

Methodological and Educational Foundations for Information Systems in the Age of Generative Artificial Intelligence

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Abstract: Large generative models have transformed automated interaction with information by enabling the production of high-quality content, encompassing descriptive, pictorial, auditory, and argumentative elements. Their increasing application across various domains imposes both epistemological and practical challenges on information systems, demanding special attention to process and project management, requirements engineering, ethics and regulation, and professional training. The insufficient formalization of these demands harms the evolution of generative systemic solutions and suggests a key challenge for the field of information systems: establishing new methodological foundations for research and practice, alongside educational foundations for training and professional development, by adapting processes and techniques for information system development, to effectively equip organizations and professionals to responsibly adopt the paradigm of generative artificial intelligence.

Palavras-chave: large generative models, methodological foundations in information systems, educational foundations in information systems.

1. Reflection on a Key Challenge in Information Systems in Brazil for the Next 10 Years

Large generative models are artificial intelligence (AI) tools that, when exposed to vast datasets and combined with vector representation techniques [Goodfellow et al. 2016, Vaswani et al. 2017, Mikolov et al. 2013, Johnson et al. 2019] and sophisticated retrieval procedures [Lewis et al. 2020], can produce images and natural language that revolutionize automated information interaction. The high quality of generative AI outputs often meets problem-solving demands, prompting changes in information systems. This includes adapting requirements engineering, personnel and process certification, and implementing stricter evaluation, monitoring, ethical, and regulatory frameworks. While these models boost efficiency and productivity, they also require an epistemological shift in how information systems are conceived, applied, and understood, across conceptual, technical, ethical, and cultural dimensions.

Today, in Brazil, the adoption of generative AI is underway; however, it faces significant obstacles that must be overcome for this movement to thrive and keep pace with global trends in the coming years. A study commissioned by SAS: Data and AI Solutions and conducted by the B2B market research agency Coleman Parkes [SAS Institute Inc. and Parkes 2024] highlights points that deserve close attention. This study ranks Brazil in 11th place globally in terms of generative AI adoption among companies (46% of Brazilian companies are engaging in this movement, compared to 54% worldwide), and identifies factors that hinder progress in Brazil, including:

- the difficulty of transitioning from the conceptual phase to practical application, and the challenge of establishing secure governance frameworks to ensure both value maximization and risk minimization — highlighting that generative AI creates value only when embedded within information systems that support business processes and enable services; and
- the lack of internal expertise, coupled with organizational leaders' acknowledgment that they do not possess full knowledge in this domain — underscoring the urgent need to develop mechanisms for training and upskilling information technology professionals in generative AI across all stages of the information system development lifecycle.

The Challenge for the Next Decade and Its Urgency and Criticality

The challenge is to create solid methodological and educational foundations to support the management and development of information systems with generative solutions, and to prepare Brazilian information technology professionals for this new way of interacting with information. This requires continuous attention over the next decade to ensure lasting solutions, but it must begin immediately. The urgency comes from the rapid growth of this field and the aggressive spread of foreign technologies in our country, bringing not only technology but also methods and values, imposing ways of life and work that undermine national autonomy and strengthen a form of colonialism.

2. The Criticality of Directing Community Efforts Toward Overcoming This Challenge

The transition to generative model-based information systems marks a conceptual and methodological milestone. It drives the development of more intelligent systems and demands technical progress, ethical rigor, creative engagement, and alignment with global players to secure Brazil's position in the field through effective use of generative AI. Nonetheless, while certifying bodies advance risk and accountability protocols [Jobin et al. 2019], core areas such as professional training and information system management evolve slowly. Implementation aspects of generative AI remain largely confined to discussions within the AI field, which often overlook the specificities of information systems and fail to address them with sufficient depth and sociotechnical responsibility [Bommasani et al. 2021].

The remainder of this section explores key aspects of the proposed challenge and presents examples of actions that can help overcome it, considering two fundamental dimensions: methodological and educational.

Methodological Foundations

The primary concern regarding generative models is that they employ statistical reasoning, inherently prone to errors manifesting as imprecise or incorrect information.

Specifically, in natural language generation, such inaccuracies may be obscured by the high linguistic quality of the output, causing both experts and nonexperts to accept falsehoods as truths [Zellers et al. 2019]. This issue has been mitigated through information retrieval procedures; however, these remain unreliable, as they also are based on inductive principles. The second concern pertains to the degree of autonomy imposed by generative models. These models are minimally, if at all, verifiable formally; i.e., even with a well-formulated task, there is no formal guarantee that the model's output will meet the specified requirements and constraints. Efforts to measure compliance have demanded substantial effort in AI [Bommasani et al. 2021], without producing satisfactory procedures for practical assurance.

Considering this uncertainty, the field of information systems needs to adopt mechanisms aware of the presence of generative AI in information systems, to associate confidence levels with the deployment of these systems [Mitchell et al. 2019, Floridi and Cowls 2022], taking into account their sociotechnical position, in which people, businesses, and organizations are impacted by their performance. This entails, for example, the explicitly indicating the presence of a generative model in the business management lifecycle, as an artifact or agent; the incorporation of the evaluation of generative AI's capabilities and limitations into the system's risk matrix; reformulating and formalizing the non-functional requirements of an information system, given the generative model's implicit functionalities; devising strategies to translate the outputs of a generative model into tangible elements for process monitoring; and establishing guidelines and regulations for generative models that consider the sociotechnical characteristics of an information system, thereby ensuring transparency regarding their use and assigned responsibilities.

Changes in the spectrum of concerns among process and project managers, as well as across the various roles assumed by Information Technology (IT) professionals throughout the information systems lifecycle, include, but are certainly not limited to, the following:

- Strategic planning with greater emphasis on infrastructure feasibility, accounting for direct costs (e.g., hardware) and indirect ones (e.g., sustainable energy). Alternatively, organizations may rely on third-party infrastructure, which introduces additional concerns regarding the delegation of information management responsibilities to external providers.
- Requirements and quality management must consider changes in system interactions with users and external systems. This will require defining minimum confidence thresholds, and embedding transparency and fairness issues into service level agreements.

- Development and maintenance phase will involve simulation and real-time monitoring (e.g., digital twins), telemetry for continuous output analysis, and the design of automated alerts against non-deterministic or adversarial behavior.
- Evolution and decommissioning phases will demand practices such as auditable reuse of interaction histories and the concept of ethical deactivation (e.g., the secure disposal of models or training data that may contain sensitive or proprietary content) as part of a broader governance framework.
- Transversally, human-AI collaboration reshapes roles in IT projects and in business process, requiring revised human resources strategies and accountability policies for AI-influenced decisions.

Educational Foundations

The rapid evolution of large generative models requires a shift in the knowledge and practices of IT professionals. Generative AI concepts should extend beyond those professionals directly involved in generative AI-model development [Rahwan 2018]. Other professionals in the information systems life cycle need training to understand the advantages, limitations, costs, and ethical, regulatory, and social risks of these models, enabling informed application decisions.

To address the complexities and opportunities introduced by generative models, it is necessary to reformulate curricula in the field of Information Systems, taking into account emerging roles for IT professionals. This calls for action from government agencies responsible for defining core curricula for technical and university-level programs, as well as from professional societies that guide the field's development in a national level, including processes related to certification and the training of auditors. However, given the urgency of the topic and the speed at which it is permeating society, targeted and feasible actions are required in the short term, particularly through the revision of course syllabi in subjects such as "Introduction to Information Systems", "Programming" (to incorporate prompt engineering concepts and practices), "Software Engineering", "Project Management", and "Process Management". It is therefore essential to integrate generative model conceptualization and practice with transversal topics such as ethics and law. In addition, to ensure the effectiveness of these courses, priority must be given to faculty training and the development of updated teaching materials.

3. The Risks of Not Making Progress in Solving This Challenge

Brazil faces organizational challenges that hinder the broader adoption of generative AI, the most critical of which is the lack of internal expertise. The aforementioned study [SAS Institute Inc. and Parkes 2024] also reveals a perception among IT professionals that the key lies in integrating generative AI into decision-making processes, supported by orchestration and governance layers. In other words, without adequate efforts to develop specialized knowledge in generative AI and information systems, to integrate generative models into educational curricula, and to raise both professional and organizational awareness, the national information systems sector may become inefficient and ineffective, jeopardizing any opportunity to position the Brazilian software and services industry as a sovereign technological innovator.

4. Related Problems, Fields, Knowledge, Actions, Initiatives, and Technologies Associated With This Challenge

The proposed challenge involves methodological and educational actions in information systems, linked to initiatives in AI and high-performance computing. It also addresses transversal issues like legal regulation, international relations, market positioning, and sustainability, given the environmental impact of generative models. Positioning the information systems field in the era of generative models demands an interdisciplinary approach within computing and administration fields, alongside a multi- and transdisciplinary perspective on the other fields mentioned and potential new ones.

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