Development of AI Guidelines for Engineering Education in Emerging Countries

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Abstract

Artificial intelligence has transformed numerous sectors of society, most notably education. The key observable outcomes include the possibility of personalized learning, the automation of assessment processes, and assistance for teacher and student decision-making. Therefore, it is crucial to comprehend how to develop policies, practices, and training programs that incorporate both the potential of these technologies and the actual conditions for their implementation. The goal of this research is to provide guidelines for the use of AI in education in emerging contexts, assisting institutions and faculty members in the critical and equitable integration of these tools. To create the guidelines, a benchmarking study was conducted with three US colleges, mapping institutional norms and policies that govern the ethical and pedagogical use of AI. In parallel, interviews with students from a Brazilian university were undertaken to learn how AI is being used and to validate and improve the proposed ethical, pedagogical, and technical principles. As a result, a set of guidelines were developed to guide the use of AI in education in emerging contexts, including: (i) allowing faculty autonomy to restrict or encourage the use of AI tools in their practices; (ii) promoting continuous faculty training and professional development focused on pedagogical and technological competencies; (iii) fostering open dialogue with students about ethics, authorship, and learning in the use of AI; and (iv) ensuring curriculum and infrastructure adjustments that guarantee equitable access and use. The suggested recommendations aim to improve institutional trust and create an ethical and critical integration of these technologies in higher education by recognizing the existing reality of AI usage and encouraging discourse among the various parties involved in this process.

Introduction

The advancement of artificial intelligence (AI) has driven significant transformations across multiple sectors of society, affecting productive processes, forms of interaction, decision-making, and knowledge construction. Among these domains, education stands out as one of the most directly impacted areas, as AI has assumed a relevant role in supporting teaching and learning processes [1], [2], [3]. When used with responsibility, critical awareness, and pedagogical intentionality, AI can become an important ally in knowledge development and in the expansion of learning opportunities [4].

Within educational contexts, AI can be applied in different ways and by distinct actors [5]. From the students' perspective, these tools can support the understanding of content not fully assimilated in the classroom, content review, the search for academic materials, as well as the transcription and writing of texts and references that serve as theoretical support for learning [6], [7]. For instructors, AI can contribute to lesson planning, organization of academic documents, development of activities and assessments, and support administrative processes related to teaching management [8]. Regarding assessment, AI-based tools have also been used for the automated grading of exams and assignments [9], as well as for plagiarism monitoring.

Cognitive enhancement, personalized learning, and increased engagement in classroom activities can be strengthened through the use of generative AI [10]. Nevertheless, its adoption must be grounded in ethical and responsible practices [4], [11]. Inappropriate use of AI may reduce students' cognitive engagement, as rapid and automated responses can replace essential stages of the learning process [11].

The indiscriminate use of AI in education also highlights structural and institutional challenges. Limited infrastructure in some higher education institutions, which lack adequate technological support, along with insufficient investment in paid AI platforms, may exacerbate inequalities among students. Another central issue concerns the lack of specific training for both faculty and students, which hinders the understanding of the boundaries between pedagogically meaningful use and practices that compromise learning outcomes [12]. In this context, it becomes essential for educational institutions to establish clear guidelines and promote training initiatives that support the conscious and responsible use of these technologies, helping to balance appropriate and effective AI adoption [13].

The consequences of inappropriate AI use can be observed across different stakeholders. For students, the most significant impact is related to potential impairment of cognitive development due to excessive reliance on AI tools [14], as learning processes may be bypassed through the immediate acquisition of answers generated by automated systems, leading to dependency on such technologies [15]. The ease of producing reports, academic assignments, and scientific texts also complicates assessment processes, making it more difficult to evaluate students' actual learning. In educational contexts characterized by traditional pedagogical practices rather than active learning approaches [16], the perception that knowledge can be easily obtained through AI tends to reduce interest in academic activities [11].

For instructors, the uncritical use of AI-generated content, such as ready-made lesson plans or teaching materials, may result in the dissemination of unverified or inaccurate information [17], compromising the quality of instruction. From the perspective of

academic coordination, there is a growing need to update curricula and course content in line with societal changes, as well as to ensure that faculty and educational professionals remain attentive to these transformations.

Despite the existence of institutional guidelines and policies developed in countries such as the United States [4], [13], [18], many of these recommendations lack adequate contextualization for realities marked by access inequalities, infrastructure limitations, and gaps in faculty training. In some countries, there is limited evidence of consolidated guidelines that serve as a reference for AI use in higher education [19].

Given this scenario, it is relevant to understand how higher education institutions in developed countries have structured guidelines related to the use of AI in education, in order to identify elements that can be adapted to the context of emerging countries [20]. This understanding is complemented by the analysis of students' perceptions and experiences, allowing for insights into how these technologies are used in practice and what challenges are perceived by their users. Therefore, this study aims to explore institutional approaches to AI use in higher education in order to propose context-sensitive guidelines for emerging educational settings.

This study contributes to the literature by developing guidelines for AI use in engineering education that explicitly account for structural inequalities in emerging countries. Unlike existing frameworks, which are based on well-resourced institutional settings, the proposed guidelines are grounded in empirical benchmarking of North American practices and refined through student perspectives from a Brazilian context, enabling their adaptation to environments with limited infrastructure, uneven access, and gaps in faculty training.

This research is associated with the Modernization of Undergraduate Education Program (PMG), supported by Fulbright, CAPES, and the U.S. Embassy in Brazil [21]. Industrial Engineering at the Federal University of Rio Grande do Sul is one of the participating programs. This public university has taken part in the initiative since 2019, with faculty members undertaking missions to partner with North American institutions [21], [22].

Methodological Procedures

This study adopted a qualitative and exploratory approach [23], aiming to investigate institutional practices and perceptions related to the use of AI in higher education. The exploratory design was chosen due to the emerging nature of the topic, as policies, norms, and practices regarding AI use are still in the process of consolidation, particularly within educational contexts in both developed and emerging countries. The study sought to understand how AI has been incorporated into higher education institutions in the United States and to reflect on the potential adaptation of these practices to the Brazilian context. The research was conducted in four main stages.

The first stage consisted of institutional benchmarking visits to North American universities [24]. The three universities were selected based on their recognized relevance in research, innovation, and the development of institutional initiatives related to AI in education, particularly through active Teaching and Learning Centers and documented AI-related policies. These visits involved meetings with faculty members, program coordinators, and representatives from centers for teaching and learning, to

understand institutional positioning, governance structures, and pedagogical approaches related to the use of AI in education. Across the visits, approximately 8 to 10 participants per institution were involved.

During these visits, unstructured interviews were conducted [25], guided by previously defined thematic axes. In addition, document analysis was carried out based on institutional materials provided by participants, such as internal guidelines, regulations, institutional policies, and orientation documents related to AI use. The main thematic axes addressed during these interactions included:

- Institutional policies, norms, and guidelines regarding the use of AI in education;
- Digital platforms and tools used by faculty members and students;
- Perceptions of how and how frequently students use AI tools;
- Faculty and student training strategies for AI use;
- Institutional monitoring practices and the existence of guidance, oversight, or sanctions related to the inappropriate use of AI.

These interactions focused on understanding institutional practices and the discourses associated with AI use, without a formal evaluative or comparative intent among the visited institutions. All interviews were recorded and fully transcribed for subsequent analysis.

The second stage involve unstructured interviews were conducted with a group of alumni from an undergraduate Industrial Engineering program at a Brazilian university. The goal of this stage was to learn about students' perspectives of the usage of AI in higher education, as well as how it relates to curriculum updates and job readiness. The conversations mostly addressed the following:

- Students’ perceptions of the adequacy and modernization of undergraduate curricula in response to emerging technological trends;
- How AI tools are used throughout their academic trajectory;
- Students’ opinions regarding the need for regulation, monitoring, or evaluation of AI use in undergraduate education.

The third stage involved data collected from benchmarking visits, document analyses, and guided talks were analyzed using content analysis techniques, following the framework proposed by Bardin [26]. Initially, a floating reading of the complete dataset, which included full interview transcripts and institutional papers, was performed to find passages pertinent to the research aims. Subsequently, thematic coding was performed, combining categories obtained from the literature on AI governance, pedagogical practices, ethics, faculty development, and equity of access with emergent categories inductively identified from the data.

The analytical process involved organizing codes into interpretative axes, allowing for the identification of patterns, convergences, and contrasts between the institutional discourses of North American universities and the perceptions of Brazilian students (Table 1). To enhance the reliability of the analysis, categories and interpretations were iteratively reviewed, ensuring internal consistency and alignment with the study’s objectives. The results of this stage directly informed the formulation of the proposed

guidelines, ensuring that they reflected both empirical evidence and relevant theoretical and contextual foundations.

Based on the content analysis findings, in the fourth stage, practical guidelines were proposed to support the ethical, pedagogical, and responsible use of AI in higher education. These guidelines were structured across three levels (faculty, students, and academic coordination) and were designed to serve as a reference for inclusion in course syllabi and institutional documents, contributing to the standardization and contextualization of AI-related practices in higher education institutions within emerging contexts.

Table 1 - Examples of data sources, initial codes, and analytical categories related to AI use in higher education

Data source	**Data excerpt (example)**	**Initial code**	**Analytical category**
Faculty member (University A)	"Each instructor decides whether AI can be used in assignments. The most important thing is that students clearly understand what is allowed in each course."	Faculty autonomy in AI-related decisions	Governance and autonomy
Institutional document	"The university recommends that syllabi include a specific section addressing the acceptable use of artificial intelligence tools."	Formal communication about AI use	Institutional transparency
Student (Brazil)	"We use AI to better understand exercises, but sometimes it's hard to know where the limit is and what the professor considers acceptable."	Uncertainty about usage boundaries	Pedagogical clarity
Faculty member (University B)	"Even when AI is allowed, I mainly assess whether the student can explain the reasoning they followed."	Assessment based on explanation	Pedagogical practices and learning
Program coordinator	"We offer monthly workshops so that faculty can exchange experiences on how they are using AI in the classroom."	Continuous faculty development	Institutional culture and professional development
Student (Brazil)	"Not everyone can afford better versions of the tools, so some students are at a disadvantage."	Inequality of access to tools	Equity and access
Faculty member (University C)	"I always ask students to disclose when they used AI and for what purpose."	AI use disclosure	Academic ethics and responsibility

Results

Benchmarking in North American Universities

The findings are based on three institutional benchmarking visits made in 2025 at three different North American universities. Each visit included around eight one-hour interviews, all of which were organized by the host universities. The purpose of these interviews was to present institutional practices, structures, and reflections related to the use of AI in higher education. Across all universities, it was possible to engage with undergraduate and graduate program coordinators, faculty members affiliated with engineering programs, and representatives from centers for Teaching and Learning.

Contact with the institutions was established in advance, and all visits were planned to facilitate the sharing of academic and scientific information. The visited universities authorized the use of the collected information for research purposes; nevertheless, in this study, the results are provided in an aggregated and analytical manner, without direct identification of the institutions, to protect participant confidentiality.

During these benchmarking visits, several aspects related to the use of AI in education were identified. The first finding addresses the most widely utilized AI technologies at the visiting institutions. A prevalence of generative AI tools was noted, notably popular platforms like ChatGPT, Microsoft Copilot, Gemini, Notebook LM, and Claude. These tools are utilized in commercial versions as well as protected institutional environments when universities make them public.

The results indicate that the use of generative AI is already widespread within the pedagogical practices of the visited universities. Institutional reports and surveys conducted directly with students suggest that the majority of students use AI tools on a regular or daily basis, both within and outside the classroom. From the students' perspective, AI is understood as a practical learning support tool, used to clarify doubts, review content, provide technical assistance for previously taught topics, and assist with exercise resolution. Some universities have created proprietary AI platforms expressly to answer student questions productively. Instead of providing straight or ready-made solutions, these tools are intended to help students build their reasoning and knowledge construction skills. Furthermore, AI is used to provide technical support in laboratory activities, robotics, and data analysis, eliminating initial obstacles and allowing students to focus more directly on core topics.

From the faculty perspective, AI is used both as technical support in the classroom and as a tool for preparing instructional materials. Faculty members reported using generative models to create summaries, systematize content, and generate podcasts and review materials based on recorded lectures. Practices were also identified in which students are taught how to create and adjust generative models across different platforms, using them to design exercises, reinforcement activities, and conceptual explorations, thereby strengthening active learning strategies.

At the undergraduate program coordination level, AI is used to assess and change course syllabi, organize student and staff input, and support continuous improvement activities within courses. AI is also used to arrange workshops and faculty exchange meetings, to share experiences and best practices for employing technology in the classroom. Despite the widespread adoption of AI, a common finding was the

perception that the use of these technologies remains marked by uncertainty. The visited universities acknowledge that there is still no clear consensus on how to use AI most effectively or how to structure definitive institutional policies for its use in education. As a result, flexible and decentralized governance models have emerged.

No institutional policies limitng the use of AI were identified. On the contrary, there is a strong emphasis on faculty autonomy, whereby each instructor is responsible for defining how and to what extent AI may be used in their courses, provided that these decisions are communicated clearly and objectively to students, particularly through course syllabi. Transparency and trust in the faculty–student relationship emerge as central elements in ensuring alignment with principles of academic integrity.

Some faculty members expressed concern about the good influence of AI on learning, particularly in evaluation. In such circumstances, other assessment procedures such as oral examinations, presentations, or individual meetings were used, even when AI was permitted in problem-solving activities. According to these professors, the most important aspect of assessment is the student's capacity to argue the problem, explain the logic used, and exhibit conceptual knowledge.

Similarly, there are no clearly established thresholds for permissible AI use, and no standardized consequences or sanctions for inappropriate uses. The management of such circumstances is typically delegated to faculty members, in accordance with their level of institutional autonomy, and is always consistent with broader academic integrity norms. Another interesting conclusion is about faculty development plans for AI use. Teaching and Learning Centers are important to this process at all visited institutions. These centers are in charge of encouraging ongoing professional development initiatives, including frequent workshops, support materials, and pedagogical consultations on incorporating AI into teaching practices.Initiatives were identified, such as informal lunchtimegatherings in which faculty members share their experiences using AI in their classes, address practical issues, and propose solutions implemented in their academic routines. These initiatives help to disseminate best practices, lower technological adoption obstacles, and strengthen an institutional culture based on experimentation, dialogue, and collaborative learning.

Students’ Perceptions of AI

The second data collection was conducted through a focus group with eight undergraduate students enrolled in the Industrial Engineering program, all in the final stage of their studies. During a two-hour session, the students responded to questions regarding the integration of different technologies throughout the program, as well as the adaptation of curricular content in response to societal changes. The examination of interviews with Industrial Engineering graduates demonstrates a constant sense that academic training struggles to keep up with technological changes in the labor market. The utilization of advanced digital tools, automation, data science, and computational platforms was frequently noted during the interviews, indicating a clear link to modern artificial intelligence applications.

Participants highlighted the importance of continuing curriculum modernization, pointing out that market technologies move faster than formal curriculum updates. According to their experiences, many digital technologies crucial to professional practice are mastered independently or after graduation, resulting in a gap between

academic instruction and actual market demands. This mismatch is most noticeable in areas such as programming, data analysis, and the use of computational platforms, which are currently regarded as key competencies for engineers.

Another frequent theme in the students' statements is the use of technological platforms to promote teaching and learning, both within and outside the classroom. Students reported using institutional virtual learning environments and electronic forms as standard practices, but they also identified limits in more advanced pedagogical study of these tools. The program is expected to use technology not only as administrative or communication tools, but also as active tools for learning, simulation, and problem solving in the real-world setting.

The interviewees also mentioned individual initiatives aimed at tackling rising technology concerns, such as lectures given by alumni and industry professionals on practical data science, information security, and data-intensive work. These activities were scored well, however they were viewed as sporadic and not systemically integrated into the curriculum.The findings also show that, from the students' perspective, the debate over the use of artificial intelligence in education is not restricted to the use of certain technologies, such as generative models. Rather, it is related with the program's ability to adapt to new technological demands, incorporate market-aligned platforms, and promote practical lessons that foster autonomy and critical thinking. These findings highlight the need of institutional policies and pedagogical guidelines that view AI as more than just a technical resource, but as part of a larger strategy for curricular innovation and constant updating of engineering education, particularly in emerging countries.

Guidelines for the use of AI in emerging countries

Based on an examination of practices seen in North American institutions, perceptions of students from a developing country, and a review of the research [4], [13], [18], [27], it is conceivable to suggest a set of guidelines for the use of AI in higher education. These guidelines aim to support institutions, academic coordination, and faculty in the conscious and pedagogically grounded adoption of AI platforms, while respecting diverse institutional contexts and promoting responsible and equitable use of these technologies. The guidelines were organized according to conceptual axes and the main actors involved in the educational process, to facilitate their understanding, implementation, and adaptation across different higher education contexts, particularly in emerging countries. The proposed guidelines are directly derived from recurring patterns identified in both benchmarking data and student perspectives. These guidelines are presented in Table 2.

Table 2 - Guidelines for the Use of Artificial Intelligence in Higher Education

Guideline axis	Primary actor	Proposed guideline
Governance and autonomy	Faculty	Ensure faculty autonomy to define the level and manner of AI use in their courses, respecting the pedagogical specificities of each area of knowledge.
	Academic coordination	Adopt flexible and decentralized governance models for AI use, avoiding generalized prohibition policies.
Transparency and communication	Faculty	Clearly and objectively communicate to students what is permitted or not regarding AI use in each course, preferably through the syllabus.
	Academic coordination	Define institutional or departmental standardized statements that explicitly indicate when AI use is authorized, encouraged, or restricted, as well as the pedagogical objectives of such use.
Pedagogical practices and learning	Faculty	Develop creative classes and active learning strategies that reduce excessive dependence on AI, fostering student engagement, critical thinking, and problem-solving skills.
	Faculty	Use AI as a learning support tool within active methodologies, rather than replacing students' reasoning.
	Faculty	Prioritize assessment strategies that emphasize explanation of reasoning, argumentation, and conceptual understanding, even when AI use is permitted.
Professional development and institutional culture	Academic coordination	Promote institutional spaces for sharing experiences related to AI use, such as workshops, communities of practice, and informal faculty meetings.
	Academic coordination	Encourage and support faculty participation in in-person and/or online courses on the pedagogical use of AI, addressing both technical and didactic aspects.
	Academic coordination	Strengthen the role of Teaching and Learning Centers, where available, in the continuous professional development of faculty for the responsible and pedagogical use of AI.
Ethics, authorship, and responsibility	Faculty / Students	Promote open dialogue with students about ethics, authorship, responsibility, and AI use in academic activities.
	Students	Encourage transparency by students regarding the use of AI tools in the completion of academic tasks.
Equity and access	Academic coordination	Develop curricula and institutional environments that ensure equitable access to AI platforms, considering socioeconomic inequalities and infrastructure limitations common in emerging countries.

Conclusion and First Steps for Implementation

The purpose of this study was to propose guidelines for the use of artificial intelligence in higher education in emerging countries, taking into account the fact that such technologies still lack widely prescribed or clearly defined standards for pedagogically beneficial use by faculty members, students, and academic collaboration. An exploratory qualitative approach that combined benchmarking visits to universities in developed countries with student perceptions of an institution in an emerging country allowed for the identification of practices, challenges, and opportunities that informed the development of an initial set of guiding recommendations.

The results indicate that the integration of AI in higher education tends to be more effective when grounded in flexible and decentralized models that preserve faculty autonomy, promote transparency in communication with students, and prioritize continuous professional development. In this regard, the importance of expanding training initiatives, discussion groups, and workshops focused on the conscious, responsible, and ethical use of AI as a tool to support knowledge development is emphasized. Equally relevant is the encouragement of open dialogue between professors and students to clearly define, within each course, the boundaries and possibilities for the use of AI technologies. Another central aspect concerns the need to create institutional environments that ensure equitable access to AI platforms, preventing their use from being restricted to students with more favorable socioeconomic conditions or privileged infrastructure.

Beyond the conceptual and propositional contributions of this study, initial steps toward implementing the proposed guidelines are already being adopted within the analyzed institutional context. Among these actions is the development of standardized syllabus statements intended to facilitate clear communication regarding the permitted use of AI in academic activities. Four categories of AI use were established: (i) full permission for AI use; (ii) partial permission for AI use during in-class activities; (iii) partial permission for AI use in out-of-class assignments; and (iv) prohibition of AI use in the course. Figure 1 presents, as an example, one of these standardized texts corresponding to the category of “full permission for AI use.”

An additional outcome observed is the incentive for faculty development, with approximately 30% of the program’s professors having already participated in training activities related to the pedagogical use of AI, many of which were inspired by practices observed at the North American universities visited. Furthermore, institutional workshops are planned to promote collective discussions among faculty regarding the use of AI in their courses, as well as discussion sessions with student academic organizations focused on the conscious and responsible use of AI technologies.

As a limitation of this study, it should be noted that data collection in the emerging country context was restricted to student perceptions, not yet incorporating the perspectives of faculty members and academic coordination. The proposed guidelines should be understood as initial and context-sensitive propositions derived from an exploratory qualitative study. As such, they are not intended to be statistically generalizable, but rather to offer analytically grounded insights that can inform future adaptations and empirical validations in other institutional contexts. Further studies are

needed to expand the evidence base, particularly by incorporating perspectives from faculty members and academic coordination in emerging countries.

Future research is therefore encouraged to expand the scope of analysis by including these institutional actors and by examining, through longitudinal studies, the effectiveness and adequacy of the proposed guidelines. Additional studies may also contribute to the empirical validation of these guidelines by assessing their impact on pedagogical practices, assessment processes, and learning experiences over time.

Figure 1 – Standardized syllabus text for AI use in the course

Example 1 – Full permission for the use of AI tools in the course
In this course, the use of artificial intelligence tools is permitted as support for the learning process, including exercises and graded activities, in accordance with the instructor's guidance. AI should be used to support the development of reasoning and the organization of ideas and must not replace the student's own cognitive effort. Students are responsible for the accuracy, coherence, and quality of the information presented, including content generated with the support of AI tools. Ethical, responsible, and conscious use of these technologies is expected, in compliance with principles of authorship, academic integrity, information security, and data privacy. Whenever AI tools are used, their application must be explicitly disclosed in the submitted work, according to the model below. AI Use Statement: In completing this assignment, I used the artificial intelligence tool _____ to support the following task(s): _____. I am responsible for verifying the accuracy of the information and for the final content submitted.

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