years, with an average age of 51.56 years. Most participants have a PhD (83.1%).

Around 16.9% of the individuals have a background in exact and natural sciences, 28.6% in engineering sciences and technology, 35.1% in social sciences, 10.4% of the participants have a background in the humanities and the remaining participants are distributed among other unspecified areas. Only 14% of individuals do not research in their area of training. Figure 1 shows the distribution of participants' publication frequencies over the last 5 years in the study.
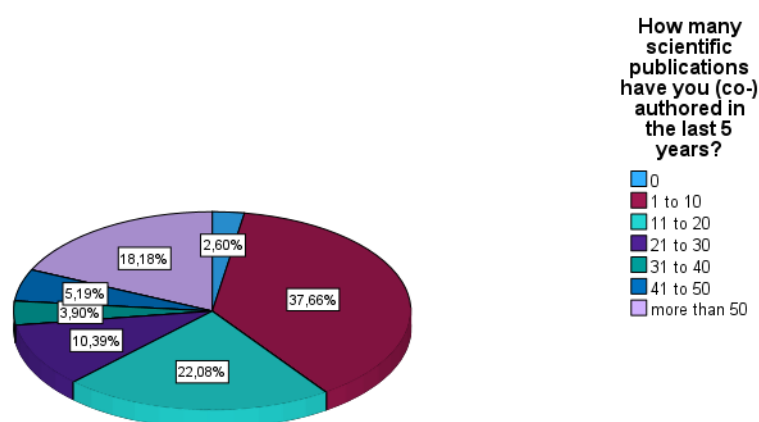

Figure 1: Pie for percentage of quantity of publications in the last 5 years

The questionnaire consists of a question about the GAI tools that are used in research by the participants involved in this study and questions about 4 dimensions, namely 1) what the use of GAI enables (in this context), 2) how often they use GAI to carry out a series of tasks and 3) the strengths and 4) weaknesses of using GAI. Cronbach's alpha reliability analysis was employed to assess whether the variance among items within each dimension (responses to the questions) genuinely stemmed from variations from the perspectives of the participants in the questionnaire.

Cronbach's alpha relies between 0 and 1 and the closer to 1, the greater the reliability. All of the four dimensions presented values which can be considered very good (alpha=0.880, alpha=0.915, alpha=0.884 and alpha=0.790, respectively).

Starting by evaluating which GAI tools were used, a bar chart was constructed showing the percentage use of each of the eighteen tools listed (Figure 2).
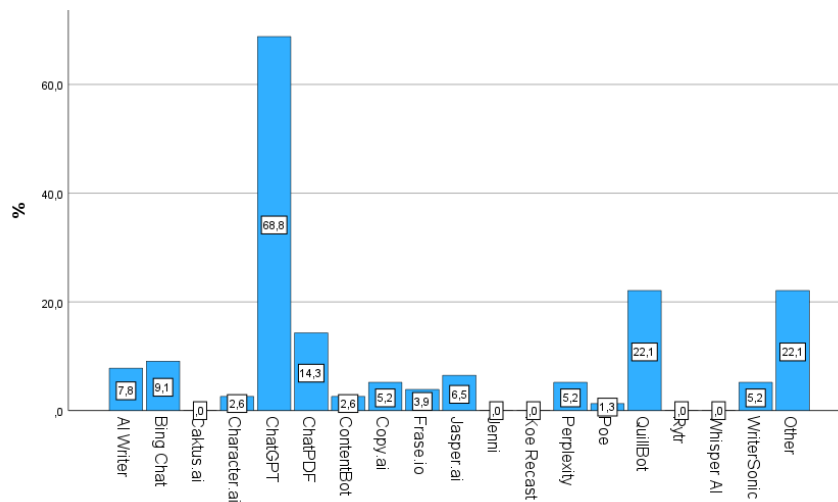
Figure 2: Frequency of use of GAI tools for research

The most used tool is ChatGPT (68.8%), followed by QuilBot (22.1%) and ChatPDF (14.3%). It should also be noted that 22.1% of participants also use tools other than those indicated in the questionnaire.

Next, we analyzed the participants' opinions on what the GAI enables for research (5 Likert scale from 1- Strongly disagree to 5- Strongly agree). Figure 3 shows that at least 75% of participants agree that GAI allows them to "Clarify issues", "Explore historical events", "Simplify scientific concepts", "Summarize articles" and "Simplify difficult vocabulary". Although the responses are more dispersed, at least 50% agree that GAI allows them to "Find important resources" and "Summarize large texts". We should also highlight the existence of some moderate outliers in some topics, namely two in "Clarify issues", "Summarize articles" and "Summarize scientific concepts", three in "Explore historical events" and one in "Summarize difficult vocabularies". The most frequent outlier (participant 15) is a woman with a master's degree and a researcher.
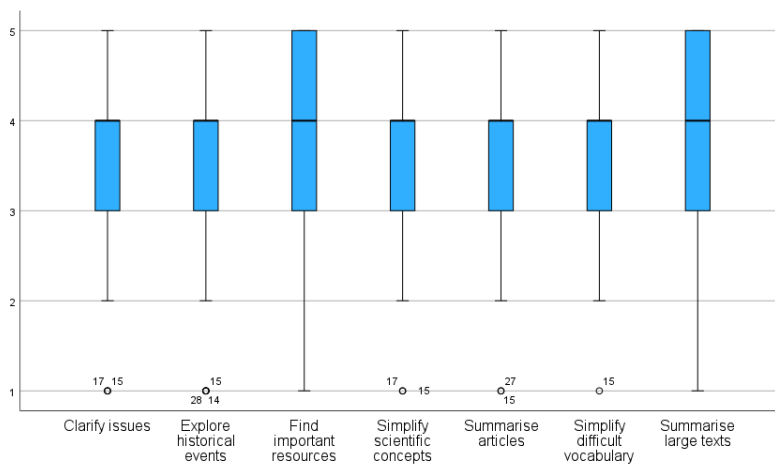

Figure 3: Boxplot for enablers in Research

To analyze the possible association between the information on the number of publications of each of the participants and what the GAI enables in the research, Spearman's rank correlation coefficient was used (given the ordinal nature of the variables in question) which led us to conclude that there is no correlation between the two questions/variables (Table 1).

Table 1: Results of Spearman correlation between enables and number of publications.

Correlations			Clarify issues	Explore historical events	Find important resources	Simplify scientific concepts	Summarize articles	Simplify difficult vocabulary	Summarize large texts
Spearman's rho	How many scientific publications?	Correlation	-.091	-.083	-.017	.026	-.049	-.063	.076
		Sig. (2-tailed)	.429	.476	.882	.825	.671	.586	.511
		N	77	77	77	77	77	77	77

To evaluate potential disparities in agreement regarding what the GAI permits based on participants' gender, the Mann-Whitney non-parametric test was conducted, with results presented in Table 2. We can conclude at a significance level of 5 per cent that there are differences in the degrees of agreement regarding "Clarify issues" (p-value=0.044), "Explore historical events" (p-value=0.034), "Simplify scientific concepts" (p-value=0.003) and "Simplify difficult vocabulary" (p-value=0.028), depending on gender.

Table 2: Results of Mann-Whitney test for enables for research, by gender.

	Clarify issues	Explore historical events	Find important resources	Simplify scientific concepts	Summarize articles	Simplify difficult vocabulary	Summarize large texts
Mann-Whitney U	529.000	517.500	594.500	447.000	547.500	509.500	573.500
Wilcoxon W	1025.000	1013.500	1090.500	943.000	1043.500	1005.500	1069.500
Z	-2.015	-2.115	-1.282	-2.921	-1.803	-2.196	-1.510
Asymp. Sig. (2-tailed)	.044	.034	.200	.003	.071	.028	.131
a. Grouping Variable: Gender							

Analyzing in more detail, through the values of the descriptive measures (mean, quartiles, standard deviation, and coefficient of variation), where these differences exist (Table 3), it was found that in any of the four situations, the male participants tended to agree more with the fact that the GAI enabled them to carry out these tasks. It should be noted, however, that the answers given by female participants show much greater variability than the answers given by male participants. The coefficients of variation associated with the female gender lies between 33% and 38%, while for the male gender is around 20%. This means that the answers given by men are much more homogeneous.

Table 3: Descriptive measures for enables for research, by gender.

Statistics				Clarify issues	Explore historical events	Simplify scientific concepts	Simplify difficult vocabulary
Gender							
Female	n	Valid		31	31	31	31
	Mean			3.45	3.26	3.32	3.19
	Std. Deviation			1.150	1.237	1.045	1.167
	C.V. (%)			33	38	35	37
	Percentiles	25		3.00	3.00	3.00	2.00
		50		4.00	3.00	3.00	3.00
		75		4.00	4.00	4.00	4.00
Male	n	Valid		46	46	46	46
	Mean			4.00	3.87	3.98	3.76
	Std. Deviation			.816	.909	.830	.874
	C.V. (%)			20	23	21	23
	Percentiles	25		3.00	3.00	4.00	3.00

Statistics							
Gender			Clarify issues	Explore historical events	Simplify scientific concepts	Simplify difficult vocabulary
		50	4.00	4.00	4.00	4.00
		75	5.00	5.00	5.00	4.00

Next, we analyzed what the participants say about how often they use the GAI to carry out certain assignments in the research (5 Likert scale from 1- Never to 5- Always) (Table 4). Evaluating all the descriptive measures presented in Table **4**, but given particular attention to the median (since this is ordinal data), we see that participants sometimes use GAI to "Prepare visual aids **(b)**", "Proofreading **(h)**", and "Generate/create ideas **(i)**" and almost never use it to "Write a text based on the results **(a)**", "Interpret a text **(c)**", "Write conclusions **(d)**", "Analyze data **(f)**", "Identify the appropriate teaching methodology **(e)**", "Write a literature review **(g)**" and "Write a discussion of the results **(j)**".

Table 4: Descriptive measures for the frequency of GAI use for some tasks.

		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Mean		2.34	2.51	2.60	2.13	2.39	2.10	2.36	2.64	2.95	2.10
Std. Deviation		1.177	1.231	1.280	1.140	1.237	1.263	1.234	1.347	1.234	1.165
Percentiles	25	1.00	1.00	1.50	1.00	1.00	1.00	1.00	1.00	2.00	1.00
	50	2.00	3.00	2.00	2.00	2.00	2.00	2.00	3.00	3.00	2.00
	75	3.00	4.00	4.00	3.00	3.00	3.00	3.00	4.00	4.00	3.00

The Kruskal-Wallis test was applied to assess the possibility of differences between the degree of frequency attributed to the use of GAI to carry out these tasks, but no statistically significant differences were found; all p-values exceed 0.05.

Applying the same non-parametric test led to the conclusion that there were significant differences at 5% between level of education and "Writing a discussion of the results" and "Writing a text based on the results obtained" (p-value=0.036 and 0.031, respectively). Calculating the correlation for these two cases, we concluded with a significance level of 1% that there is a negative correlation, i.e. the higher the level of education, the less the participants use the GAI to write texts or the results of their research.

It is also interesting to note that are significant differences at 5%, resulting from the application of the Mann-Whitney test, were detected for certain objectives of using the GAI, depending on the area of research, namely with regard to the use of the GAI to "Explain concepts" between participants researching in the area of exact sciences and those in the area of humanities (p-value=0.030) and between participants in the area of engineering and those in the area of humanities (p-value=0.05). In "Idea generation" there were also differences between participants from the social sciences and humanities and finally in "Proofreading" between participants from the engineering and social sciences and between participants from the exact sciences and social sciences.

Figure 4 and Figure 5 refers to the strengths and weakness identified in the use of GAI for research, respectively. For these two questions, an ordinal scale of agreement was used (5 Likert scale from 1- Strongly disagree to 5- Strongly agree).

The strong point with the highest level of agreement was the possibility of answering to questions, where 76.6% of participants agreed or totally agreed. This was followed by agreeing or totally agreeing that GAI generates useful content (74%), helps to complete tasks more quickly (68.8%), improves work efficiency (61%), improves the quality of work (54.5%) and can follow a dialogue coherently (52%). It should also be noted that the most heterogeneous responses are found in the degree of agreement with "It helps me to complete my tasks more quickly", "Understands the nuances of human language" and "Improves work efficiency", i.e. although there are more participants who agree or totally agree, this is where there is less uniformity in the responses. There are also some outliers associated with low levels of agreement, particularly participants with numbers 15 and 17, who are female and from the exact and natural sciences.
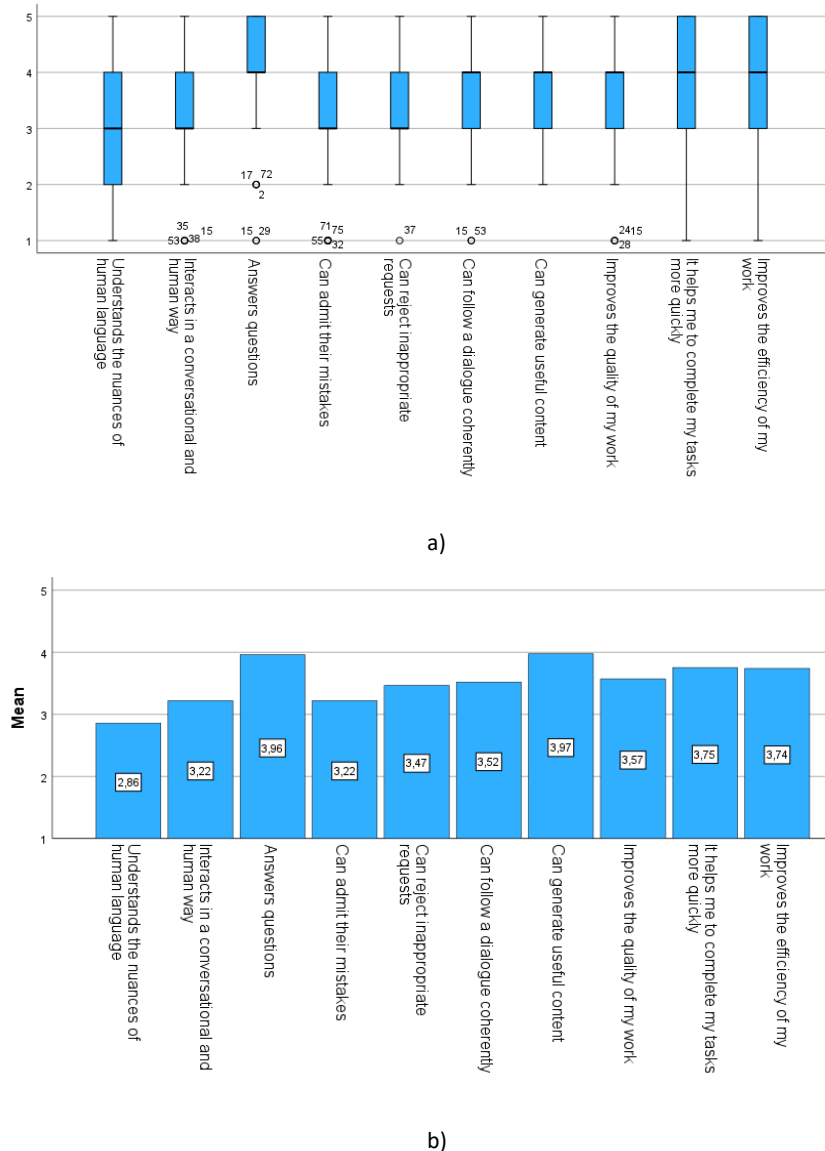
a)

b)

Figure 4: Use of GAI a) Boxplot for strengths   b) Bar for strengths.

Figure 5 shows that the most disagreed points are "Could be banned in my institution" (43% disagree or strongly disagree) and "It could replace many jobs in research and/or teaching" (42% disagree or strongly disagree). On the other hand, 61% of participants agree or totally agree that GAI "Provides bibliographical references that don't exist" and that GAI "Generates false information". The most heterogeneous responses are found in the degree of agreement with "Provides bibliographical references that don´t exist" and "Could decrease the credibility of my work".
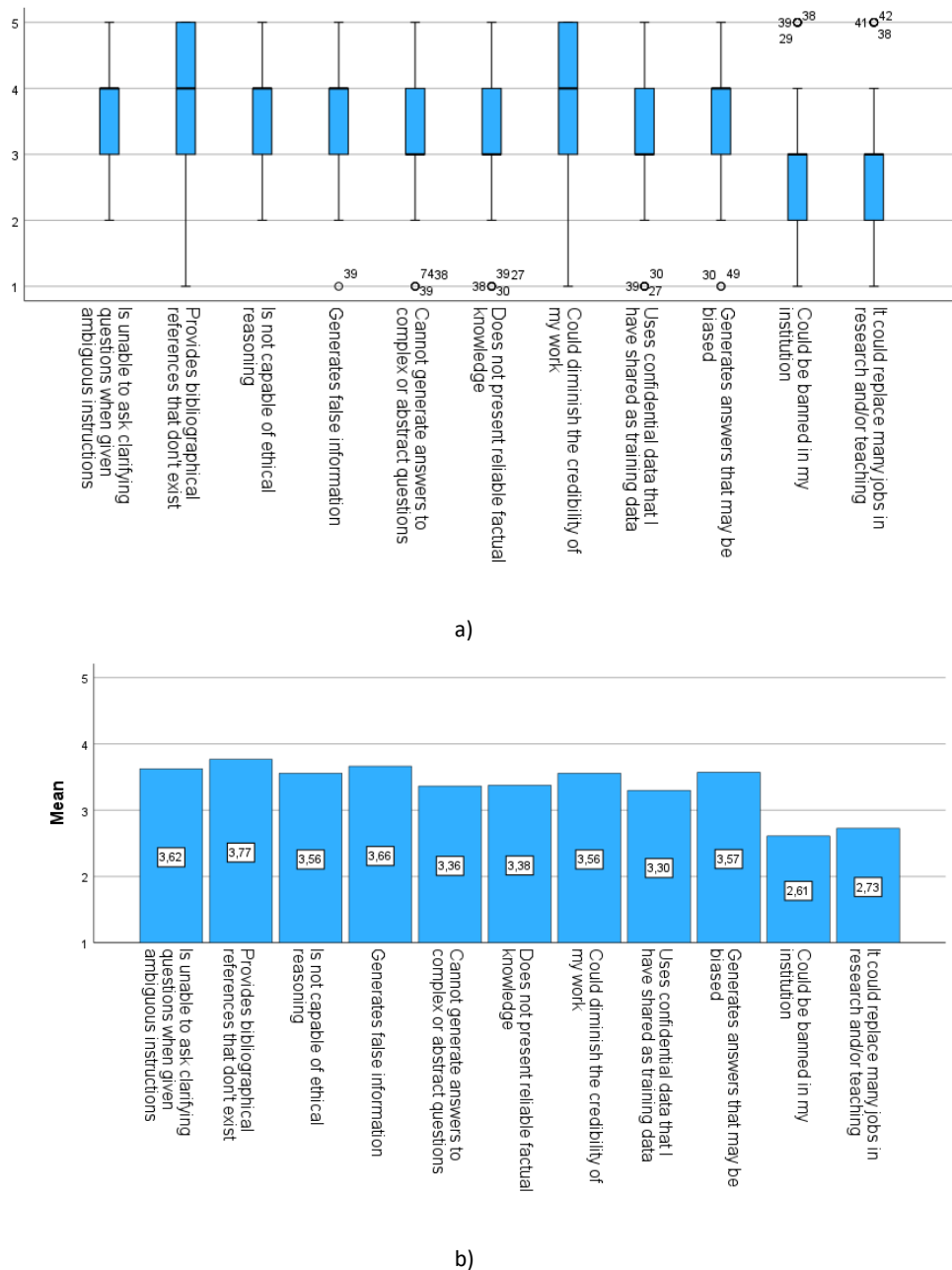
a)

b)

Figure 5: Use of GAI a) Boxplot for weakness b) Bar for weakness.

Also relevant as a weak point, "Could decrease the credibility of my work" where 54.6% agree or totally agree, "Is not capable of ethical reasoning" (52%) and with 50.7%, "Is unable to ask clarifying questions when given ambiguous instructions" and "Generates answers that may be biased".

The questionnaire also included an open question, "What impact does GAI have on Research?". Opinions on the use of AGI in scientific research and higher education are diverse, reflecting a multifaceted view of its potential and challenges. Many acknowledge the usefulness of AI, especially in tasks such as literature filtering, concept clarification, and idea generation. Additionally, they highlight its ability to simplify document writing and provide a broad view of the study area. However, the opinion is unanimous: AI must be employed with caution and full knowledge of its limits. A common concern is the possibility of errors in data affecting the results of AI models, emphasizing the importance of transparency in data collection and usage. In this regard, clear institutional policies are considered essential to mitigate concerns about privacy and academic fraud. In the context of scientific research, generative AI is seen as a tool with significant advantages, but its application requires regulation to ensure responsible use. It is recognized that AI is here to stay, and it is essential to formulate the right questions and continuously validate processes.

While some express uncertainty about AI, others see it as a powerful ally in research (and teaching), provided it is used responsibly. Academic integrity is valued, and institutional policies or norms are considered a valuable contribution to preventing academic fraud.

In summary, AI has the potential to have a profound and lasting impact, facilitating analysis, simplifying work, and providing access to vast amounts of information. However, it is essential to use it with caution, ensuring that it is a supportive tool and not a substitute for human critical thinking. Guidelines for the ethical use of AI in the academic context are suggested, aiming to promote fairness, security, and quality of education.

5. Conclusions and Future Work

GAI, as mentioned, can be defined as a technology based on learning models that generate human-like content, e.g., images and text, in response to complex and diverse requests, e.g., instructions and questions. Because of its potential, the technology is being integrated into research environments. However, as the literature shows, technology and its integration are evolving quickly. Still, the literature in the area needs to show more studies analyzing its integration, regarding the process, into research in the context of higher education.

According to the study carried out regarding the implementation of Artificial Intelligence Generating tools in research in Portuguese higher education, the majority of participants in the study were male, aged close to 50 and with a PhD; the dominant areas of training of these participants are Social Sciences and Technology, with the majority carrying out research in their area of training and in the last 5 years, the number of publications were between 1 and 20 publications (more than 55%).

It was found relevant the following conclusions in relation to the 4 dimensions:

- Dimension 1 (What the use of GAI enables (in this context)): most use ChatGPT as a generative AI application and at least 75% of participants agree that GAI allows them to "Clarify issues", "Explore historical events", "Simplify scientific concepts", "Summarize articles" and "Simplify difficult vocabulary"
- Dimension 2 (How often they use GAI to carry out a series of tasks): participants sometimes use GAI to "Prepare visual aids", "Proofreading", and "Generate/create ideas " and almost never use it to "Write a text based on the results", "Interpret a text", "Write conclusions", "Analyze data", "Identify the appropriate teaching methodology", "Write a literature review" and "Write a discussion of the results".
- Dimension 3 (Strengths of using GAI): the strength with the highest level of agreement was the possibility of answering to questions, where 76.6% of participants agreed or totally agreed. This was followed by agreeing or totally agreeing that GAI generates useful content (74%), helps to complete tasks more quickly (68.8%), improves work efficiency (61%), improves the quality of work (54.5%) and can follow a dialogue coherently (52%).
- Dimension 4 (Weaknesses of using GAI): the most disagreed points are "Could be banned in my institution" (43% disagree or strongly disagree) and "It could replace many jobs in research and/or teaching" (42% disagree or strongly disagree). On the other hand, 61% of participants agree or totally agree that GAI "Provides bibliographical references that don't exist" and that GAI "Generates false information". Also relevant as a weak point, "Could decrease the credibility of my work" where 54.6% agree or totally agree, "Is not capable of ethical reasoning" (52%) and with 50.7%, "Is unable to ask clarifying questions when given ambiguous instructions" and "Generates answers that may be biased".

The survey results show that higher education researchers are already using GAI to support their research. This suggests that not using GAI tools is unrealistic and a misuse of the added value offered by these tools. The GAI tools available can be seen as digital collaborators, allowing more "routine" tasks to be conducted by the tools more productively and effectively. On the other hand, researchers have more time and space to carry out tasks that require innovation and creativity. However, in this favorable context of use, ethical issues should not be ignored, particularly data privacy and the integrity of results. To address these issues, higher education institutions must define and implement regulatory measures to maximize the benefits of the GAI and mitigate its risks.

In future work, several points will be explored to understand and optimize the use of GAI in research. (1) Expand the research to a broader range of researchers, both in terms of the number of institutions and geographical

location, and thus determine the dimension/scope of the use of the tools. (2) Evaluate the impact of the use of GAI tools.

GAI can revolutionize research by shifting the focus from 'routine' work to fostering creativity and innovation, thereby enhancing research effectiveness and efficiency. This transformative potential of GAI in research is a cause for excitement and anticipation. However, it's of utmost importance to reiterate that ethical considerations, among other factors, are not just crucial but integral to the successful and responsible use of GAI in research.

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